DRAFT FINAL
REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT

PLASTIC SALES & SERVICE, INC. SITE
6860 AND 6870 WOODLAWN AVENUE NORTHEAST
SEATTLE, WASHINGTON
AGREED ORDER NO. DE 7084

Submitted by:
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For:
Plastic Sales & Service, Inc.
6870 Woodlawn Avenue Northeast
Seattle, Washington

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ACRONYMS AND ABBREVIATIONS

3-DME	3-Dimensional Microemulsion
AAG	Assistant Attorney General
Agreed Order	Washington State Department of Ecology Agreed Order No. DE 7084 dated September 14, 2009
ARARs	applicable or relevant and appropriate requirements
bgs	below ground surface
cis-1,2-DCE	cis-1,2-dichloroethene
CLARC	Cleanup Levels and Risk Calculations
cm/sec	centimeters per second
COCs	constituents of concern
COPCs	constituents of potential concern
DCE	dichloroethene
Deep Zone	soil strata underlying the Shallow Zone, comprised of dense to very dense poorly graded sand and gravel to well-graded sand and silty sand with semi-confined groundwater flowing in a northeasterly direction. The Deep Zone is underlain by a silt layer encountered at a depth of approximately 70 feet bgs.
DNAPL	dense nonaqueous-phase liquid
DRO	total petroleum hydrocarbons as diesel-range organics
Dry Cleaner Building	adjoining one- and two-story warehouse/office buildings at 6870 Woodlawn Avenue Northeast and 6569 4th Avenue Northeast, respectively, where a dry cleaner was formerly operated from about 1948 to 1977
Dry Cleaner Building Property	comprises King County Assessor Parcel Nos. 9528104725 and 9528104735, where the Dry Cleaner Building is situated, located at 6870 Woodlawn Avenue Northeast
Ecology	Washington State Department of Ecology
EOS	emulsified oil substrate

EPA	U.S. Environmental Protection Agency
ET-DSP	Electro-Thermal Dynamic Stripping Process
Farallon	Farallon Consulting, L.L.C.
foc	fraction organic carbon
former Laundry Building	the building formerly situated at 6860 Woodlawn Avenue Northeast
former Scott Trophy Building	the building formerly situated at 6560 Latona Avenue Northeast
FS	Feasibility Study
GeoEngineers	GeoEngineers, Inc.
GRO	total petroleum hydrocarbons as gasoline-range organics
Hearthstone Property	comprises King County Assessor Parcel Nos. 9528104695 (former Laundry Building Property, where what is known as the former Laundry Building was situated, 6860 Woodlawn Avenue Northeast) and 9528104696 (former Yasuko Property, where the former Scott Trophy Building was situated, 6560 Latona Avenue Northeast)
HVOCs	halogenated volatile organic compounds
IRAWP	*Final Interim Remedial Action Work Plan for the Hearthstone Property* dated April 6, 2011 prepared by Sound Environmental Strategies
ISOTEC	In-Situ Oxidative Technologies, Inc.
Laundry Building Property	comprises King County Assessor Parcel No. 9528104695 located at 6860 Woodlawn Avenue Northeast
McMillan-McGee	McMillan-McGee Corporation
mg/kg	milligrams per kilogram
µg/l	micrograms per liter
mg/l	milligrams per liter
$\mu g/m^3$	micrograms per cubic meter
MTCA	Washington State Model Toxics Control Act Cleanup Regulation
ORO	total petroleum hydrocarbons as oil-range organics
PCE	tetrachloroethene

Phase II ESA Report	*Phase II Environmental Site Assessment, Plastic Sales and Service Site, 6569 4th Avenue Northeast, Seattle, Washington* dated August 6, 2004 prepared by GeoEngineers, Inc.
Plastic Sales	Plastic Sales & Service, Inc.
PLPs	Potentially Liable Persons
PQL	practical quantitation limit
RAO	remedial action objective
RCW	Revised Code of Washington
RI	Remedial Investigation
RI/FS Work Plan	Draft Remedial Investigation/Focused Feasibility Work Plan dated September 23, 2005 prepared by Farallon Consulting, L.L.C.
scfm	standard cubic feet per minute
SES	Sound Environmental Strategies, Inc.
Shallow Zone	soil strata between the ground surface and a depth of 20 feet bgs comprised of stiff to very stiff silt and medium dense to very dense silty sand with unconfined groundwater occurring between approximately 6 and 20 feet below ground surface flowing in a northerly direction
Site	the properties generally located at 6860 and 6870 Woodlawn Avenue Northeast in Seattle, Washington and identified as the Plastic Sales & Service, Inc. Site
SOD	soil oxidant demand
Sunshine Cleaners	former Sunshine Laundry and Dry Cleaning Company
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
TEE	Terrestrial Ecological Evaluation
TOC	total organic carbon
trans-1,2-DCE	trans-1,2-dichloroethene
UIC	underground injection control
UST	underground storage tank
VCP	Voluntary Cleanup Program

WAC	Washington Administrative Code

EXECUTIVE SUMMARY

Farallon Consulting, L.L.C. (Farallon) has prepared this draft final Remedial Investigation (RI) and Feasibility Study (FS) Report on behalf of Plastic Sales & Service, Inc. (Plastic Sales), the owner of the Plastic Sales & Service, Inc. facility at 6870 Woodlawn Avenue Northeast in Seattle, Washington. The Plastic Sales & Service, Inc. Site is defined in Washington State Department of Ecology (Ecology) Agreed Order No. DE 7084 dated September 14, 2009 (Agreed Order) to be the property generally located at 6860 and 6870 Woodlawn Avenue Northeast (herein referred to as the Site) that currently is owned by the Lutheran Retirement Home of Greater Seattle (Hearthstone) and Plastic Sales, respectively.

The RI/FS was completed in accordance with the scope of work described in the Draft Remedial Investigation/Focused Feasibility Work Plan dated September 23, 2005 prepared by Farallon (RI/FS Work Plan) and approved by Ecology. The RI/FS was performed according to the Agreed Order and in accordance with the Washington State Model Toxics Control Act Cleanup Regulation (MTCA), as established in Chapter 173-340 of the Washington Administrative Code (WAC 173-340).

The RI focused on identification of the sources of the dry cleaning solvent tetrachloroethene (PCE) and characterization of the nature and extent of PCE contamination in soil and groundwater. The scope of the FS included an initial screening of remediation technologies, field-testing of remediation technologies, and detailed evaluation of six cleanup alternatives that are most likely to be technically feasible for existing Site conditions, meet MTCA requirements, and be protective of human health and the environment.

The Site is located in Section 5, Township 25 South, Range 4 West in King County, Washington. Four parcels with a total area of 28,830 square feet located at the southwest corner of the intersection of Woodlawn Avenue Northeast and 4th Avenue Northeast compose the properties located at 6860 and 6870 Woodlawn Avenue Northeast. The four parcels include:

- King County Assessor Parcel Nos. 9528104735 (6870 Woodlawn Avenue Northeast) and 9528104725 (6569 4th Avenue Northeast) developed with adjoining one- and two-story warehouse/office buildings, respectively. The buildings are herein referred to collectively as the Dry Cleaner Building, and the parcels are herein referred to collectively as the Dry Cleaner Building Property because a dry cleaner was formerly operated on this Property from about 1948 to 1977. Plastic Sales currently owns and occupies these parcels for its business activities, which include printing, laminating, engraving, and finishing.

- King County Assessor Parcel Nos. 9528104695 (where what is known as the former Laundry Building was situated, 6860 Woodlawn Avenue Northeast), 9528104696 (former Yasuko Property where the former Scott Trophy Building was situated, 6560 Latona Avenue Northeast), located across the alley southwest of the Dry Cleaner Building. In 2006, Hearthstone purchased this property and the Laundry Building from Plastic Sales and demolished the Laundry Building. Hearthstone also purchased west- and south-adjacent King County Assessor Parcel No. 9528104696 from the Yasuko family and demolished the Scott Trophy building that was located there. Collectively, these two parcels comprise what is referred to as the Hearthstone Property. There are plans to develop the Hearthstone Property, which currently is a vacant lot, with an open excavation. Interim remedial action elements have been completed at the Hearthstone Property.

The Site is located within the city limits of Seattle in King County, Washington. According to King County Assessor Parcel records, the property type for the Hearthstone Property is commercial, and the present use is light industrial. According to these records, the property type for the Dry Cleaner Building Property is commercial, and the present use is general purpose industrial. The property types for adjacent properties are a mixture of commercial and single- and multi-family residential. The Site topography is relatively flat, sloping slightly toward the northeast. The ground surface elevation at the Site is approximately 150 feet above mean sea level.

Discussions in March 2004 with the owners/operators of the former Sunshine Laundry and Dry Cleaning Company (Sunshine Cleaners) indicated that Sunshine Cleaners owned and occupied the former Laundry Building beginning in 1931. According to the former owners of Sunshine

Cleaners, only laundry, pressing, and packaging operations were conducted at the former Laundry Building. Sunshine Cleaners initiated dry cleaning operations in 1948 in the adjacent Dry Cleaner Building located northeast of the former Laundry Building.

The property now occupied by the Dry Cleaner Building was developed with a residence at the time Sunshine Cleaners acquired the property in approximately 1948. The residence subsequently was demolished, and the Dry Cleaner Building was constructed on these parcels by Sunshine Cleaners to house dry cleaning operations.

The dry cleaning equipment installed in the Dry Cleaner Building by Sunshine Cleaners in 1948 used Stoddard solvent, which was the primary dry cleaning solvent in use from the late 1920s to the late 1950s. Stoddard solvent is a mixture of petroleum distillate fractions comprising over 200 different compounds, primarily in the same carbon chain range as gasoline. The Stoddard solvent was stored in two underground storage tanks (USTs), including one 1,500-gallon and one 2,000-gallon UST, which are located in Woodlawn Avenue Northeast, adjacent to the north side of the Dry Cleaner Building. The USTs reportedly were decommissioned in-place in 1958 when Sunshine Cleaners switched to the use of PCE for the dry cleaning operation.

PCE reportedly was stored in a 200-gallon aboveground storage tank inside the Dry Cleaner Building, which is consistent with historical industry practices. The former location of the aboveground storage tank is unknown. The former dry cleaning equipment used both Stoddard solvent and PCE and was located in the northwestern portion of the Dry Cleaner Building. Dry cleaning operations continued at the Site until 1977.

Plastic Sales began leasing the Dry Cleaner Building in 1978 and has occupied the building to the present. Historical and present operations conducted by Plastic Sales have not involved dry cleaning, but have included the use of small quantities of solvents.

The scope of work performed by Farallon included an RI component, which was necessary to address the data gaps identified following previous Site characterization efforts that confirmed a release of PCE to soil and groundwater at the Site. Subsurface investigation of the Site was initiated in 2004 and included multiple phases of characterization, culminating in completion of the RI in 2012. The RI completed at the Site included the following elements:

- Drilling and sampling of 86 borings at and adjacent to the Site;
- Collection of 197 soil samples for laboratory analysis;
- Collection of 52 reconnaissance groundwater samples from 37 locations for laboratory analysis;
- Installation and development of 30 groundwater monitoring wells;
- Collection of 91 groundwater samples from the monitoring wells for laboratory analysis;
- Aquifer testing, including slug tests in multiple wells, and a constant-rate aquifer pump test;
- Physical parameter testing of soil samples collected from the Site; and
- Laboratory analysis of groundwater samples for selected geochemical parameters to evaluate natural attenuation.

The stratigraphy at the Site is divided into the Shallow Zone and the Deep Zone. The Shallow Zone is comprised predominantly of stiff to very stiff silt and medium dense to very dense silty sand to a depth of approximately 20 feet below ground surface (bgs). Shallow Zone groundwater occurs between approximately 6 and 20 feet bgs and is under unconfined aquifer conditions. Shallow Zone groundwater elevation contours indicate a northerly groundwater flow direction, with an average gradient of approximately 0.05 foot per foot. The Deep Zone, underlying the Shallow Zone, is under semi-confined to confined aquifer conditions, with groundwater occurring from approximately 20 to 70 feet bgs. Deep Zone soil consists of dense to very dense poorly graded sand and gravel to well-graded sand and silty sand. Deep Zone groundwater elevation contours indicate a northeasterly groundwater flow direction, with an average gradient of approximately 0.05 foot per foot. The Deep Zone is underlain by a silt layer encountered at a depth of approximately 70 feet bgs that was present to 80 feet bgs, the maximum depth explored at the Site.

Interpretation of analytical data along with groundwater elevations, the groundwater flow gradient, and historical reconnaissance groundwater sampling results indicates that PCE concentrations in Shallow Zone groundwater exceed the MTCA Method A cleanup level beneath the Dry Cleaner Building, beneath the north-central portion of the Hearthstone Property, beneath the alley between these properties, and in the rights-of-way of Woodlawn Avenue Northeast to the north and 4th Avenue Northeast to the east. Two distinct source areas were identified at the Site, including one at the Dry Cleaner Building Property and one at the Hearthstone Property, as described below.

The source at the Dry Cleaner Building Property is attributed to releases from the former dry cleaning equipment and/or the floor drain system located in the northwest corner of the Dry Cleaner Building. In addition to the dry cleaning equipment source area, other minor source areas are suspected to be present in the southern portion of the Dry Cleaner Building. These minor source areas may have resulted from releases of PCE from the floor drain/sanitary sewer lines in these areas. Alternatively, the presence of PCE in soil and groundwater in these areas may be due to vapor-phase migration of PCE from the dry cleaning equipment source area.

Soil data collected to date indicate that soil impacted with PCE released from the dry cleaning equipment source area is primarily on the Dry Cleaner Building Property, but extends into the Woodlawn Avenue Northeast right-of-way and the alley in the northwest corner of the Dry Cleaner Building and into the 4th Avenue Northeast right-of-way east of the Dry Cleaner Building.

Data from the May 2010 groundwater monitoring event and the 2011 and 2012 investigations conducted beneath the Dry Cleaner Building and in the intersection of Woodlawn Avenue Northeast and 4th Avenue Northeast indicate that the Shallow Zone groundwater PCE plume associated with the Dry Cleaner Building is bounded to the north, east, south, and west. The groundwater analytical data for Shallow Zone monitoring well and reconnaissance groundwater samples collected during the RI field program have sufficiently delineated the lateral extent of the dissolved-PCE plume in Shallow Zone groundwater exceeding the MTCA Method A cleanup level of 5 micrograms per liter. These data demonstrate that dissolved concentrations of PCE and its degradation compounds in Shallow Zone groundwater attenuate rapidly with distance down-gradient of the dry cleaning equipment source area. The estimated length of the PCE plume in the Shallow Zone is approximately 50 feet down-gradient of the dry cleaning equipment source area. This is consistent with the low transmissivity of the saturated silt and silty sand comprising the Shallow Zone beneath the source area and the gradation to silt observed in areas down-gradient of the source. These factors appear to have significantly limited the lateral migration of PCE in groundwater to areas down-gradient of the Site.

Vertical migration of PCE from the source area beneath the former dry cleaning equipment and/or nearby floor drain system is affecting groundwater quality in the upper portions of the Deep Zone. Comparison of PCE and other halogenated volatile organic compound (HVOC) concentrations in groundwater proximate to the dry cleaning equipment source area prior to chemical oxidation pilot testing to down-gradient monitoring locations indicates that concentrations of these compounds in Deep Zone groundwater attenuate rapidly with distance down-gradient of the Shallow Zone source area. The lateral extent of the dissolved-PCE plume in the Deep Zone exceeding the MTCA Method A cleanup level is limited to a plume approximately 40 by 130 feet that has been sufficiently bounded to the northwest, north, northeast, and south. The vertical extent of the dissolved-PCE plume in the Deep Zone exceeding the MTCA Method A cleanup level is limited to the upper portion of the Deep Zone, extending from approximately 21 to 50 feet bgs. The lateral and vertical extent of PCE concentrations in Deep Zone groundwater has been sufficiently characterized with the existing Deep Zone monitoring well network and deep borings.

In addition to the dry cleaning equipment source area, a separate and distinct source area with elevated PCE concentrations in groundwater was identified on the Hearthstone Property in the area proximate to the former side sewer line in the north-central portion of the Hearthstone Property. This source area may be attributed to suspected releases of PCE from the former sanitary side sewer line proximate to this area. The lateral extent of the dissolved-PCE plume in the Shallow Zone exceeding the MTCA Method A cleanup level is limited to a plume approximately 60 by 90 feet that was sufficiently delineated during the RI field program. Existing data indicate that the Deep Zone is not affected by PCE in this area. In July 2012, an interim action was conducted at the Hearthstone Property as part of a development project requiring excavation to a depth of 15 feet bgs for an underground parking garage. The interim action consisted of excavation of 5,541 tons of PCE-contaminated soil. Some dewatering of PCE-contaminated groundwater also occurred to facilitate the initial excavation work.

Based on the results of the RI for the Site, the target media identified for the cleanup action are soil and groundwater because these media represent the highest probable risk to human health and the environment based on the exposure pathway analysis performed. Soil vapor and indoor air have been retained as media of concern based on the elevated concentrations of PCE in Shallow Zone soil and groundwater beneath the Dry Cleaner Building concrete floor slab. The constituents of concern (COCs) identified for the RI/FS included the following HVOCs:

- PCE;
- Trichloroethene;
- cis-1,2-dichloroethene;
- trans-1,2-dichloroethene; and
- Vinyl chloride.

Other chemicals identified as constituents of potential concern during previous investigations included fuel products (gasoline, diesel fuel, oil-range organics, benzene, toluene, ethylbenzene, xylenes), Stoddard solvent, and metals. The results of the laboratory analysis presented in the 2005 Site Characterization Report prepared by Farallon indicate that these compounds were not released to soil or groundwater from potential or confirmed source areas at concentrations exceeding MTCA Method A cleanup levels. Therefore, these compounds were not retained as COCs for further analysis during the RI/FS.

Because PCE and its degradation products share similar environmental fate and transport characteristics and are present in the same media, PCE is the COC targeted for remediation of soil and groundwater. MTCA cleanup levels protective of potential exposure pathways at the Site are specified for each COC and for each medium of concern.

As part of the FS, Farallon evaluated remediation technologies for the Site with respect to the cleanup requirements set forth in MTCA. Treatability studies were conducted to evaluate performance, determine process sizing, and estimate costs in sufficient detail to evaluate and screen specific remediation technologies for Site-specific conditions. Treatability studies were conducted at bench- and pilot-scale levels depending on the specific technology evaluated. The treatability studies included bench-scale testing of chemical oxidants, bench-scale testing of electrical resistivity, and pilot-scale chemical oxidant injection testing. Groundwater modeling was performed to assess aquifer characteristics and contaminant fate and transport, and numerical modeling was conducted in support of a preliminary design of an in-situ thermal treatment system. In December 2012, six additional soil samples were collected at three locations beneath the Dry Cleaner Building to provide additional characterization of PCE in soil and its leachability.

Initial screening of potential remediation technologies typically applied to sites contaminated with PCE and associated HVOCs was performed to eliminate technologies that did not meet MTCA minimum requirements for implementability, effectiveness, and cost. A number of remediation technologies were eliminated during the initial screening process set forth in WAC 173-340-350(8)(b). These technologies included but were not limited to air sparging and soil vapor extraction, soil flushing (co-solvents), and groundwater extraction. Farallon also considered a no-action scenario, but it did not meet the remedial action objectives, protectiveness criteria, or permanence minimum requirements.

The screening of potential technically feasible cleanup alternatives considered practicable remediation technologies confirmed to be implementable and effective at treating PCE and its degradation compounds in the affected media of concern. Farallon also considered whether Site-specific constraints may preclude application of a remediation technology by creating a greater risk to human health and/or the environment, or would result in substantial costs not proportional to the benefits of implementing that remediation technology.

Based on the cumulative subsurface investigation results and the feasibility testing results, six cleanup alternatives for the Dry Cleaner Building Property were retained for evaluation in the FS. Hearthstone evaluated remedial approaches appropriate for the Hearthstone Property separately. The six cleanup alternatives considered for the Dry Cleaner Building Property include:

- Cleanup Alternative 1: Institutional and Engineering Controls, Monitored Natural Attenuation;
- Cleanup Alternative 2: In-Situ Thermal Treatment Shallow Zone, Excavation of Shallow Zone Soil, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls;
- Cleanup Alternative 3: In-Situ Thermal Treatment Shallow Zone, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls;
- Cleanup Alternative 4: Shallow- and Deep-Zone In-Situ Thermal Treatment, Excavation of Shallow Zone Soil, Monitored Natural Attenuation, Institutional Controls;
- Cleanup Alternative 5: Excavation of Shallow Zone Soil, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls; and
- Cleanup Alternative 6: Excavation of Shallow and Deep Zone Soil (baseline).

Cleanup Alternatives 1 and 6 represent the least- and most-permanent solutions, respectively. Cleanup Alternative 6 includes excavation of Shallow Zone and Deep Zone soil where PCE exceeds the MTCA Method A cleanup level on the Dry Cleaner Building Property and down-gradient in the Woodlawn Avenue Northeast right-of-way and cross-gradient in the 4th Avenue Northeast right-of-way, and has the highest degree of permanence according to MTCA. Cleanup Alternative 6 serves as a baseline for evaluating permanence to the maximum extent practicable in the disproportionate cost analysis.

The Agreed Order specified that alternatives be evaluated according to MTCA criteria under four scenarios:

- Development of only the former Laundry Building Property will proceed in conjunction with the remedial action at the Site.

- Development of only the Dry Cleaner Building Property will proceed in conjunction with remedial action at the Site.
- Development of both the Former Laundry Building and Dry Cleaner Building Properties will proceed in conjunction with remedial action at the Site.
- Development will not occur in conjunction with the remedial action.

During a discussion with Ecology and the Washington State Assistant Attorney General on October 2, 2012, Plastic Sales confirmed that evaluation under these four scenarios would no longer be required because an interim action was conducted at the Hearthstone Property in 2011 and 2012, and the Dry Cleaner Building Property and adjacent rights-of-way will be addressed after the Dry Cleaner Building is vacated by Plastic Sales.

Cleanup Alternatives 2 through 6 meet the threshold criteria under MTCA for protection of human health and the environment, compliance with cleanup standards, and compliance with applicable state and federal laws, and include provisions for compliance monitoring. Cleanup Alternative 1 would achieve threshold requirements only over the long term.

Of the six cleanup alternatives, Cleanup Alternatives 2 and 3 rank highest using MTCA criteria to evaluate permanence to the maximum extent practicable. Under Cleanup Alternative 3, cleanup objectives can be achieved in a reasonable time frame at a cost that is substantially less than other active cleanup alternatives, if remediation is not to be conducted concurrently with development of the Dry Cleaner Building Property. There are no current or expected plans for development. If, however, remediation is to be conducted concurrently with development of the Dry Cleaner Building Property, the estimated cost for Cleanup Alternative 5 is about $50,000 less than Cleanup Alternative 3 and is comparably ranked under MTCA.

As there is no development project currently being planned for the Dry Cleaner Building Property, Cleanup Alternative 3 is considered to be the preferred cleanup alternative for the Dry Cleaner Building Property and the adjacent rights-of-way. The general sequence of work for implementing Cleanup Alternative 3 is as follows: demolish the Dry Cleaner Building; conduct thermal treatment of Shallow Zone soil and groundwater; remove the decommissioned USTs;

apply a chemical oxidant reagent to the Shallow Zone to assess the practicability to treat residual PCE down-gradient of the dry cleaning equipment source area in the Woodlawn Avenue Northeast right-of-way, treat Deep Zone groundwater using chemical oxidation or bioremediation; and establish institutional and engineering controls to prevent exposure to residual contamination and provide for long-term monitoring. Active treatment of the Shallow Zone on the Dry Cleaner Building Property will occur during the first year, followed by active treatment in the Deep Zone of the dry cleaning equipment source area and down-gradient in the Woodlawn Avenue Northeast right-of-way. Natural attenuation of PCE remaining after active treatment will be monitored as part of a compliance monitoring program with provisions for contingency actions. The estimated cost for implementing Cleanup Alternative 3 is $2,698,400. The estimated restoration time frame for achieving preliminary cleanup levels for groundwater at the standard point of compliance including the down-gradient rights-of-way is 25 to 35 years for both the Shallow and Deep Zones. Specific design details concerning implementation of the preferred cleanup alternative, the decision process for evaluating whether modifications to the selected approach are warranted, and the monitoring requirements that will be implemented to document effectiveness will be provided in the Engineering Design Report.

1.0 INTRODUCTION

Farallon Consulting, L.L.C. (Farallon) has prepared this draft final Remedial Investigation (RI) and Feasibility Study (FS) Report on behalf of the Lutheran Retirement Home of Greater Seattle (Hearthstone); Plastic Sales & Service, Inc. (Plastic Sales); Karkrie, LLC; and Ruben and Patricia Rael, the Potentially Liable Persons (PLPs) named in Washington State Department of Ecology (Ecology) Agreed Order No. DE 7084, dated September 14, 2009 (Agreed Order). The Agreed Order between Ecology and the PLPs is for the actions required at the property generally located at 6860 and 6870 Woodlawn Avenue Northeast in Seattle, Washington, currently owned by Hearthstone and Plastic Sales, respectively, and identified as the Plastic Sales & Service, Inc. Site (herein referred to as the Site) (Figures 1 and 2).

The property comprising King County Assessor Parcel Nos. 9528104725 and 9528104735 (where the Dry Cleaner Building is situated) located at 6870 Woodlawn Avenue Northeast is known as the Dry Cleaner Building Property because a dry cleaner was formerly operated at this location from about 1948 to 1977. The Dry Cleaner Building Property is currently owned by Plastic Sales, whose business activities include printing, laminating, engraving, and finishing (Figure 2). The property comprising King County Assessor Parcel Nos. 9528104695 and 9528104696 located at 6860 Woodlawn Avenue Northeast is known as the former Laundry Building Property. Hearthstone purchased the former Laundry Building Property from Plastic Sales in 2006, and the adjacent parcel to the west (6560 Latona Avenue Northeast, where the former Scott Trophy Building was situated) from the Yasuko family. The former Laundry Building Property and the adjacent parcel to the west are collectively referred to in this document as the Hearthstone Property.

The *Draft Remedial Investigation and Feasibility Study Report, Plastics Sales and Service Site, 6870 Woodlawn Avenue Northeast, Seattle, Washington*, prepared by Farallon (2007) (Draft RI/FS Report) was submitted to Ecology on October 30, 2007 on behalf of Plastic Sales. The work for that document was completed under the Ecology Voluntary Cleanup Program (VCP) and in accordance with the scope of work described and approved by Ecology in the *Draft Remedial Investigation/Focused Feasibility Work Plan, Plastics Sales and Service Site, 6870*

Woodlawn Avenue Northeast, Seattle, Washington dated September 23, 2005 (Farallon 2005d) (RI/FS Work Plan) and the Washington State Model Toxics Control Act Cleanup Regulation (MTCA) as established in Chapter 173-340 of the Washington Administrative Code (WAC 173-340). Ecology (2008a) and the Washington State Assistant Attorney General (AAG) (Ecology 2008b) comments on the Draft RI/FS Report were received in 2008. Additional subsurface investigation subsequently was conducted at the Site to address specific Ecology comments and requests for additional information, and to complete characterization of the nature and extent of tetrachloroethene (PCE) in soil and groundwater on the western portion of the Site. A revision to the Draft RI/FS Report (Farallon 2011a) (Revised Draft RI/FS Report) was submitted to Ecology on January 14, 2011.

The Draft RI/FS Report presented the results of the RI conducted at the Site through October 2007 to address the data gaps identified following initial site characterization efforts in 2004. The RI confirmed the release of the dry cleaning solvent PCE to soil and groundwater at the Site. At that time, the suspected source area of PCE was associated with former dry cleaning operations in the Dry Cleaner Building at the Site. Elevated concentrations of PCE are present in shallow soil and groundwater beneath the suspected source area proximate to the former dry cleaning equipment. The subsurface investigations focused on sufficiently defining the sources of PCE and characterizing the nature and extent of related PCE contamination in soil and groundwater.

Ecology (2008a) and the AAG (Ecology 2008b) provided comments on the Draft RI/FS Report and requested additional RI work and more-detailed evaluation of specific components of the FS. To address the Ecology and AAG comments and the request for additional information to complete the RI field program, Plastic Sales conducted an additional phase of subsurface investigation in 2008.

Hearthstone demolished the former Laundry Building and the adjacent former Scott Trophy Building at 6560 Latona Avenue Northeast in March 2009. During 2008 and 2009, Hearthstone conducted additional subsurface investigation in support of development plans for the Hearthstone Property (Figure 2). During this work, elevated concentrations of PCE were detected in groundwater samples collected from a newly installed monitoring well north of the central portion of the Hearthstone Property in the Woodlawn Avenue Northeast right-of-way. These results indicated that additional subsurface investigation was necessary to characterize the nature and extent of PCE in soil and groundwater on the western portion of the Site. Ecology approved work plans submitted by Hearthstone and by Plastics Sales to conduct this additional subsurface investigation (Sound Environmental Strategies, Inc. [SES] 2009a; Farallon 2009, 2010). Plastic Sales work was completed in May 2010 and confirmed that elevated concentrations of PCE were present in soil and groundwater in the north-central portion of the Hearthstone Property. The suspected source of this PCE is unknown, but likely is related to historical releases from the former sanitary side-sewer line in this area. The Hearthstone submitted a draft Interim Remedial Action Work Plan (IRAWP) for regulatory review to partially address the cleanup of PCE-contaminated soil and groundwater at the Hearthstone Property (SES 2010). The Final IRAWP was issued in 2011 (SES 2011) and was implemented in 2011 and 2012. Hearthstone submitted a draft Interim Remedial Action Preliminary Completion Report for regulatory review on August 1, 2012 (SES 2012).

Ecology submitted comments on the Revised Draft RI/FS Report in the following correspondence:

- Letter regarding Ecology's Comments on the ―Revised Draft Remedial Investigation and Feasibility Study Report by Farallon Consulting, dated January 14, 2011," March 2, 2011 (Ecology 2011a);
- E-mail message regarding Plastic Sales & Service, Inc. Site sent May 2, 2011 (Ecology 2011b);
- Letter regarding Remedial Investigation and Feasibility Study at Plastic Sales Site dated August 10, 2011 (Ecology 2011c);
- Letter regarding The Remedial Investigation/Feasibility Study Report for Plastic Sales Site, Seattle, Washington dated December 6, 2011 (Ecology 2011d); and
- Letter regarding Ecology's Final Recommendations for the Remedial Investigation/Feasibility Study (RI/FS) Report for Plastic Sales Site, Seattle, WA dated December 21, 2012 (Ecology 2012).

The Ecology comments have been discussed with Ecology at length on multiple occasions via e-mail messages and telephone, and at project meetings, including meetings on March 14 and March 31, 2011; January 31, March 13, and October 2, 2012; and April 2, 2013. Plastic Sales has responded to Ecology comments and concerns in the following correspondence:

- Technical Memorandum Regarding Response to Comments, Revised Remedial Investigation/Feasibility Study Report, Plastic Sales & Service, Inc. Site, Seattle, Washington dated October 6, 2011, prepared by Farallon (2011b);
- Technical Memorandum Regarding Key Technical Issues, Plastic Sales & Service, Inc., Seattle, Washington dated October 23, 2012, prepared by Farallon (2012);
- Technical Memorandum Regarding Response to Washington State Department of Ecology Final Recommendations for the Remedial Investigation/Feasibility Study Report, Plastic Sales & Service, Inc. Site, Seattle, Washington dated January 31, 2013, prepared by Farallon (2013a); and
- Technical Memorandum Regarding Summary of Activities to Complete Agreed Order Requirements, Plastic Sales and Service, Inc. Site, Seattle, Washington dated April 11, 2013, prepared by Farallon (2013b).

Subsequent to the issuing of the Revised Draft RI/FS Report, Plastic Sales and Hearthstone have conducted the following additional work:

- The Hearthstone interim action conducted between July 2011 and July 2012 included the excavation and off-site disposal of approximately 5,541 tons of PCE-contaminated soil from the Hearthstone Property (SES 2012). The Hearthstone interim action is summarized in Section 4, Hearthstone Property Interim Action.
- A supplementary subsurface investigation was conducted beneath the Dry Cleaner Building in February 2011 to refine the area of Shallow Zone treatment with the preferred cleanup alternative indicated in the Revised Draft RI/FS Report (Farallon 2011a). The results of this additional subsurface investigation are provided in Section 3, Completion of Remedial Investigation.

- An additional bench-scale test of electrical resistivity of soil in the dry cleaner equipment source area was conducted in February 2011 to support the design of the preferred cleanup alternative. The results of this bench-scale testing are discussed in Section 7.2.4, Bench-Scale Treatability Testing.
- Additional numerical modeling of subsurface conditions under an applied electrical field was conducted in 2011 and 2012 to support the design of the preferred cleanup alternative. The results of this additional modeling are discussed in Section 7.2.5, Thermal Treatment Numerical Modeling and Conceptual Design.
- At the request of Ecology, additional monitoring well MW-27 was installed in the intersection of Woodlawn Avenue Northeast and 4th Avenue Northeast in June 2011 to further evaluate the potential for preferential migration of contamination within the utility corridor of the subsurface sewer-main line in the Woodlawn Avenue Northeast right-of-way. The results of this additional subsurface investigation are provided in Section 3, Completion of Remedial Investigation.
- At the request of Ecology, additional computer modeling of natural attenuation processes was conducted in the Woodlawn Avenue Northeast right-of-way in October 2012 to refine the estimated restoration time frame. The results of this additional modeling have been incorporated into the discussion in Section 7.2.3, Two-Dimensional Modeling.
- During the summer of 2011, five monitoring wells in the intersection of Woodlawn Avenue Northeast and 4th Avenue Northeast were damaged during a Seattle Department of Transportation paving project. Four of the wells were repaired in December 2012. Monitoring well MW-23 was not repairable and was decommissioned.
- In support of the FS, additional borings SB-37 through SB-39 were advanced through the floor slab of the Dry Cleaner Building in December 2012. Six soil samples were analyzed for PCE, and two soil samples were analyzed for leachable PCE.

1.1 PURPOSE

The purpose of the RI for the Site was to collect and evaluate sufficient information to describe the nature and extent of Site contamination, to develop a conceptual site model, and to evaluate technically feasible cleanup alternatives in accordance with WAC 173-340-360 through 173-340-390. The purpose of the FS for the Site was to develop and evaluate cleanup alternatives to facilitate selection of a cleanup remedy in accordance with WAC 173-340-350(8). The FS was conducted to screen available remediation technologies and assemble a range of viable cleanup alternatives for evaluation in accordance with the minimum requirements for cleanup actions in WAC 173-340-360(2). WAC 173-340-360(3) provides requirements for determining whether a cleanup action uses permanent solutions to the maximum extent practicable, and WAC 173-340-360(4) provides requirements for determining whether a cleanup action provides for a reasonable restoration time frame.

The objective of this RI/FS Report is to provide sufficient information to enable Ecology and the PLPs to select and approve a cleanup remedy for the Site. The selected cleanup action for the Site will be documented in a Cleanup Action Plan that will be prepared in conformance with WAC 173-340-380.

1.2 REPORT ORGANIZATION

This RI/FS Report has been prepared to meet the general requirements under WAC 173-340-350(7) and 173-340-350(8). This report has been organized into the following sections:

- **Section 2—Site Background.** This section provides a description of the Site features and location; a summary of historical Site use; a description of the local geology, hydrogeology, and land use pertaining to the Site; and a summary of previous subsurface investigations conducted at the Site. The summary of previous subsurface investigations includes work by Farallon and others that was used to develop a preliminary conceptual site model for the Site, and to focus the scope of the FS.
- **Section 3—Completion of Remedial Investigation.** This section provides a description of the RI field program completed at the Site by Farallon in 2011 and in 2012, and includes a discussion of the scope of work completed and the results of the RI. This section also includes a discussion of the Terrestrial Ecological Evaluation (TEE) requirement under MTCA.

- **Section 4—**Hearthstone Property Interim Action. This section summarizes the interim action conducted on the Hearthstone Property in 2011 and 2012.
- **Section 5—Conceptual Site Model.** This section provides a summary of the conceptual site model derived from the results of the subsurface investigations performed at the Site. Included is a discussion of the confirmed and suspected source areas, affected media, contaminant fate and transport, and the contamination exposure assessment.
- **Section 6—Technical Elements**. This section identifies the remedial action objectives for the Site, and includes a description of the media and constituents of concern (COCs), cleanup standards, including preliminary cleanup levels for potential exposure pathways and points of compliance, and other potentially applicable state and federal regulations for the Site.
- **Section 7—Feasibility Study.** This section provides a summary of the scope of work and results for the FS, including chemical oxidant pilot testing, two-dimensional groundwater modeling, bench-scale testing, and numerical modeling and conceptual design of the thermal treatment. This section summarizes the overview, screening and evaluation of potential remediation technologies. The most-favorable technologies were assembled into a series of remedial alternatives, which were evaluated to identify a preferred cleanup alternative.
- **Section 8—Preferred Cleanup Alternative.** This section presents the preferred cleanup alternative for implementation at the Site and the rationale for its recommendation. Also included in this section is a description of potential contingency actions if modification of the recommended cleanup alternative is deemed necessary.
- **Section 8—Bibliography.** This section provides a list of the source materials used in preparing this report.
- **Section 9—Limitations.** This section presents Farallon's standard limitations associated with conducting the work reported herein and preparing this report.

2.0 SITE BACKGROUND

This section provides a description and the historical background of the Site and surrounding area, the environmental setting, hydrogeology, and prior investigations. The sources of historical data used to develop the site background include previous site investigations conducted by GeoEngineers, Inc. (GeoEngineers) (2004a, 2004b) in 2002, 2003, and 2004; Farallon in 2004 (Farallon 2005a), 2006, 2007 (Farallon 2007), and 2008, and SES (2010) in 2008 and 2009. Most-recent work by Farallon (2011a) in 2010, 2011, and 2012; and by SES (2012) in 2011 and 2012 is summarized in Section 3, Completion of Remedial Investigation. Additional sources of historical information pertaining to the Site included Ecology files, Site plans, aerial photographs, and information from the City of Seattle Department of Planning and Development, Seattle Public Utilities, Sanborn Fire Insurance Maps, Kroll Atlases, Polk and Cole City Directories, and Puget Sound Regional Archives.

2.1 SITE DESCRIPTION

The Site is located in Section 5, Township 25 South, Range 4 West in King County, Washington (Figure 1) and is generally located at 6860 and 6870 Woodlawn Avenue Northeast in Seattle, Washington (Figure 2). The Site is defined by the extent of contamination caused by the release of hazardous substances at the Site. PCE contamination has been identified south of Woodlawn Avenue Northeast between 4th Avenue Northeast and Latona Avenue. PCE contamination has migrated northward into the Woodlawn Avenue Northeast right-of-way and onto the property at 6869 Woodlawn Avenue Northeast on the north side of Woodlawn Avenue Northeast. Land parcels affected by releases from the Site are described in the following sections.

2.1.1 Plastics Sales Parcels

Plastic Sales operations currently occupy contiguous King County Assessor Parcel Nos. 9528104735 (6870 Woodlawn Avenue Northeast) and 9528104725 (6569 4th Avenue Northeast). These two parcels are developed with adjoining one- and two-story warehouse/office buildings, respectively. These structures are collectively referred to herein as the Dry Cleaner Building because a dry cleaner was formerly operated on this Property from about 1948 to 1977. Plastic Sales currently owns and occupies these parcels for its business activities, which include printing, laminating, engraving, and finishing.

2.1.2 Hearthstone Property Parcels

King County Assessor Parcel Nos. 9528104695 (6860 Woodlawn Avenue Northeast, where the former Laundry Building was situated) and 9528104696 (6560 Latona Avenue Northeast, where the former Scott Trophy Building was situated) are located across the alley southwest of the Dry Cleaner Building. Plastic Sales sold the 6860 Woodlawn Avenue Northeast parcel to Hearthstone in 2006 and leased the property back for a period of time. In 2009, Hearthstone demolished the one-story buildings formerly situated on these parcels, including the former Laundry Building and the former Scott Trophy Building.

2.1.3 Other Parcels

King County Assessor Parcel Nos. 9528100525 and 9528100535 (6869 Woodlawn Avenue Northeast) across Woodlawn Avenue Northeast, north of the Dry Cleaner Building Property is currently used for commercial offices, with ground-level daylight paved parking beneath the western half of the building.

2.2 UNDERGROUND UTILITIES

Woodlawn Avenue Northeast is a traffic arterial with moderate traffic load, including bus services. The Woodlawn Avenue Northeast right-of-way utility corridor comprises a subsurface sanitary sewer main and multiple side sewer laterals, water main and multiple side service lines, storm drains, and a natural gas main and multiple gas laterals. Overhead electrical power lines are present along the south side of Woodlawn Avenue Northeast.

The subsurface utilities that enter the Dry Cleaner Building Property and the Hearthstone Property from the north and east sides include natural gas, sanitary sewer, and water services (Figure 3). Sanitary sewer service is provided to the Dry Cleaner Building by a municipal sewer main that runs southeast to northwest in the center of 4th Avenue Northeast on the east side of the Site and joins a southwest-to-northeast-trending main down the center of Woodlawn Avenue Northeast. Based on review of the City of Seattle Department of Planning and Development side sewer plans for the Site and information obtained from a private utility locate performed by Farallon, the sanitary sewer service enters the Dry Cleaner Building at four locations, including two on the north side of the building and two on the east side the building (Figure 3). The sanitary sewer service to the former Laundry Building entered on the north side of the building, and the side sewer remains connected to the sewer main in Woodlawn Avenue Northeast (Figure 3). The Hearthstone Property drain and sump system shown on Figure 3 was removed when the buildings were demolished in 2006.

2.3 SITE HISTORY

Discussions in March 2004 with the owners/operators of the former Sunshine Laundry and Dry Cleaning Company (Sunshine Cleaners) indicated that Sunshine Cleaners owned and occupied the former Laundry Building starting in 1931. According to the former owners of Sunshine Cleaners, only laundry, pressing, and packaging operations were conducted at the former Laundry Building (Figure 3). Sunshine Cleaners initiated dry cleaning operations in 1948 in the adjacent Dry Cleaner Building northeast of the former Laundry Building.

The property now occupied by the Dry Cleaner Building was developed with a residence at the time that Sunshine Cleaners acquired the property in approximately 1948. The residence subsequently was demolished, and the Dry Cleaner Building was constructed on these parcels by Sunshine Cleaners to house dry cleaning operations.

The dry cleaning equipment installed by Sunshine Cleaners in the Dry Cleaner Building in 1948 used Stoddard solvent, which was the primary dry cleaning solvent in use from the late 1920s to the late 1950s. Stoddard solvent is a mixture of petroleum distillate fractions comprising over 200 different compounds, primarily in the same carbon chain range as gasoline. The Stoddard solvent was stored in two underground storage tanks (USTs) that are located in the Woodlawn Avenue Northeast right-of-way adjacent to the north side of the Dry Cleaner Building (Figure 3). The USTs are of 1,500- and 2,000-gallon capacities. The USTs reportedly were decommissioned in-place in 1958, when Sunshine Cleaners switched to the use of PCE in its dry cleaning operation.

PCE reportedly was stored in a 200-gallon aboveground storage tank inside the Dry Cleaner Building, which is consistent with historical industry practices. The former location of the aboveground storage tank is unknown. The former dry cleaning equipment, which was used for both the Stoddard solvent and PCE operations, was located in the western portion of the Dry Cleaner Building (Figure 3). Dry cleaning operations continued at the Site until 1977.

Plastic Sales began leasing the Dry Cleaner Building in 1978 and has occupied the building to the present. Historical and present operations conducted by Plastic Sales have not involved dry cleaning, but have included the use of small quantities of solvents.

2.4 ENVIRONMENTAL SETTING

This section provides a summary of the environmental setting of the Site. The information presented in this section has been obtained from national, state, and local records, including national census statistics.

2.4.1 Land Use

The Site is located within the city limits of Seattle in King County, Washington (Figure 1). According to City of Seattle Department of Planning and Development (2010) records, the parcels comprising the Site are zoned Neighborhood Commercial 3. Immediately south are properties zoned for single- and multi-family residential use. According to the King County, Washington (2010) Department of Assessments, the present use of the Dry Cleaner Building Property is general purpose industrial. The Hearthstone Property is currently being redeveloped by Hearthstone and is vacant pending construction of a retirement community apartment building with underground parking.

2.4.2 Demographics

The Site is located north of downtown Seattle in the Green Lake neighborhood. This neighborhood is used predominantly for commercial office, retail, and residential activities. The population of Seattle is approximately 608,660 (U.S. Department of Commerce 2010).

2.4.3 Topography

The Site topography is relatively flat, with a slight slope toward the northeast (Figure 1). The ground surface elevation at the Site is approximately 150 feet above mean sea level (U.S. Geological Survey 1981).

2.4.4 Meteorology

According to the Western Regional Climate Center (2005), the climate of the Seattle area is maritime, characterized by cool summers and mild winters influenced by ocean air. The average annual minimum temperature is 45.1 degrees Fahrenheit, and the average maximum temperature is 61.5 degrees Fahrenheit (Western Regional Climate Center 2005). The average annual precipitation in Seattle is 36.22 inches, with over 4 inches of precipitation per month from November through March.

2.4.5 Groundwater Use

City of Seattle water is supplied from the Cedar River and South Fork Tolt River watersheds. A small amount of city water is supplied by groundwater wells. There are no drinking water supply wells within a 0.5-mile radius of the Site (Ecology 2003). Shallow Zone groundwater at the Site, described in Section 2.5.2.2, is not used as a drinking water source and likely is a non-potable resource as defined in WAC 173-340-720(2)(b)(i) due to the nature of the subsurface lithology in the Shallow Zone, which predominantly comprises silty sand and silt. Deep Zone groundwater underlying the Shallow Zone may qualify as a potential future source of potable water.

2.5 HYDROGEOLOGY

A summary of the Site and Site vicinity geology and hydrology is provided below.

2.5.1 Geology

According to geologic mapping by the U.S. Geological Survey (2005), the Site is underlain by artificial fill, Quaternary alluvium, and glacial till deposits (Vashon Till). The alluvium consists of silt, sand, gravel, and cobbles deposited by streams. The shallow subsurface geology north-northwest of the Site comprises artificial fill and landfill debris overlying Quaternary lake deposits. The lake deposits consist of silt and clay with local sand layers, peat, and other organic sediments deposited in slow-flowing water (U.S. Geological Survey 2005). The underlying Vashon Till is a dense to very dense gray unsorted gravelly silty sand or sandy silt that is locally clayey and contains scattered or agglomerated cobbles and boulders (Galster and Laprade 1991).

The general subsurface stratigraphy encountered in the borings advanced by GeoEngineers and Farallon consisted of alluvium comprising stiff to very stiff silt and medium dense to very dense silty sand from the ground surface to a depth of approximately 20 feet below ground surface (bgs), herein referred to as the Shallow Zone. The soil encountered from depths of approximately 20 to 70 feet bgs consisted of dense to very dense poorly graded sand and gravel to well-graded sand and silty sand, herein referred to as the Deep Zone. In general, the silty sand layers encountered in the Shallow Zone contained a higher percentage of silt (30 to 40 percent) versus silty sand layers encountered in the Deep Zone. The Deep Zone is underlain by a silt layer encountered at a depth of approximately 70 feet bgs to the total depth drilled of 80 feet bgs in boring MW-18.

2.5.2 Hydrology

This section summarizes the surface water and groundwater characteristics at the Site and vicinity.

2.5.2.1 Surface Water

The Site is located approximately 1,000 feet southeast of Green Lake, which was formed during the Vashon glaciation approximately 12,000 to 18,000 years ago. Prior to the placement of fill (over 1 million cubic yards) along the northern and eastern shores of the lake in the early 1900s, surface water drainage from Green Lake flowed from the east end of Green Lake into Ravenna Creek in an easterly direction, and eventually into Union Bay on the west side of Lake Washington (Galster and Laprade 1991). A drainage outlet reportedly formerly flowed southeast from Green Lake between 4th and 5th Avenues Northeast approximately one-half block northeast of the Site (GeoEngineers 2004b) (Figure 2). According to records reviewed by Farallon and interviews with personnel from the City of Seattle Department of Planning and

Development and Seattle Public Utilities, drainage from the east end of Green Lake now flows southeast in an underground storm drain that eventually discharges to Portage Bay.

2.5.2.2 Groundwater

Shallow groundwater in the Seattle area generally occurs in the most-recent alluvial deposits overlying the glacial till or over-consolidated sands and gravels (Esperance Sand) that underlie the glacial till. The dense and relatively impermeable nature of the glacial till and the commonly discontinuous lateral continuity of the groundwater-bearing materials impede lateral and vertical migration of groundwater. Permeability values for the glacial till range from 0.003 foot to 30 feet per day (Galster and Laprade 1991).

Two groundwater-bearing zones are present within the alluvial deposits beneath the Site. A shallow unconfined water-bearing zone is present from approximately 6 to 20 feet bgs, herein referred to as Shallow Zone groundwater. The Shallow Zone is underlain by a semi-confined to confined groundwater-bearing zone at depths of 20 to 70 feet bgs, herein referred to as Deep Zone groundwater. Groundwater levels were contoured for the Shallow Zone using May 7, 2010 water level measurements collected by Farallon (Figure 4; Table 1). The groundwater contours indicate a northerly groundwater flow direction with a gradient of about 0.05 foot per foot in the Shallow Zone. Groundwater levels were contoured for the Deep Zone using May 7, 2010 water level measurements collected by Farallon (Figure 5; Table 1). The groundwater contours indicate a northeasterly groundwater flow direction with a gradient of about 0.05 foot per foot in the Deep Zone.

2.6 PREVIOUS INVESTIGATIONS

The following sections describe previous investigations conducted by Farallon and others at the Site and on adjacent properties. Additional information on the investigation procedures and results are provided in the referenced documents.

2.6.1 2002 and 2003 GeoEngineers Subsurface Investigations

GeoEngineers conducted subsurface investigations at the Site in November 2002 and October 2003 as part of a due diligence assessment for a prospective purchaser of the Site. These subsurface investigations included drilling seven borings to collect soil samples, and installing five monitoring wells to collect groundwater samples. Monitoring wells MW-1 through MW-5 were each installed to a total depth of approximately 20 feet bgs and were screened over the interval from 5 to 20 feet bgs (Figure 3). However, the boring for monitoring well MW-1 was advanced to a total depth of 50 feet bgs prior to construction of monitoring well MW-1. The results of the 2002 and 2003 GeoEngineers (2004a) subsurface investigations were provided in a Phase II Environmental Site Assessment report (Phase II ESA Report). The soil and groundwater analytical results summarized in tables in the Phase II ESA Report have been incorporated into applicable soil and groundwater summary tables presented in this RI/FS Report. The stratigraphy encountered in the majority of the borings advanced during the subsurface investigation by GeoEngineers (2004a) consisted of silty sand from 4 to 20 feet bgs, interbedded with a silt layer ranging from 2 to 5 feet in thickness at varying depths, with the exception of boring MW-1. Boring MW-1 was advanced to a total depth of 50 feet bgs. Silty sand was encountered to 28 feet bgs, underlain by poorly graded sand to 50 feet bgs. Groundwater was measured at depths of 6 to 8 feet below the top of the casing in monitoring wells MW-1 through MW-5 in October 2003. GeoEngineers inferred that the groundwater flow direction was to the north based on the water level measurements obtained in October 2003.

Soil and groundwater samples collected from the monitoring wells and borings were submitted for the following laboratory analyses:

- Halogenated volatile organic compounds (HVOCs) by U.S. Environmental Protection Agency (EPA) Method 8260B;
- Total petroleum hydrocarbons as gasoline-range organics (GRO), as diesel-range organics (DRO), and as oil-range organics (ORO) by Northwest Method NWTPH-HCID;
- Total petroleum hydrocarbons as DRO by Northwest Method NWTPH-Dx; and/or
- Metals by EPA Method 6020.

All samples analyzed for petroleum hydrocarbon constituents and metals were reported either non-detect at the laboratory practical quantitation limit (PQL) or below respective MTCA Method A or B cleanup levels.

PCE was the only HVOC detected in soil at a concentration exceeding the MTCA Method A soil cleanup level. A concentration of 0.26 milligram per kilogram (mg/kg) PCE was detected in soil sample GP-6-6, which exceeded the MTCA Method A cleanup level of 0.05 mg/kg. This soil sample was collected from boring GP-6 inside the Dry Cleaner Building at 6 feet bgs (Figure 6; Table 2). Several other HVOCs were detected in soil sample GP-6-6 at concentrations below the respective MTCA Method A or B cleanup levels, including trichloroethene (TCE) and cis-1,2-dichloroethene (cis-1,2-DCE), which are common degradation products of PCE (Table 2).

PCE was detected in groundwater samples collected from monitoring wells MW-3 through MW-5 and in a reconnaissance groundwater sample collected from boring GP-6 at concentrations ranging from 163 to 2,100 micrograms per liter (µg/l), which exceeded the MTCA Method A cleanup level for PCE in groundwater of 5 µg/l (Figure 7; Tables 3 and 4). The highest concentration of PCE (2,100 µg/l) was detected in a groundwater sample collected from monitoring well MW-4 on the north side of the Site, adjacent to the former Stoddard solvent USTs (Figure 7). Other HVOCs detected in the groundwater samples collected from monitoring wells MW-3 through MW 5 and boring GP-6 included TCE; cis-1,2-DCE; trans-1,2-dichloroethene (trans-1,2-DCE); and/or vinyl chloride, common degradation products of PCE (Tables 3 and 4). Analytical results for groundwater samples collected from monitoring wells MW-1 and MW-2 on the up-gradient southeast side of the Site were reported non-detect at the laboratory PQL for all HVOCs, including PCE (Table 4).

The results of the GeoEngineers subsurface investigation confirmed the release of PCE to soil and shallow groundwater at the Dry Cleaner Building Property. However, no specific sources were identified, and potential sources were not investigated. In addition, the areal and vertical extent of HVOCs in soil and groundwater was not defined.

2.6.2 2004 Farallon and GeoEngineers Subsurface Investigation

Farallon conducted a subsurface investigation at the Site in 2004, which included a Shallow-Zone subsurface investigation in August 2004 and a Deep Zone subsurface investigation in November 2004. In addition to the subsurface investigation conducted by Farallon, GeoEngineers conducted an additional subsurface investigation in November 2004 that included collection of soil and groundwater samples from the Shallow Zone at locations cross- and down-gradient of the Site. A summary of the results of the additional investigations conducted by Farallon and GeoEngineers is provided below. A detailed description of the scope of work for each phase of the subsurface investigation is provided in the Site Characterization Report (Farallon 2005a) and the Site History Review and Soil and Groundwater Sampling report (GeoEngineers 2004b).

The Shallow Zone subsurface investigation conducted by Farallon included the advancement and sampling of borings SB-1 through SB-10 at the Site (Figure 3). The purpose of the Shallow-Zone subsurface investigation was to evaluate potential source areas associated with former dry cleaning activities by assessing soil and groundwater conditions in the upper 20 feet of the subsurface beneath the Dry Cleaner Building and proximate areas immediately down-gradient. Potential sources at the Site identified by Farallon included the following:

- The former dry cleaning equipment area in the northwest corner of the Dry Cleaner Building;
- The floor drains and sumps associated with the side sewer lines exiting the north and east sides of the Dry Cleaner Building;
- The former Stoddard solvent USTs in the City of Seattle right-of-way on the north side of the Dry Cleaner Building; and
- A former heating oil UST beneath the Dry Cleaner Building.

The November 2004 Deep Zone subsurface investigation included the installation, development, and sampling of Deep Zone monitoring wells MW-7 through MW-10 at the Site (Figure 3). The purpose of the Deep Zone investigation was to assess the following:

- The vertical extent of HVOCs in soil and groundwater proximate to the identified source located in the area of the former dry cleaning equipment and associated floor drain/sanitary sewer line beneath the Dry Cleaner Building;
- The gradient, groundwater flow direction, and concentrations of HVOCs in the Deep Zone in the assumed down-gradient groundwater flow direction north-northwest of the Site; and
- The extent of hydraulic communication, if any, between groundwater in the Shallow Zone and Deep Zone.

As part of the Shallow Zone subsurface investigation in 2004, soil and groundwater samples collected from selected reconnaissance borings and monitoring wells also were submitted for laboratory analysis for Stoddard solvent and/or DRO and ORO. These samples were collected to assess the potential for a release of heating oil to have occurred from the former heating oil UST on the east side of the boiler room and/or Stoddard solvent from the USTs adjacent to the north side of the Dry Cleaner Building that were abandoned in-place. A soil sample collected from boring SB-4 at a depth of 6 to 8 feet bgs was submitted for analysis for DRO and ORO by Northwest Method NWTPH-Dx. The analytical result for the sample was reported non-detect at the laboratory PQL for DRO and ORO. ORO was detected in a reconnaissance groundwater sample collected from boring SB-4 at a concentration of 460 µg/l, which is below the MTCA Method A cleanup level of 500 µg/l for ORO in groundwater. Analytical results for reconnaissance groundwater samples collected from borings SB-1, SB-4, and SB-7, and a groundwater sample collected from monitoring well MW-4 were reported non-detect for Stoddard solvent at the laboratory PQL.

PCE was detected at concentrations ranging from 0.18 to 570 mg/kg in soil samples collected from depths of less than 20 feet bgs in borings SB-1 through SB-10 and borings MW-7 and MW-8 (Figure 6; Table 2). The highest concentrations of PCE were detected in soil samples collected from borings SB-1 through SB-3, which were advanced beneath the former dry cleaning equipment area (Figure 6). Probable product-phase PCE or dense nonaqueous-phase liquid (DNAPL) was observed in the samples by a Farallon Geologist during collection of the soil sample from boring SB-1 at approximately 5.75 to 7 feet bgs (Figure 6). These data confirmed the former dry cleaner equipment area as a source of PCE to soil and groundwater at the Site. TCE and/or cis-1,2-DCE were the only other HVOCs detected in soil samples collected from borings SB-2, SB-4, SB-10, and MW-7 in the Shallow Zone (Table 2). TCE was detected at concentrations exceeding the MTCA Method A cleanup level of 0.03 mg/kg in soil samples collected from borings SB-2, SB-4, SB-10, and MW-7 (Table 2).

The concentrations of PCE detected in soil samples collected from borings GP-6, SB-5, and SB-10 in the southern portion of the Dry Cleaner Building (Figure 6) indicated that potential minor releases of PCE had occurred from the floor drain/sanitary sewer lines. Alternately, the source of PCE concentrations in this area may have been the result of the dispersion of PCE in Shallow Zone groundwater or by vapor-phase migration from the dry cleaning equipment source area. PCE was detected at a concentration of 0.46 mg/kg in a soil sample collected from boring SB-8 north of the Site. The potential source of PCE in soil at this location was not identified.

GeoEngineers collected soil and reconnaissance groundwater samples from borings GP-8 through GP-13 in the area of the Hearthstone Property to assess soil and groundwater conditions in the Shallow Zone in November 2004. PCE was detected at concentrations of 1.5 and 0.22 mg/kg in soil samples collected from boring GP-11 at 6 and 8 feet bgs, respectively (Figure 6; Table 2). The analytical results for soil samples collected at borings GP-9, GP-10, GP-12, and GP-13 were reported non-detect at the laboratory PQL for PCE. Groundwater was not encountered in borings GP-8 or GP-12, which were advanced to a total depth of 18 and 12 feet bgs, respectively.

Soil samples collected from borings at the Site indicated that the highest concentrations of PCE were limited to depths of less than 20 feet bgs in the Shallow Zone. PCE concentrations reported for soil samples collected from Deep Zone borings MW-7 through MW-10 at depths of greater than 20 feet bgs were reported either non-detect at the laboratory PQL or below the MTCA Method A cleanup level for PCE in soil, with the exception of one soil sample collected from boring MW-9 (Figure 6; Table 2). The concentration of PCE in this soil sample was 0.13 mg/kg, which slightly exceeds the MTCA Method A cleanup level for PCE of 0.05 mg/kg.

Groundwater sampling results for the Shallow Zone indicated that the primary source area at the Dry Cleaner Building Property was in the immediate vicinity of the former dry cleaning equipment area in the northwest corner of the Dry Cleaner Building (Figure 7). PCE was detected at concentrations of 160,000 and 66,000 µg/l in reconnaissance groundwater samples collected at borings SB-1 and SB-2, respectively, proximate to this source (Figure 7; Table 3). Monitoring well MW-4 in the cross-/down-gradient direction to the northeast, and monitoring well MW-5 and boring SB-4 in the up-gradient direction to the southwest bounded this source area within the Shallow Zone.

Groundwater sample results for the Deep Zone indicated a contribution of PCE to Deep Zone groundwater from the dry cleaning equipment source area in the Shallow Zone. A maximum PCE concentration of 7,000 µg/l was detected in November 2004 in a groundwater sample collected from monitoring well MW-7, which was installed to monitor groundwater quality in the Deep Zone directly down-gradient of the dry cleaning equipment source area (Figure 8; Table 4). The concentration of PCE attenuated rapidly down-gradient of the dry cleaning equipment source area to 210 µg/l at monitoring well MW-9 in November 2004. Monitoring well MW-9 is located less than 50 feet down-gradient to the northwest of monitoring well MW-7 and the dry cleaning equipment source area. Low PCE concentrations of 0.36 and 2.5 µg/l were detected in groundwater samples collected from Deep Zone monitoring wells MW-8 and MW-10, respectively, located east and northeast of the dry cleaning equipment source area, respectively.

Other HVOCs, including TCE, cis-1,2-DCE, trans-1,2-DCE, and/or vinyl chloride, were detected in groundwater samples collected from monitoring wells MW-4 through MW-7 and in reconnaissance groundwater samples collected from borings GP-6, SB-2, SB-4, SB-9, and SB-10 (Tables 3 and 4). These HVOCs are common degradation products of PCE and indicate that PCE in Shallow Zone groundwater is undergoing anaerobic degradation because of natural conditions in subsurface soil and groundwater. No degradation compounds were detected in groundwater samples collected from Deep Zone monitoring wells MW-8 through MW-10, indicating that conditions in the Deep Zone are not as conducive to anaerobic reductive degradation as those in the Shallow Zone.

2.6.3 2006 through 2007 Farallon Subsurface Investigation

Farallon conducted another phase of RI at the Site in 2006 and 2007 to address data gaps identified during prior investigations. A description of the work conducted and the results were presented in the Draft RI/FS Report. The 2006 and 2007 field program was divided into four work elements, including reconnaissance sampling, monitoring well installation and development, groundwater monitoring, and aquifer testing. Documentation regarding disposal of investigation-derived waste is provided in Appendix C. Work conducted and the results of the investigation are summarized below.

2.6.3.1 Reconnaissance Sampling

Shallow Zone borings SB-15 through SB-19 were advanced on April 20, 2006 inside the former Laundry Building prior to its demolition (Figure 3). The purpose of these borings was to assess whether concentrations of PCE detected in soil samples collected at boring GP-11 adjacent to and north of the former Laundry Building are the result of potential releases of PCE from the floor drain/sanitary sewer lines in the building or are due to vapor-phase migration of PCE from the dry cleaning equipment source area beneath the adjacent Dry Cleaner Building. Soil samples were retained for chemical analysis for HVOCs using EPA Method 8260B.

A series of deep borings SB-11 through SB-13 were advanced on April 17 through 19, 2006 to a maximum depth of 75.5 feet bgs in the alley parallel to and north of 6857 and 6869 Woodlawn Avenue Northeast (Figure 3). The purpose of these borings was to evaluate the down-gradient extent and vertical distribution of the dissolved-phase PCE plume in Deep Zone groundwater migrating from the dry cleaning equipment source area at the former Dry Cleaner Building. Reconnaissance groundwater samples were collected from each boring using temporary wells constructed using 2-inch-inner-diameter, Schedule 40 polyvinyl chloride blank casing, with 5 feet of 0.010-inch slotted polyvinyl chloride well screen. The tops of the temporary well screen intervals were placed at depths of between 22.5 and 65 feet bgs. A reconnaissance groundwater sample was collected from each temporary well screen interval using a peristaltic pump and dedicated polyethylene tubing in accordance with EPA guidance for low-flow sampling. The reconnaissance groundwater samples were submitted for analysis for HVOCs using EPA Method 8260B.

2.6.3.2 Monitoring Well Installation and Development

As part of the 2006 subsurface investigation, eight monitoring wells were installed and developed at the Site from April 21 through May 25, 2006, including three monitoring wells screened in the Shallow Zone (monitoring wells MW-15 though MW-17), and five monitoring wells screened in the Deep Zone (monitoring wells MW-11 through MW-14 and MW-18) (Figure 3). The purpose of the new monitoring wells was to complete the characterization of the nature and extent of HVOCs in groundwater in the Shallow and Deep Zones.

2.6.3.3 Groundwater Monitoring Event

Depth to groundwater was measured in Site wells on May 31 and June 22, 2006 and on January 8 and April 20, 2007 for evaluation of groundwater flow direction and gradient. Groundwater samples were collected from monitoring wells MW-1 through MW-5 and MW-7 through MW-18 on June 1 and 2, 2006 and were submitted for laboratory analysis for HVOCs by EPA Method 8260B. Low-flow groundwater purging and sampling was conducted in accordance with EPA guidance. Six additional groundwater samples were collected from monitoring wells MW-1, MW-7, and MW-11 through MW-14 using low-flow sampling techniques for analysis for nitrate and sulfate by EPA Method 300.0; dissolved manganese by EPA Method 6010; total iron by EPA Method SM 3500-Fe; ferrous iron using a compound-specific field test kit; and methane, ethene, and ethane by Headspace.

2.6.3.4 Summary of Soil Results

The general stratigraphy encountered at the Site is divided into the Shallow Zone and the Deep Zone. The Shallow Zone is composed predominantly of silt and silty sand from near the ground surface to 20 feet bgs. The soil encountered in the Deep Zone from depths of approximately 20 to 70 feet bgs consists of poorly graded sand to well-graded sand and silty sand. The Deep Zone is underlain by a silt layer encountered at a depth of approximately 70 feet bgs to the total depth drilled of 80 feet bgs in boring MW-18 (Figure 3). The silty sand layers encountered in the Shallow Zone contained a higher percentage of silt (30 to 40 percent) versus silty sand layers encountered in the Deep Zone. Borings SB-11 through SB-13 and MW-16 through MW-18 advanced in areas northwest and northeast of the Dry Cleaner Building identified a lateral gradation from predominantly silty sand to silt in the Shallow Zone (Figure 3).

A summary of the soil analytical data for the constituents of potential concern (COPCs) at the Site is provided in Table 2, and concentrations of PCE in soil are shown on Figure 6. Figure 6 shows the approximate extent of soil exceeding the MTCA Method B cleanup level, and presents concentrations exceeding the MTCA Method A cleanup level in bold font. PCE in soil associated with the dry cleaning equipment source area is present primarily on the Dry Cleaner Building Property, but extends into the Woodlawn Avenue Northeast right-of-way and the alley in the northwest corner of the Dry Cleaner Building, and into the 4th Avenue Northeast right-of-way east of the Dry Cleaner Building. Concentrations of PCE in soil samples collected from two of five borings advanced inside the former Laundry Building in 2006 exceeded the MTCA Method A cleanup level. PCE was detected at concentrations of 0.92 and 0.068 mg/kg in soil samples collected at depths of 4 to 6 feet bgs in borings SB-15 and SB-16 (Figure 6; Table 2). PCE was detected in soil samples collected from borings SB-15, SB-16, and SB-18 at 8 to 10 feet bgs at concentrations that were below the MTCA Method A cleanup level. Other COPCs, including TCE, cis-1,2-DCE, and trans-1,2-DCE, also were detected in the soil samples collected from boring SB-15 (Table 2). Analytical results for soil samples collected from borings SB-17 and SB-19 advanced in the western portion of the former Laundry Building were reported non-detect for HVOCs at the laboratory PQLs. The distribution of PCE in soil samples collected from borings advanced beneath and adjacent to the former Laundry Building in 2004 and

2006 appeared to indicate lateral migration from the release at the former dry cleaner equipment area in the Dry Cleaner Building.

PCE concentrations in soil samples collected from the series of four Deep Zone borings SB-11 through SB-13 and MW-12 advanced in the alley parallel to and about 120 feet north of Woodlawn Avenue Northeast, were reported non-detect at the laboratory PQLs (Table 2). PCE concentrations for soil samples collected in 2006 from Deep Zone borings MW-11 through MW-14 and MW-18 at depths of greater than 20 feet bgs were reported either non-detect at the laboratory PQL or below the MTCA Method A cleanup level for PCE in soil, with the exception of one soil sample collected from boring MW-15 (Figure 6; Table 2). The PCE concentration in the soil sample collected from boring MW-15 at a depth of 25.5 feet bgs was 9.5 mg/kg, which exceeds the MTCA Method A cleanup level for PCE. These results bound the north-northwest extent of soil contamination in the Deep Zone to the southern portion of the block north-northwest of the Hearthstone and Dry Cleaner Building Properties.

2.6.3.5 Soil Physical Properties

Two soil samples collected from borings MW-11 and MW-14 at depths of 4.5 to 5 feet bgs were submitted for analysis for the physical properties of the soil matrix in the Shallow Zone. The laboratory analytical results for these soil samples indicate the following:

- Moisture content ranged from 17.5 to 19.8 percent;
- Dry bulk density ranged from 1.55 to 1.69 grams per cubic centimeter;
- Total porosity ranged from 38.2 to 42.7 percent;
- Effective porosity ranged from 13.7 to 25.1 percent;
- Total organic carbon (TOC) content ranged from 1,750 to 2,200 mg/kg; and
- Effective hydraulic conductivity ranged from 2.81×10^{-5} to 4.91×10^{-6} centimeters per second (cm/sec).

The moisture content present in the two soil samples is representative of a moist soil. The porosity range for these two samples is within the range of a silt and sand that is consistent with the observed soil profile for these soil samples. The TOC results are discussed in further detail below. The effective hydraulic conductivity for the two soil samples is within the range of silt to silty sand, which is consistent with the slug test results for Shallow Zone groundwater, as discussed in Section 2.6.3.8, Aquifer Testing.

Four soil samples collected from borings MW-11, MW-13, and MW-14 were submitted for analysis for the physical properties of the soil matrix in the Deep Zone. These four soil samples were collected from depth intervals ranging from 54.5 to 55 feet bgs at boring MW-11, to 64 to 64.5 feet bgs at boring MW-14. The laboratory analytical results for these soil samples indicate the following:

- Moisture content ranged from 20.0 to 21.2 percent;
- Dry bulk density ranged from 1.49 to 1.68 grams per cubic centimeter;
- Total porosity ranged from 40.7 to 45.6 percent;
- Effective porosity ranged from 29.0 to 33.4 percent; and
- TOC content ranged from 1,500 to 2,200 mg/kg.

The moisture content present in the four soil samples is representative of a very moist to wet soil. The porosity range for these four samples is within the range of a sand that is consistent with the observed soil profile for these four soil samples. The TOC results are discussed in further detail below.

TOC analyses were performed on soil samples collected from the borings for monitoring wells MW-11, MW-13, and MW-14. The results of TOC analysis provide a means of estimating the potential for the soil matrix to retard contaminant movement, but can be biased by the organic carbon associated with the chemicals present. Therefore, soil samples to assess the potential retardation capacity of the soil matrix typically are collected in areas not affected by contamination. Naturally occurring organic matter in the soil matrix has the capacity to increase the sorptive properties of the soil matrix and retard the movement of chemicals such as PCE. TOC values are converted to fraction organic carbon (foc) equivalents that are used to assess the retardation capacity of the soil matrix. Foc values for soil typically range from 0.0002 to 0.02, with lower values representing little to no retardation capacity.

The analytical results for the six soil samples analyzed for physical parameters indicated that the TOC content ranged from 1,500 to 2,200 mg/kg, and foc equivalents of 0.0015 to 0.0022, respectively. These results indicate that the TOC concentrations in soil are relatively constant in the Shallow and Deep Zones. The foc values indicate a low to moderate sorptive capacity of the soil matrix to reduce PCE contaminant movement within the Shallow and Deep Zones at the Site.

2.6.3.6 Summary of Groundwater Results

Drilling conducted during 2006 at locations down-gradient of the dry cleaning equipment source area indicates that the Shallow Zone lithology changes from silty sand to silt in the vicinity of borings SB-11 through SB-13 and MW-18, located cross- and down-gradient of the Site. Soil in the Shallow Zone at these borings was not saturated. These data indicate a hydrogeologic discontinuity in the Shallow Zone that effectively retards the lateral migration of groundwater in the Shallow Zone to the areas down-gradient of the dry cleaning equipment source area.

Shallow Zone groundwater elevation data collected on January 7, 2005 indicated a groundwater flow direction to the north, with an average gradient of 0.02 foot per foot (Table 1). Deep Zone groundwater level data collected on April 20, 2007 indicated a groundwater flow direction to north-northeast, with an estimated gradient ranging from 0.003 to 0.01 foot per foot (Table 1).

Shallow Zone groundwater sampling results for the June 2006 monitoring event confirmed the presence of a source area at the Site in the immediate vicinity of the former dry cleaning equipment area in the northwest corner of the Dry Cleaner Building. The extent of the dissolved-PCE plume exceeding the MTCA Method A groundwater cleanup level is limited to an area bounded by monitoring wells MW-15 through MW-17 and borings SB-6 and SB-7 in the cross- and down-gradient directions northwest, north, and northeast of the Site, and by monitoring wells MW-1 and MW-2 in the up-gradient direction south and southeast within the Shallow Zone (Figure 7). The north and east extents of PCE in Shallow Zone groundwater exceeding the MTCA Method A groundwater cleanup level are limited to the rights-of-way of Woodlawn Avenue Northeast and 4th Avenue Northeast, about 1,000 feet south of Green Lake. The limited down-gradient extent of the PCE plume in the Shallow Zone corresponds with the hydrogeologic discontinuity noted in the Shallow Zone down-gradient of the dry cleaning equipment source area, which grades from a silty sand to a silt, effectively retarding the down-gradient migration of PCE in Shallow Zone groundwater from the dry cleaning equipment source area.

Deep Zone groundwater sample results for the June 2006 monitoring event and reconnaissance groundwater samples collected from deep borings SB-11 through SB-13 indicate a contribution of PCE to Deep Zone groundwater from the dry cleaning equipment source area in the Shallow Zone. A maximum PCE concentration of 7,000 µg/l was detected in a groundwater sample collected in November 2004 from monitoring well MW-7, which was installed to monitor groundwater quality in the Deep Zone directly beneath the dry cleaning equipment source area. The concentration of PCE attenuates rapidly both laterally and vertically from the dry cleaning equipment source area. A low PCE concentration of 0.99 µg/l was detected in Deep Zone monitoring well MW-14, which is screened from 63 to 73 feet bgs at the base of the Deep Zone adjacent to monitoring well MW-7 and the dry cleaning equipment source area.

Based on the results for the June 2006 monitoring event and reconnaissance groundwater sampling from borings SB-11 through SB-13, the lateral extent of the dissolved PCE plume in the Deep Zone exceeding the MTCA Method A cleanup level is limited to an estimated area about 120 feet long and 50 feet wide. The plume is bounded by monitoring wells MW-10, MW-12, and MW-18 and borings SB-11 through SB-13 in the cross- and down-gradient directions northwest, north, and northeast of the Site, and by monitoring well MW-11 in the up-gradient direction southwest in the Deep Zone. The north extent of PCE in Deep Zone groundwater exceeding the MTCA Method A groundwater cleanup level extends about 30 feet onto the property at 6869 Woodlawn Avenue Northeast, north of Woodlawn Avenue Northeast and the Dry Cleaner Building Property, and about 1,000 feet south of Green Lake. The vertical extent of the dissolved-PCE plume in the Deep Zone exceeding the MTCA Method A cleanup level is limited to the upper portion, extending from approximately 20 to 50 feet bgs.

2.6.3.7 Natural Attenuation Assessment

An assessment of the potential for natural attenuation by biodegradation processes to reduce the concentrations of dissolved-phase PCE in groundwater in the Shallow and Deep Zones was conducted during the June 2006 groundwater monitoring event. The assessment included measurement and analysis of parameters that provide data regarding whether biodegradation is occurring and by what processes. The measurements and laboratory analyses for the assessment included the primary electron receptors that are potential energy sources for native bacteria capable of biodegradation of PCE and associated degradation compounds, and indicators of groundwater geochemistry. The assessment included analyses for the following:

- Dissolved oxygen;
- Nitrate;
- Ferric iron;
- Sulfate;
- Metabolic by-products of biodegradation and groundwater geochemistry parameters;
- Dissolved manganese;
- Ferrous iron;
- Methane; and

- o Ethene and ethane.

Additional geochemical indicators of whether the subsurface environment is amenable for biodegradation of PCE and associated degradation compounds include oxidation-reduction potential, temperature, and pH measurements.

The geochemical measurements and analytical results for groundwater samples were obtained for monitoring wells MW-7 and MW-11 through MW-14 screened in the Deep Zone. Monitoring well MW-11 is located up-gradient of the dissolved-phase PCE plume. The geochemical data collected from monitoring well MW-11 represent background subsurface conditions. Monitoring wells MW-7 and MW-14 are located directly down-gradient of the dry cleaning equipment source area within the dissolved-phase PCE plume. The geochemical data collected from monitoring wells MW-7 and MW-14 are considered representative of subsurface conditions within the dissolved-phase PCE plume. Monitoring well MW-12 is located farther down-gradient of the dissolved-phase PCE plume, and monitoring well MW-13 is located west and cross-gradient of the dissolved-phase PCE plume. The geochemical data collected from monitoring wells MW-12 and MW-13 represent subsurface conditions down- and cross-gradient of the dissolved-phase PCE plume.

Farallon also collected groundwater samples at monitoring well MW-1 to monitor background subsurface conditions in the Shallow Zone. Monitoring well MW-1 is located up-gradient of the dissolved-phase PCE plume in the Shallow Zone.

The field instrumentation and laboratory analytical results for natural attenuation parameters and geochemical indicators are summarized in Table 5. The results of the assessment indicate that the Deep Zone is under moderately anaerobic conditions, where manganese-reducing to near sulfate-reducing conditions occur in the Deep Zone at monitoring wells MW-7 and MW-11 through MW-14. In addition, there is evidence that anaerobic biodegradation resulting in the reductive dechlorination of PCE is occurring in the Deep Zone near the dry cleaning equipment source area, based on the results of the natural attenuation parameters, geochemical indicators, and concentrations of PCE and its degradation compounds in monitoring well MW-7. The results of the assessment indicate that the Shallow Zone is under aerobic to slightly anaerobic conditions, where aerobic respiration or nitrate-reducing conditions occur in the Shallow Zone at monitoring well MW-1. However, the empirical groundwater analytical results from the groundwater samples collected at monitoring wells MW-2 through MW-6 indicate that concentrations of the PCE degradation compounds are present in groundwater in the Shallow Zone. The presence of degradation compounds in the groundwater samples indicates that reductive degradation of PCE is occurring in the Shallow Zone down- and cross-gradient of the dry cleaning equipment source area.

2.6.3.8 Aquifer Testing

During January 2007, Farallon performed aquifer slug tests at Shallow Zone monitoring wells MW-4, MW-5, and MW-15, and performed an aquifer pump test at Deep Zone monitoring well MW-11 to obtain hydraulic conductivity data for the Shallow and Deep Zones in the Site vicinity. Data generated from the aquifer slug tests and aquifer pump test, and the results from physical parameter testing of aquifer material collected from the Shallow and Deep Zones during monitoring well installation were used to support the modeling effort and the evaluation of potential source control measures at the Site.

Farallon performed six aquifer slug tests on January 5 and 6, 2007 at monitoring wells MW-4, MW-5, and MW-15. Water levels in the test wells were monitored using a down-hole pressure transducer and a data logger. The purpose of the aquifer slug tests was to qualitatively evaluate the hydrologic characteristics of the Shallow Zone at the Site (Figure 4).

In addition, Farallon performed a constant rate pumping test to evaluate aquifer parameters and assess hydrostratigraphic relationships at the Site. Deep Zone monitoring well MW-11 was used as the pumping well. A total of 11 monitoring wells were monitored in the surrounding area to measure drawdown at these locations during the test. Water level measurements were collected in each well using pressure transducers and data loggers. Water levels were also measured manually during testing. A step drawdown test was performed initially to determine the optimal pumping rate for the constant rate pumping test. Pumping was conducted for approximately 12 hours at a rate of 13 gallons per minute, and recovery was measured for approximately 32 hours after pumping ceased.

Following slug testing in the Shallow Zone, plots of groundwater displacement versus time were produced using AQTESOLV software to expedite the fitting of type-curves to the aquifer testing data (Duffield 2008). The analytical solution chosen for the slug tests performed at monitoring wells MW-4, MW-5, and MW-15 was the Bouwer-Rice Method, based on the assumption that these wells are screened in the Shallow Zone under unconfined conditions. The horizontal hydraulic conductivity results calculated for each well using AQTESOLV are summarized in Table 6. Data analysis plots for the slug tests are provided in Appendix D.

The geometric mean value of horizontal hydraulic conductivity calculated from the three Shallow Zone monitoring wells is 1.33×10^{-5} cm/sec (0.038 foot/day) (Table 6). The estimated hydraulic conductivity at monitoring wells MW-4, MW-5, and MW-15 is consistent with the typical range for silt and silty sand (Freeze and Cherry 1979 Table 2.2, page 29). These findings are consistent with the subsurface soil encountered in borings MW-4, MW-5, and MW-15 from the ground surface to a depth of approximately 20 feet bgs.

During the Deep Zone aquifer test, data loggers were programmed to collect data at 1-minute intervals. Pumping from well MW-11 began at 12:50 p.m. on January 10, 2007 and continued for 11.8 hours. A data logger connected to a barometric transducer also recorded barometric pressure data at 1-minute intervals. During the test, manual measurements were compiled and compared to electronic data collected by the data loggers to identify anomalous data suggesting potential transducer malfunction, cable slippage, or other unexpected conditions.

Heavy rainfall occurred at several times during the test. To limit the potential impact of surface water conditions on test activities and data, Farallon personnel placed sandbags around several monitoring well locations and kept monitoring well vaults closed between manual measurements. These measures prevented rainfall and resultant surface runoff conditions from adversely impacting the data collection activities or the data obtained.

The objective of an aquifer pumping test is to pump groundwater from a well (pumping well) and measure drawdown in other nearby wells (observation wells) at known distances from the pumping well, and use these measurements to estimate the ability of the water-bearing zone to transmit groundwater and other hydraulic characteristics of the aquifer. Important parameters in the analysis of aquifer pumping tests include the type of aquifer (unconfined, semi-confined, or confined), the depth of the well pump and observation well screens, the distance of the observation wells from the pumping well, the frequency of drawdown measurements, the type of measurement device, and the duration of the pumping test.

The analytical methods used to estimate values for hydraulic parameters were selected based on Site hydrogeology and the geometric relationship between the pumping and the observation wells (i.e., the conceptual site model). The methods used are well-established mathematical solutions for unsteady-state flow to a pumping well that are documented in standard reference materials.

The type of aquifer under analysis is important in the choice of well-flow equations that may be used to represent the drawdown-discharge relationship for the well. For this test, some wells were screened in a relatively shallow zone (to a depth of about 40 feet bgs) in the portion of the aquifer composed of relatively low-permeability materials (silt and silty sand), whereas other wells (including the pumping well) were screened in a higher-permeability zone that extends to a depth of up to approximately 80 feet bgs. Based on these stratigraphic relationships, the Deep Zone was treated as a semi-confined or leaky confined hydrogeologic unit, whereas the Shallow Zone was assumed to be under unconfined or semi-confined conditions.

The analytical solution chosen for each well was based on the anticipated hydraulic conditions at each location. For data from wells screened in the Shallow Zone (inferred to be an unconfined water-bearing zone), the Theis (1935) and Cooper-Jacob solutions were used. For leaky conditions, the Hantush-Jacob solution was selected, and for fully confined conditions, the Theis solution was used. See Appendix E for a summary of assumptions inherent in the different solutions.

The aquifer testing analysis software package AQTESOLV was used to expedite the fitting of type-curves to the aquifer testing data (Duffield 2008). The corrected water level data expressed as drawdown in the spreadsheet files were written to temporary files and then imported to the files for AQTESOLV. A data filter was applied with the AQTESOLV program to discard any negative drawdown values. Additional benefits of using AQTESOLV, which aided in constraining the fit of type-curves to the aquifer testing data, included:

- Simultaneous analysis of data from the pumping and recovery portions of the test;
- Graphical sensitivity analysis of key parameters; and
- Graphical comparison of each solution to the classic Theis (1935) confined solution.

A review of the drawdown versus time plots for the pumping and observation wells indicated that barometric pressure changes were influencing observed heads in the observation wells. In Shallow Zone wells MW-3, MW-4, MW-5, MW-15, and MW-17, the background conditions obscured the drawdown response to the extent that the data could not be used in the pump test analysis. In the remaining wells, the drawdown response was strong enough for interpretation of the data and estimation of aquifer parameters. In most of the wells, full recovery did not occur. Recovery typically ranged from 70 to 90 percent of the original value; drawdown increased again during the latter part of the test. This indicates an external stress on the system during the latter part of the test; thus recovery analysis was based on the data to the point where the water level reached its maximum value of recovery. The drawdown was not corrected for barometric effects because the applied corrections likely would have little influence on the interpretation of aquifer properties.

The results of the aquifer pump test analysis are presented in Table 7. Both the drawdown and recovery portions of the aquifer pump test were analyzed simultaneously. Data analysis plots are provided in Appendix E. As these plots illustrate, the wells screened in the Shallow Zone and upper portions of the Deep Zone aquifer (wells MW-1, MW-7, MW-8, and MW-9) indicate a delayed response to pumping and did not match the theoretical type curves well. This likely is due to the weak communication between the Shallow Zone and upper portions of the Deep Zone with lower portions of the Deep Zone aquifer. The fact that a response was observed indicates hydraulic communication between the Shallow Zone and the Deep Zone.

Plots for wells screened in the deeper portion of the Deep Zone aquifer (wells MW-11 through MW-14 and MW-18) indicate a leaky confined aquifer response. Pumping well MW-11 did not match the early time portion of the analysis curve, possibly due to well bore or skin effects. The other wells matched the leaky confined curves reasonably well. Of note is the response time observed in monitoring wells MW-12 and MW-18, screened at the base of the Deep Zone at distances of approximately 330 and 270 feet from the pumping well, respectively. Monitoring well MW-12 is located northwest of the pumping well, and monitoring well MW-18 is located almost due north of the pumping well. Drawdown was observed in monitoring well MW-12 after about 8 minutes of pumping, while drawdown was not observed in monitoring well MW-18 until almost 2 hours after pumping began. These data suggest a preferential flow pathway between the pumping well and observation well MW-12 to the northwest, and a damped (limited) flow pathway between the pumping well and observation well MW-18 to the north. This may be due to channelized flow or other geologic conditions that increase hydraulic conductivity in a northwesterly direction.

The geometric mean value of horizontal hydraulic conductivity calculated from all wells included in the aquifer pump test is 3.1×10^{-3} cm/sec (8.8 feet/day). The geometric mean hydraulic conductivity calculated for wells screened in the Shallow

Zone and the upper portion of the Deep Zone is 4.21×10^{-3} cm/sec (11.9 feet/day). This is significantly higher than the hydraulic conductivity calculated from slug tests at Shallow Zone monitoring wells MW-4, MW-5, and MW-15 because of the combined results from the Shallow and Deep Zone wells. The geometric mean hydraulic conductivity calculated for wells screened in the Deep Zone is 2.85×10^{-3} cm/sec (8.1 feet/day).

The estimated values of storativity in the Shallow Zone and upper portions of the Deep Zone range from about 0.007 to 0.17 (indicating unconfined or semi-confined conditions), and in the lower portion of the Deep Zone from 0.004 to 0.0003 (indicating semi-confined to confined conditions).

2.6.4 2008 Farallon Subsurface Investigation

Ecology (2008a) and the AAG (Ecology 2008b) provided comments on the Draft RI/FS Report on June 16 and November 18, 2008, respectively. Ecology provided specific comments and requested additional characterization of Shallow Zone groundwater in several areas cross- and down-gradient of the former dry cleaner equipment source area, and additional characterization of Deep Zone groundwater in the area of the former Laundry Building on the Hearthstone Property.

The 2008 subsurface investigation conducted by Farallon to address Ecology's comments included installing and sampling two additional Shallow Zone monitoring wells, installing and sampling two additional Deep Zone monitoring wells, and conducting a Site-wide monitoring event. Documentation regarding disposal of investigation-derived waste is provided in Appendix C. The work is summarized below.

2.6.4.1 Shallow Zone Groundwater Down-Gradient of Dry Cleaner Building

Two Shallow Zone monitoring wells were installed by Farallon in street rights-of-way down-gradient of the Dry Cleaner Building (Figure 3). On November 10, 2008, monitoring well MW-21 was installed in the Woodlawn Avenue Northeast right-of-way down-gradient of monitoring well MW-6 to further assess the potential for underground utilities to act as preferential migration pathways for Shallow Zone contamination. Monitoring well MW-23 was installed on November 12, 2008 in the 4^{th} Avenue Northeast right-of-way down-gradient of monitoring well MW-3 to further delineate Shallow Zone contamination. Monitoring wells MW-21 and MW-23 were screened at 14 to 24 feet bgs and 10 to 20 feet bgs, respectively. Soil samples were collected and submitted for HVOC analysis using EPA Method 8260B. After the wells were developed, groundwater samples were collected from both of the new monitoring wells on November 20, 2008.

No HVOCs were detected at concentrations at or above the laboratory PQLs in the groundwater samples collected from either monitoring well MW-21 or MW-23. PCE was detected at a concentration below the MTCA Method A cleanup level in a soil sample collected from monitoring well MW-21 at a depth of 6 feet bgs. However, no HVOCs were detected at concentrations at or above the laboratory PQLs in a second, deeper soil sample collected from monitoring well MW-21 at 16 feet bgs or in any of the four soil samples collected from monitoring well MW-23.

The analytical results indicate that underground utilities in the Woodlawn Avenue Northeast right-of-way are not acting as contaminant migration pathways in the Shallow Zone. Data from monitoring well MW-23 indicate that HVOCs have not migrated to this location.

2.6.4.2 Deep Zone Groundwater at the Former Laundry Building

Two Deep Zone monitoring wells were installed by Farallon adjacent to the former Laundry Building (Figure 3). Monitoring well MW-20 was installed in the alley between the Dry Cleaner Building and the former Laundry Building on November 10, 2008. Monitoring well MW-22 was installed in the sidewalk north of the former Laundry Building on November 11, 2008. Both monitoring wells were screened over the depth interval from approximately 40 to 50 feet bgs. Soil samples were collected during well installation and submitted for HVOC analysis using EPA Method 8260B.

After the wells were developed, groundwater samples were collected from both monitoring wells on November 20, 2008.

PCE was detected in the groundwater sample collected from monitoring well MW-20 at a concentration below the MTCA Method A cleanup level. No other HVOCs were detected in the groundwater samples collected from monitoring wells MW-20 or MW-22 (Table 4). PCE was detected at a concentration above the MTCA Method A cleanup level in soil samples collected from both well locations at a depth of 6 feet bgs (Table 2). PCE was detected at concentrations below the MTCA Method A cleanup level in soil samples collected from monitoring well MW-20 at a depth of 26 feet bgs, and from monitoring well MW-22 at depths of 10.5, 15, and 25 feet bgs. PCE was not detected in soil samples collected from either Deep Zone well location at a depth of 45 feet bgs.

The analytical results indicate that PCE present in Shallow Zone soil and groundwater at monitoring wells MW-20 and MW-22 has not migrated into Deep Zone soil or groundwater in these areas.

2.6.4.3 2008 Site-Wide Groundwater Monitoring Event

A Site-wide groundwater monitoring event was conducted on November 19 and 20, 2008 using EPA low-flow groundwater sampling techniques to collect samples for HVOC analysis using EPA Method 8260B. All existing and new monitoring wells at the Site were sampled, with the exception of monitoring well MW-6 in the Woodlawn Avenue Northeast right-of-way, monitoring wells MW-17 and MW-18 in the northeast quadrant of the intersection of Woodlawn Avenue Northeast and 4th Avenue Northeast, and monitoring well MW-19 in the Latona Avenue Northeast right-of-way west of the Hearthstone Property.

Table 4 presents the analytical results for the November 2008 groundwater monitoring event. The November 2008 sampling results indicate elevated concentrations of PCE in Shallow Zone groundwater monitoring wells proximate to the dry cleaning equipment source area, which is consistent with results from previous monitoring events conducted at the Site. In addition, elevated concentrations of PCE were detected in monitoring well MW-24 on the north side of the Hearthstone Property. The elevated concentrations at monitoring well MW-24 indicate a potential source of PCE proximate to monitoring well MW-24.

Interpretation of the 2008 analytical data along with groundwater elevations, the groundwater flow gradient, and historical reconnaissance groundwater sampling results indicates that PCE concentrations in Shallow Zone groundwater exceed the MTCA Method A cleanup level beneath the Dry Cleaner Building, the northeastern portion of the Hearthstone Property, and in the right-of-way of Woodlawn Avenue Northeast to the north and east. Data from the November 2008 groundwater monitoring event indicate that the Shallow Zone groundwater PCE plume is bounded to the north, east, and south. The western extent of the Shallow Zone groundwater plume was not bounded proximate to monitoring well MW-24. Low transmissivity in the Shallow Zone has limited PCE migration, and the plume does not extend across either Woodlawn Avenue Northeast to the north or 4th Avenue Northeast to the east.

A chemical oxidation pilot test was conducted at the Site in March 2007 at Deep Zone monitoring wells MW-7 and MW-14. The pilot test is discussed in further detail in Section 7.2, Treatability Studies. Prior to the pilot test, the highest PCE concentrations identified were proximate to the former dry cleaning equipment area in the northwest corner of the Dry Cleaner Building. The highest PCE concentration in Deep Zone groundwater in November 2008 was in monitoring well MW-9 on the north side of Woodlawn Avenue Northeast, north-northwest of the former dry cleaning equipment area. The chemical oxidation pilot test reduced the PCE concentration in injection well MW-7 from a maximum concentration of 7,000 µg/l in 2004 to 18 µg/l in November 2008. Data from the November 2008 groundwater monitoring event confirm that the Deep Zone groundwater PCE plume is bounded to the north, east, south, and west. Low Deep-Zone transmissivity, although higher than in the Shallow Zone, has limited PCE migration, and the plume is not interpreted to extend more than about 30 feet onto the property at 6869 Woodlawn Avenue Northeast, north of the Dry Cleaner Building.

The southern extent of the Deep Zone groundwater PCE plume is inferred to extend about 40 feet south of the former dry cleaning equipment area and is bounded by monitoring well MW-20.

2.6.5 2008 through 2009 Sound Environmental Strategies Subsurface Investigations

SES conducted subsurface investigations on the Hearthstone Property in March and May 2008, and in March and September 2009. The results of these investigations are summarized below.

The May 2008 subsurface investigation included advancement of direct-push borings P01 through P10 at the Hearthstone Property inside the former Laundry Building prior to its demolition. These 10 borings were completed to depths ranging from 4 to 15 feet bgs, with soil samples collected from 9 of the borings (Figure 3). Soil samples collected from the borings were analyzed for HVOCs by EPA Method 8260B. A detailed discussion and presentation of analytical results from the direct-push borings is provided in SES (2008) and summarized below:

- PCE was detected at concentrations exceeding the MTCA Method A cleanup level in soil samples collected from borings P01, P02, and P03 in the northeast corner of the former Laundry Building at depths of 5 to 8 feet bgs (Figures 3 and 6; Table 2).
- PCE was detected at concentrations exceeding the MTCA Method A cleanup level in a soil sample collected from boring P04 in the northwest corner of the former Laundry Building at a depth of 12 feet bgs, but not in samples collected from this boring location at 2, 4, or 8 feet bgs. PCE was not detected in the three soil samples collected at depths of 5 to 10 feet bgs from boring P07, which is about 12 feet southeast of boring P04 (Figures 3 and 6; Table 2).
- PCE was detected in four soil samples collected from boring P05 in the central and eastern portion of the former Laundry Building adjacent to the alley at depths ranging from 2 to 10 feet bgs. PCE was detected in a soil sample collected from boring P06 at a depth of 4 feet bgs, but not in samples collected at this location at 8 or 14 feet bgs. In addition, groundwater samples were collected from new monitoring wells MW-19 and MW-24 and existing monitoring well MW-5 in March 2008. Concentrations of PCE exceeding the MTCA Method A cleanup level were detected in groundwater samples

collected from monitoring wells MW-24 and MW-5. Analytical results for monitoring well MW-19 were reported non-detect for HVOCs. PCE was not detected above laboratory reporting limits in soil samples collected from borings P09 or P10 at depths of 5 to 13 feet bgs (Figures 3 and 6; Table 2). No soil samples from boring P08 were submitted for laboratory analysis.

Two groundwater monitoring wells were installed by SES in the Shallow Zone in March 2008 to evaluate for dewatering requirements for the proposed development of the Hearthstone Property. Groundwater samples were collected from new monitoring wells MW-19 and MW-24 and existing monitoring well MW-5 in March 2008. Concentrations of PCE exceeding the MTCA Method A cleanup level were detected in groundwater samples collected from monitoring wells MW-24 and MW-5. Analytical results for monitoring well MW-19 were reported non-detect for HVOCs. Monitoring wells MW-19 and MW-24 are located in the Latona Avenue Northeast and the Woodlawn Avenue Northeast rights-of-way, respectively (Figure 3; Tables 1 and 4).

The March 2009 subsurface investigation conducted by SES at the Hearthstone Property included collecting soil samples beneath drain lines, concrete slabs, and sumps that were removed in conjunction with the demolition of the former Laundry Building and the former Yasuko Property building in March 2009. The purpose of the soil sampling was to evaluate whether PCE was present in the soil beneath the drain lines, concrete slabs, and sumps. Soil samples were analyzed for HVOCs by EPA Method 8260B. Nine soil samples were collected at depths ranging from 2 to 6 feet bgs using hand tools. A more-detailed discussion and analytical results from this investigation are presented in the Work Plan prepared by SES (2010). HVOCs were not detected at concentrations at or above laboratory PQLs in the soil samples collected in March 2009.

In September 2009, SES conducted a supplemental subsurface investigation on the Hearthstone Property that included advancement of hollow-stem-auger borings P11 through P17 to depths of 20 to 21 feet bgs. Borings P11 through P14 were advanced within the footprint of the former Laundry Building, and borings P15 through P17 were advanced on the former Yasuko Property (Figure 3). Soil samples were collected at various depths throughout the soil column. Sample selection was based on field observations and field-screening results obtained using a hand-held gas analyzer equipped with a photoionization detector. Soil samples were screened also for the presence or absence of DNAPL using an OilScreenSoil (Indigo Blue) field-screening test kit, which gives immediate qualitative results with regard to detection of DNAPL in soil and water (SES 2010). The borings were converted to temporary monitoring wells, which were screened using 2-inch casing from 8 to 18 feet bgs, with a sand filter pack emplaced over the depth interval from approximately 7 to 18 feet bgs. The depth to groundwater in the temporary monitoring wells ranged from approximately 9 to 16 feet bgs. Before reconnaissance groundwater samples were collected, one casing volume was purged from each monitoring well using a peristaltic pump. Reconnaissance groundwater samples were collected from the temporary monitoring wells when the depth to groundwater reached 90 percent of the pre-purge depth to water. Reconnaissance groundwater samples were collected under low-flow conditions. The pump intake for each monitoring well was placed in the middle of the screen interval. Soil and reconnaissance groundwater samples from each boring and temporary monitoring well were analyzed for HVOCs by EPA Method 8260B. Results of the supplemental subsurface investigation are presented in the letter report and the Work Plan prepared by SES (2009b, 2010).

The results of the September 2009 soil and reconnaissance groundwater sampling conducted at the Hearthstone Property by SES are summarized below:

- Concentrations of PCE ranging from 0.087 to 0.77 mg/kg, exceeding the MTCA Method A cleanup level, were detected in soil samples collected from borings P11, P12, P14, and P17 (Figure 3; Table 2).
- Concentrations of PCE ranging from 5 to 87 μg/l were detected in reconnaissance groundwater samples collected from borings P11 through P13. These data indicate decreasing concentrations to the west, cross-gradient of the dry cleaning equipment source area, and were consistent with previous sampling results for borings advanced on the northeast portion of the former Laundry Building and in the adjacent alley (Figure 6; Table 3).
- An elevated concentration of 300 μg/l of PCE was detected in the reconnaissance groundwater sample collected from boring P14 installed in the northwest corner of the

former Laundry Building (Figure 6; Table 3). Boring P14 was located up-gradient of monitoring well MW-24 and proximate to a former side sewer line located on the northwest portion of the former Laundry Building. Lower concentrations of PCE ranging from 1.4 to 39 µg/l were detected in reconnaissance samples collected from borings P15 through P17 advanced on the western portion of the Hearthstone Property (Figure 6). These data indicate a potential source proximate to boring P14 and monitoring well MW-24.

- DNAPL was not identified in soil or reconnaissance groundwater samples collected from borings P11 through P17.

3.0 COMPLETION OF REMEDIAL INVESTIGATION

Additional subsurface investigation activities were conducted at the Site by Farallon in 2010, 2011, and 2012 to complete the RI. The purpose of the 2010 RI effort was to obtain sufficient information to address the data gaps identified by Ecology (2009c) in a letter dated December 29, 2009 to complete the characterization of the nature and extent of PCE in Shallow Zone soil and groundwater on the western portion of the Site. The purpose of the 2011 RI effort was to further delineate the area to be treated with the preferred cleanup alternative indicated in the Revised Draft RI/FS Report (Farallon 2011a), and to further evaluate potential preferential contaminant migration within the utility corridor of the subsurface sewer main line in the Woodlawn Avenue Northeast right-of-way. Work conducted in 2012 was performed to repair five damaged wells in the rights-of-way, and to evaluate PCE leachability in support of disposal option evaluation for PCE-contaminated soil beneath the Dry Cleaner Building. The subsurface investigations conducted at the Site between 2002 and 2009 are summarized in Section 2, Site Background.

3.1 2010 REMEDIAL INVESTIGATION

This section provides a summary of the RI field program conducted between March and May 2010 to complete the RI, and includes a summary of the results of the investigation. The work included soil and reconnaissance groundwater sampling, installation of new monitoring wells, and a Site-wide groundwater monitoring and sampling event. This section also includes a summary of the management of investigation-derived waste generated during the additional RI field program, a discussion of the TEE requirement under MTCA, and the results of the TEE conducted for the Site.

3.1.1 Reconnaissance Sampling

3.1.1.1 Hearthstone Property

In March 2010, monitoring wells TMW-1 through TMW-3 were installed in the Shallow Zone to evaluate groundwater quality up-gradient of monitoring well MW-24 and boring P14 on the Hearthstone Property (Figure 3). Each well was constructed using 2-inch-diameter polyvinyl chloride casing with 10 feet of screen in the Shallow

Zone. Soil samples were collected continuously from each boring to the total depth drilled of 20 feet bgs. Four soil samples from each boring were retained for laboratory analysis. The monitoring wells were developed and sampled using EPA low-flow groundwater sampling methodology. Soil and groundwater samples were submitted for laboratory analysis for HVOCs using EPA Method 8260B. The logs of boring and well construction details are provided in Appendix A. Monitoring wells TMW-1 through TMW-3 were decommissioned during the Hearthstone interim action in 2011.

3.1.1.2 Woodlawn Avenue Northeast Right-of-Way

In April 2010, borings SB-20 through SB-25 were advanced in the right-of-way of Woodlawn Avenue Northeast using Geoprobe push-probe technology to a depth of approximately 20 feet bgs (Figure 3). Soil and reconnaissance groundwater samples were collected from each boring for laboratory analysis for HVOCs. Soil samples were collected continuously to the total depth of each boring for lithologic logging and field-screening. A temporary 4-foot screen was installed in each boring at the depth of first-encountered groundwater. Groundwater was purged and sampled using EPA low-flow groundwater sampling methodology. The logs of boring for borings SB-20 through SB-25 are provided in Appendix A. The locations and rationale for placement of the borings are summarized as follows:

- Boring SB-20 was advanced in the northern right-of-way of Woodlawn Avenue Northeast proximate to Deep Zone monitoring well MW-13. The purpose of this boring was to bound the down-gradient extent of PCE exceeding the MTCA Method A cleanup level in Shallow Zone groundwater. Three soil samples and a reconnaissance groundwater sample were retained for analysis for HVOCs using EPA Method 8260B.
- Borings SB-21, SB-22, and SB-23 were advanced in Woodlawn Avenue Northeast, north-northwest and down-gradient of monitoring well MW-24 and boring P14. The purpose of these borings was to evaluate the down-gradient extent of PCE in the Shallow Zone at approximately 20-foot intervals north-northwest of the Hearthstone Property. Three soil samples from each

boring were retained for analysis for HVOCs using EPA Method 8260B. Reconnaissance groundwater samples were collected and analyzed for HVOCs using EPA Method 8260B.

- Boring SB-24 was advanced in the Woodlawn Avenue Northeast right-of-way northwest of the Hearthstone Property to further characterize Shallow Zone groundwater conditions down-gradient of the Site. Three soil samples and a reconnaissance groundwater sample were retained for analysis for HVOCs using EPA Method 8260B.
- Boring SB-25 was advanced west-southwest of monitoring well MW-24 and boring P14 in the southern right-of-way of Woodlawn Avenue Northeast. The purpose of this boring was to bound the cross-gradient extent of PCE exceeding the MTCA Method A cleanup level in Shallow Zone groundwater. Three soil samples and a reconnaissance groundwater sample were retained for analysis for HVOCs using EPA Method 8260B.

3.1.1.3 Summary of Results

The analytical results for the 2010 RI field program are provided in Tables 2, 3, and 4. The soil analytical data are shown on Figure 6, and Shallow Zone groundwater data are shown on Figure 8. Laboratory analytical reports are provided in Appendix B.

PCE was detected at concentrations exceeding the MTCA Method A cleanup level in soil collected from borings SB-22 and SB-23 down-gradient of monitoring well MW-24 and from boring P14 at depths of between 2 and 14 feet bgs. PCE also was detected exceeding the MTCA Method A cleanup level in the soil sample collected at 12.5 feet bgs from the boring for monitoring well TMW-3 within 20 feet southeast and up-gradient of monitoring well MW-24. PCE was detected in soil samples collected at monitoring wells TMW-1 and TMW-2, up-gradient of monitoring well MW-24, although the concentrations did not exceed the MTCA Method A cleanup level. Borings SB-20 and SB-21, advanced on the north side of the Woodlawn Avenue Northeast right-of-way, were reported non-detect for PCE in soil at the laboratory PQL.

Soil samples collected from boring SB-25, completed on the south side of the Woodlawn Avenue Northeast right-of-way, were reported non-detect for PCE at the laboratory PQL. PCE and TCE were detected at concentrations below the MTCA Method A cleanup level in soil samples collected from boring SB-24 in the middle of Woodlawn Avenue Northeast.

Reconnaissance groundwater analytical data indicate that PCE in Shallow Zone groundwater exceeds the MTCA Method A cleanup level in the north-central part of the Hearthstone Property south of monitoring well MW-24, and extends down-gradient to the center line of Woodlawn Avenue Northeast proximate to boring SB-22. Borings SB-20, SB-21, SB-24, and SB-25 bound the cross- and down-gradient extent of the PCE plume in the Shallow Zone on the west side of the Site (Figure 7).

3.1.2 Monitoring Well Installation and Sampling

In April 2010, Shallow Zone monitoring wells MW-25 and MW-26 were installed in the Woodlawn Avenue Northeast right-of-way at locations selected based on the results of the reconnaissance sampling (Figure 3). Monitoring well MW-25 was installed north of monitoring well MW-24 and boring P-14, and was completed to a total depth of 18 feet bgs with a 10-foot screened interval. The purpose of monitoring well MW-25 was to confirm and bound the down-gradient extent of PCE in Shallow Zone groundwater. Monitoring well MW-26 was installed west of monitoring well MW-24 and boring P-14 to confirm and bound the cross-gradient extent of PCE in the Shallow Zone, and was completed to a total depth of 18 feet bgs with a 10-foot screened interval.

Monitoring well MW-25 was installed proximate to the location of boring SB-22, and no soil samples were retained during installation. Soil samples were collected at monitoring well MW-26 for lithologic logging and field-screening. Three soil samples were collected during the installation of monitoring well MW-26 and retained for analysis for HVOCs using EPA Method 8260B. PCE was detected at concentrations below the MTCA Method A cleanup level in the soil sample collected from monitoring well MW-26 at 5 feet bgs. PCE was not detected at concentrations at or above the laboratory PQL in the two deeper samples.

3.1.3 Groundwater Monitoring Event

Following installation of monitoring wells TMW-1 through TMW-3, MW-25, and MW-26, the wells were developed, and the locations were surveyed to tie them into the survey benchmark used for the Site monitoring well network. Groundwater level measurements were collected from all Site monitoring wells, and a groundwater sampling event was conducted that included 16 Shallow Zone monitoring wells (MW-1 through MW-6, MW-15, MW-19, MW-21, MW-23 through MW-26, and TMW-1 through TMW-3) and 10 Deep Zone monitoring wells (MW-7 through MW-14, MW-20, and MW-22). Groundwater samples were collected using EPA low-flow sampling methodology, and the samples were submitted for analysis for HVOCs using EPA Method 8260B.

Results of the groundwater sampling event are provided in Table 4, and isoconcentration contours for PCE in Shallow and Deep Zone groundwater are shown on Figures 7 and 8, respectively. These data, along with the reconnaissance groundwater data collected in the spring of 2010 and during previous sampling events, confirm a source area beneath the northwest corner of the Dry Cleaner Building in the location of the former dry cleaning equipment, with other possible minor sources related to drains and side sewer lines in the southern portion of the Dry Cleaner Building. Releases at the Dry Cleaner Building have affected both the Shallow and Deep Zone. The Shallow Zone plume is localized around the Dry Cleaner Building, with highest concentrations in the dry cleaning equipment source area, and extends into the Woodlawn Avenue Northeast and 4th Avenue Northeast rights-of-way. The Deep Zone plume is inferred to be relatively narrow (about 40 feet wide) and extends from about 40 feet up-gradient of the dry cleaning equipment source area to across Woodlawn Avenue Northeast and onto the southern edge of the property at 6869 Woodlawn Avenue Northeast. These interpretations are consistent with the observations of Shallow Zone silty sands with low transmissivity that pinch out in the Woodlawn Avenue Northeast right-of-way.

In addition to the dry cleaning equipment source area, a separate and distinct source area with elevated PCE concentrations in groundwater has been identified in the north-central portion of the Hearthstone Property in the area proximate to the side sewer line. The available data indicate that the Hearthstone Property source area is limited to the Shallow Zone and is bounded cross-gradient to the west by boring P16 and monitoring well MW-26, cross-gradient to the east by boring SB-24, down-gradient to the northwest by monitoring well MW-25 and boring SB-21, and up-gradient to the southeast proximate to monitoring well TMW-1.

3.1.4 Management of Investigation-Derived Waste

Soil cuttings, decontamination water, purge water, and other wastewater generated during the 2010 RI field program were temporarily stored on the Site in labeled 55-gallon steel drums. The analytical results for the soil and groundwater samples were used to develop a waste profile for disposal at an approved transport, storage, and disposal facility. Kleen Environmental Technologies, Inc. of Seattle, Washington, a Washington State-licensed hazardous waste transporter, was selected by Plastic Sales to manage off-Site transportation of investigation-derived waste and disposal at an approved disposal facility. Documentation regarding disposal of investigation-derived waste is provided in Appendix C

3.1.5 Terrestrial Ecological Evaluation

A TEE is intended to assess potential risk to plants and animals that live entirely or primarily on affected land. A simplified TEE was required under MTCA to assess the potential ecological risk posed by contamination at the Site, and whether a more-detailed investigation of potential ecological risk would be required. Farallon conducted a simplified TEE in accordance with Table 749-1 of WAC 173-340-900 and the protocols established in WAC 173-340-7492 to assess the potential ecologic risk associated with the presence of COPCs at the Site. The simplified TEE Worksheet per WAC 173-340-7492 (2)(a)(ii) is provided in Appendix I.

The Site qualifies for a TEE exclusion based on WAC 173-340-7492. The results of the ranking for the simplified TEE under Table 749-1 of MTCA yielded a score of 12, which qualifies the Site for the TEE exclusion per WAC 173-340-7492(2)(a)(ii) on the basis that land use at the Site and surrounding area makes substantial wildlife exposure unlikely. The TEE considers Site area, Site land use, Site habitat quality, likelihood that the Site will attract wildlife, and contaminant constituents occurring in Site soil. The Site also qualifies for a TEE exclusion based on WAC 173-340-7491 (1)(b), as all soil contaminated with hazardous substances is or will be covered by buildings, paved roads, pavements, or other physical barriers that will prevent plants or wildlife from being exposed to the soil contamination. Based on the results of the TEE, no further consideration of ecological impacts is required under MTCA.

3.2 2011 REMEDIAL INVESTIGATION

Two phases of additional subsurface investigation were conducted after the Revised Draft RI/FS Report was issued (Farallon 2011a). The first phase was to support the design of the preferred cleanup alternative for the Dry Cleaner Building property, and the second phase was conducted at the request of Ecology to support the conclusion that sewer main line backfill was not acting as a preferential pathway for contaminant migration in the Woodlawn Avenue Northeast right-of-way.

3.2.1 Additional Subsurface Investigation: Dry Cleaner Building

The first phase of additional subsurface investigation was conducted in February 2011 inside the Dry Cleaner Building to better define the extent of PCE in soil and groundwater beneath the building associated with the dry cleaning equipment source area. Limited-access Geoprobe borings SB-26 through SB-36 were advanced through the concrete floor slab of the building as shown on Figures 6 and 7. Boring SB-28 was placed in the dry cleaning equipment source area to collect a soil sample for electrical resistivity bench-testing. The other 10 locations were placed throughout the building to refine the area where concentrations of PCE in soil and groundwater exceeded cleanup standards, and to inform the design of a component of the preferred cleanup alternative identified in Section 8, Preferred Cleanup Alternative. Boring logs for the 11 borings are included in Appendix A.

Twenty-one soil samples and six reconnaissance groundwater samples were retained for HVOC testing. Analytical results for soil and reconnaissance groundwater testing are shown in Tables 2 and 3 respectively. Analytical results for soil and groundwater testing also are shown on Figures 6 and 7, respectively. Figure 14 shows the area identified for application of in-situ thermal treatment in the preferred cleanup alternative presented in Section 8. The results of this investigation corroborated results from previous subsurface investigations that the Shallow Zone beneath the Dry Cleaner Building has been impacted by releases of PCE associated with historical dry cleaning operations at the Site. The extent of contamination is discussed in detail in Section 5, Conceptual Site Model.

3.2.2 Additional Subsurface Investigation: Woodlawn Avenue Northeast and 4th Avenue Northeast Intersection

The second phase of 2011 additional subsurface investigation was conducted in June 2011, when additional Shallow Zone monitoring well MW-27 was installed in the intersection of Woodlawn Avenue Northeast and 4th Avenue Northeast. Monitoring well MW-27 was installed as close as feasible to the subsurface sewer main pipe near the center line of Woodlawn Avenue Northeast to assess whether the pipe backfill was potentially acting as a preferential pathway for PCE migration in Shallow Zone groundwater. The boring for monitoring well MW-27 was advanced using a hand-auger and an air knife to vacuum soil to a depth of 13.5 feet bgs, where drilling met with refusal. Monitoring well MW-27 was constructed of 2-inch-diameter polyvinyl chloride with a 0.01-inch slotted screen placed between 8.5 and 13.5 feet bgs. Monitoring well MW-27 was completed with a flush-mounted traffic-proof well monument. The lithologic log and well construction information are provided in Appendix A.

HVOCs were not detected above reporting limits in either the soil sample collected from the bottom of the boring at 13.5 feet bgs or in the groundwater sample. Laboratory analytical results for soil and groundwater samples are presented in Tables 2 and 4, respectively, and on Figures 6 and 7, respectively. Analytical results do not indicate that sewer line backfill is acting as a preferential pathway for contaminant migration. The extent of contamination is discussed in detail in Section 5, Conceptual Site Model.

3.3 2012 FIELD WORK

Site work in 2012 was conducted to repair damage to monitoring wells MW-10, MMW-16, MW-21, MW-23, and MW-27, whose monuments were damaged during a Seattle Department of Transportation paving project during the summer of 2011, and to evaluate PCE leachability in impacted soil beneath the Dry Cleaner Building in support of the FS. All of the monitoring wells were successfully repaired, with the exception of monitoring well MW-23 in 4th Avenue

Northeast, which was damaged beyond repair and was decommissioned per WAC 173-360, Minimum Standards for Construction and Maintenance of Wells, on December 12, 2012.

Also on December 12, 2012, additional borings SB-37 through SB-39 were advanced using a hand-auger to 10 feet bgs in and proximate to the dry cleaning equipment source area where elevated PCE concentrations were known to exist. The objective of this subsurface investigation was to evaluate the correlation between PCE concentrations measured in Site soil using EPA Method 8260B, with leachable PCE measured using the Toxicity Characteristic Leaching Procedure (TCLP) to support the FS and evaluation of off-Site disposal options for PCE-contaminated soil. Two soil samples from each of the three locations were tested for PCE; analytical results are presented in Table 3. Three of these samples were tested also using TCLP to evaluate whether some soil would be designated as dangerous waste if it was to be excavated and disposed of off the Site. The threshold for designating soil containing PCE as a dangerous waste according to the toxicity characteristic per WAC 173-303-090, the Washington State Dangerous Waste Regulations, is 0.7 milligrams per liter (mg/l), as measured using TCLP. TCLP analytical results are included in Appendix B. Boring logs are presented in Appendix A. Results of this work indicate that soil around the dry cleaning equipment source area likely would designate as dangerous waste per the toxicity characteristic.

4.0 HEARTHSTONE PROPERTY INTERIM ACTION

Pursuant to Section VII of the Agreed Order, Hearthstone conducted an interim action at the Hearthstone Property between July 2011 and July 2012 as part of a planned development project that includes an underground parking structure. The specific objectives of the interim action were to remove PCE-contaminated soil, prevent vapor intrusion, and control potentially contaminated groundwater (SES 2012). PCE was identified as the primary COC; its degradation products TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride also were identified as COCs. The interim action was deemed necessary to reduce the threat to human health and the environment by eliminating or substantially reducing direct contact, soil to groundwater, and inhalation exposure pathways. The interim action included removal of soil with PCE exceeding the preliminary cleanup level established in the Work Plan prepared by SES (2011) to the extent practicable. A temporary dewatering system was used in 2011 to reduce groundwater levels to facilitate soil removal. However, the dewatering system was not necessary to maintain low groundwater levels, and the single dewatering well was decommissioned in 2011. Sump pumps were used infrequently to provide dewatering during excavation in 2012. The Hearthstone Property development plans include a permanent dewatering system, a vapor barrier, and a passive vapor ventilation system to be incorporated in the floor slab, and are considered components of the interim action. Development construction has not yet been completed.

Between July 2011 and July 2012, 5,541 tons of PCE-contaminated soil was excavated and disposed of at the Roosevelt Regional Landfill in Klickitat County, Washington after contained-out designations were obtained from Ecology. The maximum excavation depth was 15 feet bgs, which is considered to be the maximum practicable depth based on shoring design considerations. A total of 1,700 tons of clean soil also was excavated and disposed of at Wm. Dickson Co. landfill in Tacoma, Washington.

A total of 118 soil samples were collected for compliance monitoring during the interim action, which indicate that residual concentrations of PCE exceeding the preliminary cleanup level remain in some areas as much as 2 feet below the 15-foot maximum excavation depth. The highest residual concentration of PCE was 1.2 mg/kg, which exceeds the 0.05 mg/kg preliminary soil cleanup level. Two groundwater samples were collected from the temporary dewatering well in 2011 for compliance monitoring. PCE was detected at concentrations up to 12 µg/l, which exceeds the 5 µg/l preliminary groundwater cleanup level. Other COCs were not detected at or above the laboratory PQLs in these groundwater samples (SES 2012).

Institutional controls to protect human exposure to residual concentrations of PCE will include an environmental covenant for the Hearthstone Property. Engineering controls also will be implemented, including capping the subsurface parking garage concrete floor and walls, and installing a permanent dewatering system, and a vapor barrier with a passive vapor ventilation system. Sheet piles installed along the Woodlawn Avenue Northeast right-of-way and along the alley between the Hearthstone Property and the Dry Cleaner Building Property will inhibit the down-gradient migration of PCE-contaminated Shallow Zone groundwater.

5.0 CONCEPTUAL SITE MODEL

A conceptual site model has been developed to identify confirmed and suspected sources of contamination, affected media, transport mechanisms, contaminant fate, and potential receptors and exposure pathways at the Site. The conceptual site model serves as the basis for developing technically feasible cleanup alternatives and selecting a final cleanup action. The conceptual site model is dynamic and may be refined throughout the cleanup action process as additional information becomes available.

This section discusses the components of the conceptual site model developed for the Site based on completion of multiple phases of investigation conducted by Farallon and others. Included in the following sections is a discussion of the confirmed and suspected source areas, affected media, contaminant fate and transport, and a contamination exposure assessment.

5.1 SOURCE AREAS

The observed distribution of high concentrations of PCE in soil and groundwater and the possible presence of PCE as DNAPL at boring SB-1 in the vicinity of the former dry cleaning equipment is inferred to be evidence of a release from the former dry cleaning equipment in the northwest corner of the Dry Cleaner Building and/or the floor drain system beneath the Dry Cleaner Building (Figures 6 through 11). Other minor source areas are suspected to be present in the southern portion of the Dry Cleaner Building. These minor source areas may have resulted from releases of PCE from the Dry Cleaner Building floor drain/sanitary sewer lines in these areas. Alternatively, the presence of PCE in soil in these areas may be due to vapor-phase migration of PCE from the dry cleaning equipment source area.

The observed distribution of elevated concentrations of PCE in Shallow Zone groundwater proximate to monitoring wells TMW-2, TMW-3, and MW-24 and boring P-14 indicated the presence of a former separate and distinct source area on the north-central portion of the Hearthstone Property (Figure 7). This source area was attributed to suspected releases of PCE from the sanitary side sewer line proximate to this area (Figures 7, 10, 12, and 13). Section 4, Hearthstone Property Interim Action, describes the interim action measures taken at the Hearthstone Property between July 2011 and July 2012 to reduce this PCE source.

5.2 AFFECTED MEDIA

Soil and groundwater have been confirmed as affected media of concern at the Site. Soil vapor and indoor air have been retained as media of concern based on elevated concentrations of PCE detected in Shallow Zone soil and groundwater beneath the Dry Cleaner Building concrete floor slab. More-specific details pertaining to the affected media at the Site were presented in Section 2, Site Background, and Section 3, Completion of Remedial Investigation.

5.3 CONTAMINANT FATE AND TRANSPORT

This section includes a discussion of the fate and transport characteristics of the HVOCs identified in the affected media at the Site that are relevant to the evaluation of potentially feasible remedial technologies. These HVOCs include PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride, which are confirmed to be present in both soil (Table 2) and groundwater (Tables 3 and 4) at levels requiring further action under MTCA. Although concentrations of PCE-related compounds, including the dichloroethene (DCE) isomers and vinyl chloride, have been detected in soil and/or groundwater, the concentrations have consistently been lower than PCE concentrations, suggesting that these compounds either are associated with chemical impurities in the original PCE product, or are present as a result of chemical or biological degradation of PCE. Because both PCE and the other identified HVOCs share similar environmental fate and transport characteristics and are present in the same media, PCE will be the focus of the discussion of contaminant fate and transport.

The RI activities conducted at the Site have demonstrated the following:

- Concentrations of PCE in Shallow Zone soil have migrated from source areas at the Dry Cleaner Building Property and affected a portion of the northeast corner of the Hearthstone Property and the right-of-way of Woodlawn Avenue Northeast. Migration was facilitated by vapor-phase transport in the vadose zone and/or advective movement in the groundwater-bearing zone.
- Concentrations of PCE in Shallow Zone soil have migrated from a source area at the Hearthstone Property, affecting the north-central portion of the Hearthstone Property and the south side of the Woodlawn Avenue Northeast right-of-way. Migration was

facilitated by vapor-phase transport in the vadose zone and/or advective movement in the groundwater-bearing zone.

- Section 4, Hearthstone Property Interim Action, describes interim action measures taken at the Hearthstone Property between July 2011 and July 2012 to reduce this PCE source on the Hearthstone Property (SES 2012). Residual concentrations of PCE exceeding the 0.05 mg/kg preliminary cleanup level for soil remain in some areas as much as 2 feet below the 15-foot maximum excavation depth. The highest residual concentration of PCE was 1.2 mg/kg in the area of the former sanitary side sewer line and in the area of the highest groundwater PCE concentration detected on the Hearthstone Property prior to the interim action (Figure 7).
- The highest concentrations of PCE in soil are present in the Shallow Zone at depths ranging from 5 to 20 feet bgs on the Dry Cleaner Building Property. The presence of PCE as DNAPL is probable at boring SB-1 in the vicinity of the former dry cleaning equipment.
- Concentrations of PCE in Shallow Zone groundwater attenuate rapidly down-gradient of the former dry cleaning equipment and the Hearthstone Property source areas due to high silt content and the presence of a hydrogeologic discontinuity in the Shallow Zone in the Woodlawn Avenue Northeast right-of-way.
- PCE has migrated to Deep Zone soil and groundwater in the vicinity of the dry cleaning equipment source area to a depth of approximately 50 feet bgs. Concentrations of PCE in the Deep Zone attenuate rapidly both laterally and vertically from the dry cleaning equipment source area, and no DNAPL is suspected to be present in the Deep Zone. Based on available data, the Deep Zone is not affected at the Hearthstone Property.

A discussion of the specific fate and transport mechanisms that have resulted in the distribution of PCE in the subsurface follows.

5.3.1 Transport Mechanisms Affecting Subsurface PCE

The lateral distribution of PCE concentrations in the soil matrix in the vadose zone likely is a result of vapor-phase transport via diffusion from source areas and transport over time via natural mechanisms such as barometric pumping. In addition to vapor-phase transport, PCE in the subsurface will be transported in the dissolved-phase via groundwater or other water that comes into contact with contaminated soil. PCE in groundwater will follow horizontal and vertical groundwater gradients (Figures 7 through 12). The direction of groundwater flow at the Site has consistently been to the north-northwest. Concentrations of PCE in groundwater will be greatest in monitoring wells closest to the source areas, and typically will diminish along the groundwater flow path due to dilution with unaffected groundwater, sorption onto soil particles, and other attenuation processes that occur. Concentrations of PCE in the source areas are sufficiently elevated to have resulted in the identified distribution of PCE in soil and groundwater at the Site.

The results of the TOC laboratory analysis conducted for selected soil samples indicate that TOC concentrations in soil are comparable in the Shallow Zone and the Deep Zone at the Site. The foc values at the Site indicate that the sorptive capacity of the soil matrix is within the range that PCE movement will be reduced due to the retardation capacity of the soil matrix within the Shallow and Deep Zones. This is confirmed by the empirical results for soil and groundwater samples collected in areas down-gradient of the source areas, which demonstrate a significant decrease of PCE concentrations in soil and groundwater.

5.3.2 Environmental Fate of Subsurface PCE

Once PCE enters the subsurface, chemical attenuation processes such as hydrolysis, direct mineralization, and reductive dehalogenation may affect HVOCs in soil and groundwater, resulting in a natural reduction or breakdown of HVOCs into nontoxic components such as chloride and carbon dioxide. Biological attenuation processes such as reductive dechlorination and cometabolic degradation also may affect the reduction of HVOCs in soil and groundwater under conducive subsurface conditions. If biodegradation of PCE is occurring, the first line of evidence is the presence of degradation compounds that include TCE, the DCE isomers, and vinyl chloride. Soil and groundwater analytical data indicate that concentrations of TCE, DCE isomers, and vinyl chloride have been detected in the Shallow Zone, suggesting that some biological and possibly chemical attenuation processes are occurring for these HVOCs at the Site.

PCE is a volatile compound that will volatilize into a gaseous state from soil and/or groundwater. In areas of the Site where an impermeable cover is not present, some PCE in vapor will escape to the atmosphere. Once in the atmosphere, it will rapidly attenuate via photodegradation.

5.4 EXPOSURE ASSESSMENT

The two types of exposure risk associated with the presence of COPCs at the Site are terrestrial ecological risk and human health risk. Because the Site qualifies for a TEE exclusion based on WAC 173-340-7491 (see Section 3.1.5, Terrestrial Ecological Evaluation), mitigating the potential human health risk associated with exposure to COPCs in the affected media at the Site will be the primary objective of any cleanup action implemented. This section presents the evaluation and conclusions pertaining to the exposure pathways at the Site, including identification of potential exposure scenarios that will assist in the evaluation of potential feasible remediation technologies.

5.4.1 Vapor Pathway

Soil vapor is affected by volatilization from released contamination into unsaturated soil and by volatilization from soil and groundwater. Future construction workers encountering contaminated soil and/or groundwater could result in short-term exposure to vapors. The Ecology (2009b) guidance for evaluating soil vapor intrusion into structures in Washington State presents screening levels for groundwater and soil vapor that could result in vapor intrusion exposure risks. Based on the Inhalation Cancer Potency Factor for PCE as revised by EPA in the Integrated Risk Information System database in February 2012 and equation 750-2 of WAC 173-340-750, the MTCA Method B Indoor Air cleanup level for PCE in a residential setting is 9.6 micrograms per cubic meter ($\mu g/m^3$), and in a commercial setting, 50.2 $\mu g/m^3$. According to Ecology (2009b), the presence of PCE concentrations in groundwater exceeding 1 µg/l, or in soil vapor beneath a building structure exceeding 10 times the indoor air cleanup level, has the potential to result in adverse risk via vapor intrusion to indoor air through a concrete floor slab (i.e., 96 $\mu g/m^3$ for a residential setting, or 502 $\mu g/m^3$ for a commercial setting). Potential exposure could occur via the inhalation pathway from soil vapor to indoor air inside the Dry Cleaner Building. In the areas down-gradient of the former dry cleaning machine and Hearthstone Property source areas such as the Woodlawn Avenue Northeast right-of-way, where concentrations of PCE in soil and groundwater have been detected in the Shallow Zone, there currently are no structures with the potential to accumulate vapors (Figures 6 and 7). As a result, the vapors would be dispersed into the atmosphere, where dilution and degradation would occur. The building structure at 6869 Woodlawn Avenue Northeast, down-gradient of the Dry Cleaner Building, is built above grade over open-air at-grade parking. The exposure risk posed by the vapor pathway in this area of the Site is low because vapors would be dispersed into the atmosphere, where dilution and degradation would occur.

In the vicinity of the source area beneath the former dry cleaning equipment, the concrete slab of the Dry Cleaner Building serves as a vapor barrier. However, no indoor air screening has been conducted to assess whether the concrete slab is sufficiently protective to prevent vapor intrusion.

5.4.2 Soil Pathway

Potential exposure pathways for soil contamination include volatilization into soil vapor, and subsequent exposure through the vapor pathway discussed in Section 5.4.1, Vapor Pathway, or via the direct contact pathway, which comprises direct contact via dermal contact with and/or ingestion of soil beneath the Site. Protection from direct contact exposure to affected soil would require capping or excavation. At present, soil with concentrations of PCE that exceed the MTCA Method B soil cleanup level of 480 mg/kg, considered protective of the direct contact pathway for ingestion, is covered with concrete, asphalt, and/or building structures, which minimizes the risk of direct contact. However, future development activities at the Site in the Shallow Zone could result in exposure to contaminated soil above direct contact levels.

5.4.3 Groundwater Pathways

Groundwater is affected by releases directly into a groundwater-bearing zone or by unsaturated soil contamination desorbed from soil particles into the vapor phase or the dissolved phase by infiltrating surface water or seasonally high groundwater conditions. Potential exposure pathways for groundwater contamination include volatilization into soil vapor, and subsequent exposure through the vapor pathway discussed in Section 5.4.1, Vapor Pathway, or via the direct contact pathway, which comprises both the dermal contact and ingestion pathways. There are no groundwater supply wells at or in the vicinity of the Site that are used as a potable water supply. Shallow Zone groundwater is not used as a drinking water source and likely is a non-potable resource as defined in WAC 173-340-720(2)(b)(i), due to the low transmissivity of the subsurface lithology in the Shallow Zone, which predominantly comprises silty sand and silt. Deep Zone groundwater underlying the Shallow Zone may qualify as a potential future source of potable water. However, because of the availability of the municipal water supply in the Site vicinity, there is a low probability that groundwater in the Deep Zone at the Site or adjacent properties would be used as a potable water source. Because there is no practical use of Shallow Zone groundwater in the Site vicinity, and Shallow Zone groundwater is approximately 5 feet below the ground surface, which is capped with concrete, asphalt, or building structures, excavation activities would be required for direct contact with groundwater to become a potential risk to human health. Future development activities at the Site in the Shallow Zone could result in exposure to contaminated groundwater.

5.5 CONCEPTUAL SITE MODEL SUMMARY

Geologic and hydrogeologic information and soil and groundwater analytical data were compiled on cross-sections of the Site to illustrate the conceptual model of Site conditions. As shown on cross sections A-A’, B-B’, C-C’, and D-D’ (Figures 9 through 13), the stratigraphy at the Site is distinguished by the lithology of the Shallow and Deep Zones. The Shallow Zone is composed predominantly of silt and silty sand to a depth of 20 feet bgs. The soil encountered from depths of approximately 20 to 70 feet bgs consists of poorly graded sand to well-graded sand, silty sand, and gravel in the Deep Zone. The Deep Zone is underlain by a silt layer encountered at a depth of approximately 70 feet bgs to the total depth drilled of 80 feet bgs in boring MW-18.

Soil analytical data collected during the investigations conducted at the Site indicate that PCE concentrations in the Shallow Zone decrease rapidly with distance from source areas. At the dry cleaning equipment source area, PCE, which was detected at a concentration of 570 mg/kg in soil collected at boring SB-3, declined to a concentration of less than 20 mg/kg in soil collected at boring MW-7 directly outside the Dry Cleaner Building (Figures 6 and 11). The soil analytical data further indicate that concentrations of PCE appear to attenuate to less than 1 mg/kg at depths below approximately 20 feet bgs, which is approximately coincident with the depth of the contact between the Shallow and Deep Zones (Figures 10 through 13). The presence of concentrations of PCE exceeding the MTCA Method A cleanup level in Deep Zone soil at monitoring wells MW-9 and MW-15 likely is due to partitioning from contaminated groundwater onto soil down-gradient of the source of contamination to Deep Zone groundwater.

The observed distribution of high concentrations of PCE in soil and groundwater in the Shallow Zone, and the possible presence of PCE as DNAPL at boring SB-1 in the vicinity of the former dry cleaning equipment, are inferred to be evidence of a release from the former dry cleaning equipment and/or the floor drain system in the northwest corner of the Dry Cleaner Building (Figures 6, 7, 8, 10, and 11). Other minor source areas are suspected to be present in the southern portion of the Dry Cleaner Building. These minor source areas may have resulted from releases of PCE from the floor drain/sanitary sewer lines in these areas. Alternatively, the presence of PCE in soil in these areas may be due to vapor-phase migration of PCE from the former dry cleaning equipment source area.

The observed distribution of elevated concentrations of PCE in Shallow Zone groundwater proximate to monitoring wells TMW-2, TMW-3, MW-24, and boring P-14 indicated the presence of a separate and distinct source area on the north-central portion of the Hearthstone Property prior to its reduction during the 2011 and 2012 Hearthstone Property interim action, summarized in Section 4. This source area may be attributed to suspected releases of PCE from the sanitary side sewer line proximate to this area (Figures 6, 7, 10, 12, and 13).

The groundwater analytical data for Shallow Zone monitoring wells MW-4, MW-6, and MW-15 through MW-17 and boring SB-7 demonstrate that dissolved concentrations of PCE and its degradation compounds in Shallow Zone groundwater attenuate rapidly with distance down-gradient of the former dry cleaning equipment source area (Figures 6 and 7) and within about 50 feet of the dry cleaning equipment source area. Similar attenuation of PCE concentrations occurs down-gradient of the Hearthstone Property source area (Figures 6 and 7). This is consistent with the low transmissivity of the saturated silt and silty sand composing the

Shallow Zone beneath the source areas, and the gradation to silt in areas down-gradient of the sources. These factors appear to have significantly limited the lateral migration of PCE in Shallow Zone groundwater to areas down-gradient of the Site (Figures 7, 11, and 13). The lateral extent of the dissolved-PCE plume in the Shallow Zone exceeding the MTCA Method A cleanup level of 5 µg/l is limited to an estimated area bounded by monitoring wells MW-15, MW-17, MW-19, MW-21, MW-23, MW-26, and MW-27 and borings SB-6 and SB-24 in the cross- and down-gradient directions to the west, north, and east of the Site, and by monitoring well MW-1 in the up-gradient direction to the south (Figure 7), and within about 100 feet of the dry cleaning equipment source area. The lateral and vertical extent of PCE concentrations exceeding 5 µg/l in Shallow Zone groundwater has been sufficiently characterized with the existing Shallow Zone monitoring well network and shallow borings.

Vertical migration of PCE from the source area beneath the former dry cleaning equipment and/or nearby floor drain system is affecting groundwater quality in upper portions of the Deep Zone. Comparison of HVOC concentrations in groundwater at monitoring well MW-7 before the March 2007 chemical oxidation pilot test to those in down-gradient well MW-9 indicates that concentrations of PCE and its degradation compounds in Deep Zone groundwater attenuate rapidly with distance down-gradient of the former dry cleaning equipment source area (Figures 9 and 11). The configuration of the PCE plume in Deep Zone groundwater is characterized by a narrower plume width than that in the Shallow Zone (Figures 7 and 8). In addition, elevated concentrations of PCE in groundwater extend farther down-gradient in the Deep Zone than in the Shallow Zone. This distribution is consistent with the higher transmissivity of saturated soil in the Deep Zone and the absence of a Shallow Zone groundwater-bearing zone farther down-gradient of the Site (Figures 11 and 13). Although the Deep Zone groundwater contours indicate a flow direction to the north-northeast, empirical data, including groundwater analytical results for boring SB-11 and aquifer pump test data, indicate a preferential pathway in the Deep Zone from the former dry cleaning equipment source area in a more-northwest direction toward monitoring well MW-9.

The lateral extent of the dissolved-PCE plume in the Deep Zone exceeding the MTCA Method A cleanup level of 5 µg/l is limited to an estimated area bounded by monitoring wells MW-8, MW-10, MW-12, MW-13, MW-18, and MW-22 and borings SB-11 through SB-13 in the cross- and down-gradient directions to the west, north, and east of the Site, and by monitoring well MW-20 up-gradient, to the south (Figure 8). The PCE plume in Deep Zone groundwater occurs within the Woodlawn Avenue Northeast right-of-way, at the Dry Cleaner Building Property, and in the alley west of the Dry Cleaner Building Property, and extends about 30 feet onto the southern portion of the property at 6869 Woodlawn Avenue Northeast, north of the Dry Cleaner Building Property. The vertical extent of the dissolved-PCE plume in the Deep Zone exceeding the MTCA Method A cleanup level of 5 µg/l is limited to the upper portion of the Deep Zone, extending from approximately 21 to 40 feet bgs (Figure 10). The lateral and vertical extent of PCE concentrations exceeding 5 µg/l in Deep Zone groundwater has been sufficiently characterized with the existing Deep Zone monitoring well network and deep borings.

The fate and transport analysis indicates that water-based transport via subtle preferential pathways in the saturated soil matrix is the most-likely mechanism responsible for the lateral and vertical distribution of the COPCs detected at the Site. The widespread low-level distribution of PCE, and to a lesser extent TCE, in unsaturated soil in the Shallow Zone likely is the result of vapor-phase diffusion from the former dry cleaning equipment source area, the Hearthstone Property source area, and other minor source areas.

The estimated distribution of PCE mass in soil and groundwater based on the available data for the Dry Cleaner Building Property and the rights-of way down-gradient of the Dry Cleaner Building Property is summarized below:

	Soil	**Groundwater**	**Shallow Zone**	**Deep Zone**
Dry Cleaner Building Property	92%	0.69%	74%	19%
Rights-of-way	6.9%	0.19%	4.3%	2.8%
	100%		100%	

The estimated distribution of PCE mass was developed using available soil and groundwater analytical results presented in Tables 2 and 4 and on Figures 6, 7, and 8. These data were converted to mass assuming average soil concentrations for selected areas of the Site such as the dry cleaning equipment source area. PCE mass in soil was calculated assuming a soil density of 1.7 tons per cubic yard. Similarly, average groundwater concentrations were calculated assuming a soil porosity of 0.25 to estimate approximate PCE mass dissolved in groundwater for selected areas within the Shallow and Deep Zones at the Site. Percentages of total estimated PCE mass at the Site were calculated by dividing the sum of estimated mass of PCE for selected areas (e.g., the Dry Cleaner Building Property) by the total estimated mass of PCE at the Dry Cleaner Building Property and the rights-of-way. The summary in the table above is intended to approximate relative percentages of PCE occurrence at the Site, excluding the Hearthstone Property, and is only an approximation. This summary excludes the PCE mass in soil and groundwater on the Hearthstone Property because an interim action was conducted there between July 2011 and July 2012 (see Section 4, Hearthstone Property Interim Action). These data indicate that the majority of PCE mass at the Site (i.e., greater than 90 percent) is contained in soil on the Dry Cleaner Building Property, less than 7 percent is present in soil in the rights-of-way, and less than 1 percent is contained in groundwater.

As indicated in Section 3.1.5, Terrestrial Ecological Evaluation, the Site qualifies for a TEE exclusion based on WAC 173-340-7491. Section 5.4, Exposure Assessment, discusses potential exposure pathways that could affect human health at the Site. In summary, the following exposure pathways are of concern for future human health exposure at the Site:

- **Vapor Pathway**: Indoor air inhalation of vapors emanating from soil and/or groundwater contamination intruding into existing and future structures at the Site. Short-term inhalation of volatilized contaminants by construction workers during future construction activities on the Site.
- **Soil Pathway**: Direct contact via dermal contact and/or ingestion by construction workers encountering contaminated soil during future construction activities on the Site.
- **Groundwater Pathway**: Direct contact via dermal contact and/or ingestion by construction workers encountering contaminated groundwater during future construction activities on the Site. Human health exposure via ingestion of groundwater as a potable drinking water supply is not considered to be a complete exposure pathway. Additional discussion of groundwater pathways is included in Section 5.4.3 Groundwater Pathways.

6.0 TECHNICAL ELEMENTS

The remedial action objectives (RAOs) developed for the Site were used to define the technical elements for the screening evaluation and to select remedial alternatives for cleanup at the Site. The technical elements include applicable or relevant and appropriate requirements (ARARs), COCs, media of concern, and cleanup standards.

6.1 REMEDIAL ACTION OBJECTIVES

Remedial action objectives consist of the key goals that a remedial alternative should achieve to be retained for further evaluation for the feasibility study. The overarching RAO for the cleanup action at the Site is to remediate contaminated soil and groundwater that poses a potential threat to human health via the direct contact and inhalation pathways, and that poses a potential future threat to the environment by the groundwater pathway, in an efficient and cost-effective manner that minimizes the impacts to Site use to the maximum extent practicable. The Site-specific RAOs for remediation of contaminated soil and groundwater in compliance with applicable MTCA cleanup levels are:

- Reduce concentrations of PCE in soil vapor in the Shallow Zone to mitigate potential soil vapor migration into existing or future buildings at concentrations exceeding levels protective of indoor air inhalation to the extent practicable;
- Reduce concentrations of PCE in soil and groundwater in the Shallow Zone in the immediate vicinity and down-gradient of the dry cleaning equipment and Hearthstone Property source areas; and
- Reduce concentrations of PCE in groundwater in the Deep Zone in the area directly beneath and down-gradient of the dry cleaning equipment source area.

A combination of remediation technologies were assessed as to their effectiveness at achieving the RAOs. Assessed technologies included but were not limited to: in-situ treatment of soil and groundwater in the Shallow and Deep Zones beneath the former dry cleaning equipment and Hearthstone Property source areas using thermal treatment, chemical oxidants, or bioremediation; source removal by excavation; engineering controls if needed to mitigate potential soil vapor intrusion, and confirmation groundwater monitoring to demonstrate that natural attenuation is occurring down-gradient of the source areas within a reasonable time frame.

Institutional controls (e.g., deed restrictions prohibiting use of groundwater) also will be implemented where COCs remain at concentrations above cleanup levels following completion of the remedial action. In addition, an Environmental Media Management Plan will be developed to govern the handling of potentially contaminated media during future development or utility work, as necessary.

6.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The evaluation of alternatives will consider potentially applicable chemical-, action-, and location-specific requirements. Although Ecology will be the lead agency for the cleanup action, WAC 173-340-710 requires that cleanup actions comply with applicable local, state, and federal laws. MTCA defines applicable local, state, and federal laws to include legally applicable requirements and relevant and appropriate requirements. Table 8 provides a summary of the applicable local, state, and federal laws for a cleanup action at the Site.

The following ARARs are anticipated to be the applicable requirements because they encompass the cleanup action framework, including applicable and relevant regulatory guidelines, cleanup standards, waste-disposal criteria, and documentation standards.

- Washington State Model Toxics Control Act, Chapter 70.105D of the Revised Code of Washington (RCW 70.105D);
- MTCA (WAC 173-340);
- Water Quality Standards for Groundwaters of the State of Washington (WAC 173-200);
- The Hazardous Waste Management Act (RCW 70.105);
- Washington State Solid Waste Management Laws and Regulations (RCW 70.95, WAC 173-351, and WAC 173-304);
- Dangerous Waste Regulations (WAC 173-303);

- Accreditation of Environmental Laboratories (WAC 173-50);
- The Occupational Safety and Health Act (Part 1910 of Title 29 of the Code of Federal Regulations [29 CFR 1910] and WAC 296-62);
- The State Environmental Policy Act Checklist (RCW 43.21);
- Maximum Containment Levels, National Primary Drinking Water Regulations (WAC 246-290-310 and 46 CFR 141);
- Safety Standards for Construction Work (WAC 296-155);
- Minimum Standards for Construction and Maintenance of Wells (WAC 173-160);
- National Primary and Secondary Air Quality Standards (40 CFR Part 50);
- Washington State General Requirements for Air Pollution Sources (WAC 173-400);
- Local permits required by the Puget Sound Clean Air Agency, the City of Seattle, and King County Industrial Waste; and
- Underground Injection Control (UIC) Program Requirements (WAC 173-218)

In accordance with RCW 70.105D.090, if the cleanup work is performed under a Consent Decree or an Agreed Order, the action is exempt from procedural requirements of certain state and local laws.

6.3 CONSTITUENTS OF CONCERN

The COCs for the Site include hazardous substances exceeding MTCA cleanup levels that have been detected in soil and/or groundwater. While PCE is the primary COC at the Site, associated degradation products also have been detected and are retained as COCs. The complete list of COCs for the Site is as follows:

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

- trans-1,2-DCE; and
- Vinyl chloride.

Because PCE and its degradation products share similar environmental fate and transport characteristics and are present in the same media, PCE will be the COC targeted for remediation of soil and groundwater.

Other chemicals identified as COPCs during previous investigations included GRO, DRO, ORO, benzene, toluene, ethylbenzene, xylenes, Stoddard solvent, and metals. The results of the laboratory analysis presented in the Site Characterization Report indicate that these compounds were not released to soil or groundwater from potential or confirmed source areas at concentrations exceeding MTCA Method A cleanup levels (Farallon 2005a). Therefore, these compounds were not retained as COCs for further analysis during the RI/FS.

6.4 MEDIA OF CONCERN

Soil and groundwater have been confirmed as affected media of concern at the Site. Based on the concentrations of COCs measured in Site soil and groundwater, soil vapor and indoor air also are identified as media of concern. These media represent the highest probable risk to human health and the environment based on the exposure pathway analysis performed, discussed in Section 5, Conceptual Site Model.

6.5 CLEANUP STANDARDS

As defined in WAC 173-340-700, cleanup standards for the Site include establishing cleanup levels, and the points of compliance at which those cleanup levels will be attained. The cleanup standards for the Site have been established in accordance with WAC 173-340-700 through 173-340-760 to be protective of human health and the environment and comply with the ARARs defined for the Site.

6.5.1 Cleanup Levels

The cleanup level is the concentration of a hazardous substance that protects human health and the environment under specific exposure scenarios. The Ecology (2010) Cleanup Levels and

Risk Calculations (CLARC) online database tool was queried in August 2010 for available cleanup levels for indoor air, soil, and groundwater matrices. After revision to the Integrated Risk Information System Cancer Potency Factor for PCE, MTCA Method B cleanup levels provided in CLARC were updated in 2012 from 1.9 to 480 mg/kg for soil and direct contact exposure, and from 0.42 to 9.6 µg/m^3 for indoor air with a residential land use.

6.5.1.1 Indoor Air

The preliminary cleanup levels for COCs in indoor air are listed below:

PCE	9.6 µg/m^3	MTCA Method B carcinogenic exposure cleanup level protective of indoor air inhalation
TCE	0.37 µg/m^3	MTCA Method B carcinogenic exposure cleanup level protective of indoor air inhalation
cis-1,2-DCE	16 µg/m^3	MTCA Method B non-carcinogenic exposure cleanup level protective of indoor air inhalation
trans-1,2-DCE	32 µg/m^3	MTCA Method B non-carcinogenic exposure cleanup level protective of indoor air inhalation
Vinyl chloride	0.28 µg/m^3	MTCA Method B carcinogenic exposure cleanup level protective of indoor air inhalation

Note: µg/m^3 = micrograms per meters cubed

6.5.1.2 Soil

The exposure assessment presented in Section 5, Conceptual Site Model, indicates that the most-likely human health exposure scenario for soil is by direct contact during excavation. Because groundwater in the Shallow Zone is not considered to be a potable groundwater source per WAC 173-340-720(2)(b)(i) (Section 4), MTCA Method B direct contact cleanup levels were selected as preliminary cleanup levels for soil, with one exception. The MTCA Method B cleanup level for PCE protective of direct contact is 480 mg/kg, exceeding the MTCA Method A cleanup level protective of groundwater of 0.05 mg/kg by a factor of nearly 10,000. The MTCA Method A cleanup level was selected as the preliminary cleanup level for PCE in soil.

The preliminary cleanup levels for COCs in soil are listed below:

PCE	0.05 mg/kg	MTCA Method A cleanup level protective of groundwater
TCE	11.0 mg/kg	MTCA Method B carcinogenic exposure cleanup level protective of direct contact (ingestion only)
cis-1,2-DCE	800 mg/kg	MTCA Method B non-carcinogenic exposure cleanup level protective of direct contact (ingestion only)
trans-1,2-DCE	1,600 mg/kg	MTCA Method B non-carcinogenic exposure cleanup level protective of direct contact (ingestion only)
Vinyl chloride	0.67 mg/kg	MTCA Method B carcinogenic exposure cleanup level protective of direct contact (ingestion only)

Modeling results were used to demonstrate that residual soil concentrations will be protective of groundwater for the Shallow Zone on the Dry Cleaner Building Property and the Deep Zone at the Site. In addition, empirical data from long-term groundwater monitoring will be used to demonstrate that residual soil concentrations are protective of groundwater in Shallow and Deep Zone groundwater at the Site.

6.5.1.3 Groundwater

The exposure assessment presented in Section 5, Conceptual Site Model, indicates that the most-likely human health exposure scenario for groundwater is direct (dermal) contact during future excavation. Groundwater in the Shallow Zone is not considered to be a potable groundwater source per WAC 173-340-720(2)(b)(i) (Section 5). Levels protective of groundwater quality for drinking water purposes were selected when available from applicable state and/or federal laws (WAC 246-290-310 and 40 CFR 141.61).

The preliminary cleanup levels for COCs in groundwater are listed below:

PCE	5 g/l	MTCA Method A cleanup level based on applicable state and federal laws
TCE	5 g/l	MTCA Method A cleanup level based on applicable state and federal laws
cis-1,2-DCE	80 g/l	MTCA Method B non-carcinogenic standard formula value
trans-1,2-DCE	160 g/l	MTCA Method B non-carcinogenic standard formula value
Vinyl chloride	0.2 g/l	MTCA Method A cleanup level based on applicable state and federal laws

6.5.2 Remediation Levels

A combination of cleanup technologies were considered for several of the cleanup alternatives that will require use of remediation levels prior to achieving the cleanup levels at the proposed points of compliance discussed in Section 6.5.3. The proposed cleanup technologies considered include thermal treatment in the Shallow Zone, and chemical oxidation and/or bioremediation in the Deep Zone. The remediation levels proposed for soil and groundwater for each of these components are discussed in detail in Section 7.3, Alternative Development and Description. A summary of the proposed remediation levels and rationale for their use is provided below:

- Shallow Zone Thermal Treatment—Soil and groundwater remediation levels for PCE of 2 mg/kg and 100 µg/l, respectively, are proposed in the thermal treatment area for the dry cleaning equipment source area.

The proposed remediation level for soil is protective of future direct contact exposure. In addition, the proposed soil and groundwater remediation levels were selected because they equate to a reduction of greater than 90 percent of the estimated PCE mass. There is a reasonable level of confidence that thermal treatment can achieve these remediation levels in the thermal treatment area.

- Deep Zone Chemical Oxidation or Bioremediation—Soil and groundwater remediation levels for PCE of 2 mg/kg and 20 µg/l, respectively, are proposed in the area of the Deep Zone groundwater plume at the Site.

  The soil remediation level for chemical oxidation or bioremediation in the Deep Zone was selected because it is protective of future direct contact exposure and, based on the results of the chemical oxidant pilot-testing conducted at the Site, there is a reasonable level of confidence that chemical oxidation or bioremediation treatment can achieve the proposed remediation levels.

6.5.3 Points of Compliance

The point of compliance defines the point(s) on a site where cleanup levels must be attained. Once the cleanup levels have been attained at the defined points of compliance, the site is no longer considered to be a threat to human health or the environment.

For indoor air, the point of compliance will be the standard point of compliance per WAC 173-340-750(6), which is indoor and outdoor ambient air throughout the Site, including down-gradient areas extending into the Woodlawn Avenue Northeast right-of-way to the outer boundary of the hazardous substance plume.

For soil, the point of compliance will be the standard point of compliance per WAC 173-340-740(6)(b), which for protection of ground water is throughout the Site.

For groundwater, the standard point of compliance will be the uppermost level of the saturated zone extending vertically to the lowest depth that potentially could be impacted by the COCs throughout the Site. For the Site, this includes groundwater in the Shallow and Deep Zones beneath the Dry Cleaner Building and the Hearthstone Property, and cross- and down-gradient areas in the 4th Avenue Northeast and Woodlawn Avenue Northeast rights-of-way.

However, based on the results of the disproportionate cost analysis described in Section 7.4.3, it is considered impracticable to actively remediate concentrations of PCE in Shallow Zone groundwater in areas cross- and down-gradient of the source areas (i.e., in the rights-of way). Therefore, monitored natural attenuation is used to achieve PCE groundwater cleanup levels at the standard point of compliance in the rights-of-way over a longer time frame. A conditional point of compliance for groundwater will be established along the down-gradient property line of the Dry Cleaner Building Property for the cleanup alternatives involving active source area remediation and use of proposed remediation levels. Long-term compliance groundwater monitoring will be performed to demonstrate that concentrations of COCs meet the proposed remediation levels at the conditional point of compliance monitoring wells. In addition, long-term compliance groundwater monitoring will be conducted in the rights-of-way to demonstrate attainment of cleanup levels within a reasonable restoration time frame at the standard point of compliance.

7.0 FEASIBILITY STUDY

The purpose of the FS is to develop and evaluate cleanup action alternatives to facilitate selection of a final cleanup action at the Site in accordance with WAC 173-340-350(8). The FS is intended to provide sufficient information to enable Ecology and the Site owner to reach concurrence on the selection of a final cleanup action. Ecology's selection of a final cleanup action will be documented in a Cleanup Action Plan.

The FS includes screening of potentially feasible remedial technologies and development of Site-wide cleanup alternatives intended to achieve the objectives described in Section 6.1, Remedial Action Objectives. The cleanup alternatives are evaluated with respect to threshold and other requirements for cleanup actions set forth in MTCA. The FS evaluates the alternatives and identifies those that are not effective or not technically possible, or those whose costs are disproportionate under the provisions of WAC 173-340-360(3)(e) and provides the basis for identifying a preferred cleanup alternative (Section 8).

In accordance with WAC 173-340-350(8)(c)(ii), an FS generally will include at least one permanent cleanup action alternative, as defined in WAC 173-340-200, to serve as a baseline against which other alternatives will be evaluated for the purpose of determining whether the cleanup action selected is permanent to the maximum extent practicable. In addition, the results of bench- and pilot-scale testing, where applicable, are used to evaluate the most-advantageous remediation technologies and to support selection of a preferred alternative for the Site in conformance with WAC 173-340-360 through 173-340-390.

7.1 EVALUATION OF FEASIBLE REMEDIATION TECHNOLOGIES

As part of the FS, remediation technologies for the Site were evaluated with respect to the cleanup requirements set forth in MTCA. Response actions, cleanup technologies, and process options considered potentially effective and implementable in the context of Site physical and chemical conditions in the Shallow and Deep Zones are presented in Table 9. The technologies were evaluated primarily with respect to implementability and effectiveness. The technologies were evaluated also with respect to cost relative to other process options considered for the affected environmental media (soil vapor and indoor air, soil, and groundwater). Relative cost is based on published sources and professional judgment, and is used to further distinguish technologies with similar implementability and effectiveness. If a technology is equally implementable and effective, the lower relative cost technology is preferred.

Treatment technologies considered included in-situ and ex-situ physical, chemical, and biological techniques. Containment technologies included physical barriers such as constructed covers or caps, and vertical barriers such as a slurry wall. Source removal by excavation, soil disposal at an approved landfill, and engineering and institutional controls also were considered. Table 9 identifies the cleanup technologies considered for Site remediation. Table 9 also indicates the results of the implementability, effectiveness, and cost evaluation for the cleanup technologies, and identifies those most favorable for Site conditions to be retained for inclusion in Site-wide cleanup alternatives (Section 7.3, Alternative Development and Description). Table 9 also identifies cleanup technologies eliminated from further consideration for Site application because they are not amenable, or are less suited to Site-specific conditions than other technologies, or they have a disproportionately higher cost relative to other available technologies.

The Shallow Zone at the Dry Cleaner Building Property and adjacent rights-of-way consist of an approximately 20-foot thickness of dense low-permeability silty sand and sand transitioning to silt on the north side of the Woodlawn Avenue Northeast right-of-way. Groundwater in the Shallow Zone is encountered as shallow as 5 feet bgs. Because of the low permeability, the Shallow Zone hydrogeology is not suited to in-situ technologies that rely on distribution by injection or extraction of materials (e.g., air sparge/vapor extraction, chemical oxidation, enhanced bioremediation). For dispersal of injected materials such as oxidants or bioremediation solutions to be effective in the Shallow Zone and achieve cleanup standards, injections would have to occur on a very close spacing, likely less than 10 feet. If the effective radius of influence of injected oxidant or bioremediation solution was 5 feet and if injection points were installed on 7.5-foot centers[1], approximately 100 injection points would be required in the Woodlawn Avenue Northeast right-of-way for full coverage of the Shallow Zone PCE plume. In addition,

[1] In the Deep Zone, conservative conceptual design includes injections on 15-foot centers assuming a 10-foot effective radius of influence under cleanup alternatives presented in Section 7.3, Alternative Development and Description.

approximately 200 injection points would be required for full coverage at the Dry Cleaner Building Property. Multiple injection events most likely would be required.

Obtaining authorization from the City of Seattle to install injection points in a traffic arterial is problematic, considering the impacts to traffic during construction of the injection points and multiple injection events. City approval to install approximately 100 injection points in the Woodlawn Avenue Northeast right-of-way is unlikely. Drilling proximate to numerous underground utilities is very risky. Some oxidants can be corrosive to underground utilities and can cause exothermic reactions. Additionally, injections would occur under pressure, which could also damage underground utilities. These possible adverse effects of a Shallow Zone injection program would not be desirable in a traffic arterial, an area with numerous underground utilities, and proximate to residences and businesses. Therefore, on the basis of implementability, effectiveness, and relative cost considerations, injection technologies were eliminated from consideration for the Shallow Zone in the screening of technologies summarized in Table 9.

In contrast, the more-permeable sands and gravels composing the Deep Zone below approximately 20 feet bgs are suited for use of in-situ technologies that rely on dispersal of injected materials. Therefore, in-situ injection technologies were retained for further consideration for the Deep Zone (Table 9).

Since the Draft RI/FS Report was issued, Ecology requested that active treatment occur in the Shallow Zone down-gradient in the Woodlawn Avenue Northeast right-of-way after completion of source control cleanup. Farallon (2013b) documented the results of technical discussions between Ecology and the PLPs, which indicate that implementation of the preferred cleanup alternative for the Site will include a post-source control pilot test of chemical oxidation in the Shallow Zone at the down-gradient edge of the source control area. In accordance with a general decision tree (Farallon 2013b), the pilot test will be followed by compliance monitoring, a possible contingency action (e.g., a second pilot test in the right-of-way), and possible full-scale implementation if pilot test results indicate that chemical oxidation is feasible and practicable. Procedures and decision points will be developed in detail in the Engineering Design Report for implementation of the preferred cleanup alternative. A post-source-control pilot test, including application of chemical oxidant to address residual PCE in the Shallow Zone beneath Woodlawn Avenue Northeast, is included under cleanup alternatives evaluated for cleanup at the Site in the sections that follow.

Based on the cleanup technology evaluation summarized in Table 9, remedial technologies considered most favorable for application in the Shallow and Deep Zones at the Site are summarized in the following table:

Media	Remedial Technology
Shallow Zone	
Soil Vapor and Indoor Air	Engineering controls
	Mitigate volatile constituents in soil and groundwater
Soil	Source reduction by in-situ thermal treatment
	Source containment using physical barriers (capping, constructed cover)
	Source removal by excavation and disposal
	Institutional controls
Groundwater	Source reduction by in-situ thermal treatment
	Source containment using physical barriers (capping, constructed cover)
	Monitored natural attenuation
	Institutional controls
Deep Zone	
Soil	Source reduction by in-situ enhanced bioremediation
	Source reduction by in-situ chemical oxidation
	Source reduction by in-situ thermal treatment
	Source removal by excavation and disposal
	Source containment using physical barriers (capping, constructed cover)
	Institutional controls
Groundwater	Source reduction by in-situ enhanced bioremediation
	Source reduction by in-situ chemical oxidation
	Source reduction by in-situ thermal treatment
	Source containment using physical barriers (capping, constructed cover)
	Monitored natural attenuation
	Institutional controls

A summary of the selected remedial technologies and the results of the supplemental analysis and technology screening conducted for the FS are provided below.

7.1.1 In-Situ Chemical Oxidation

In-situ chemical oxidation uses a strong oxidant to chemically react with and destroy PCE and other COCs present in soil and groundwater. The reaction converts COCs to nonhazardous compounds that are more stable and less mobile. In-situ chemical oxidation includes injection of an oxidant solution into the Deep Zone, and groundwater monitoring to evaluate effectiveness and assess whether multiple injections are required. The Ecology UIC Program requires that injection wells be registered.

Specific chemical oxidants considered applicable to the Site include permanganate and iron-catalyzed hydrogen peroxide (i.e., Fenton's Reagent). Permanganate is a solid chemical from which an aqueous solution of a desired concentration can be prepared on the Site using water. The aqueous solution is easily injectable and does not require an activator such as Fenton's Reagent. Potassium permanganate was selected for a Deep Zone pilot test in 2007 and effectively lowered PCE concentrations in groundwater. Therefore, permanganate is retained as a potential remediation alternative to treat contaminated groundwater in the Deep Zone. The silty soil and low-permeability conditions of the Shallow Zone are not suited for injection. The reaction rate of permanganate is moderate, which allows for a half-life on the order of months. The cost of permanganate is approximately $3 per pound.

In-situ chemical oxidation using hydrogen peroxide in the presence of an iron catalyst produces Fenton's Reagent, which yields a free radical that can rapidly degrade PCE and associated degradation compounds. In-Situ Oxidative Technologies Inc. (ISOTEC), a remediation vendor, provides a modified Fenton's Reagent that uses patented catalysts that allow reagents at neutral background pH conditions to be effectively distributed within the aquifer, destroying contaminants in soil and groundwater without generating organic vapors or high temperatures, which typically occurs when conventional Fenton's Reagent is used. According to ISOTEC, its modified Fenton's Reagent desorbs contaminated mass on soil, not only the dissolved-phase present in groundwater. Fenton's Reagent is shipped in liquid form, which increases its cost relative to permanganate. The reaction rate of Fenton's Reagent is very high, which allows for a half-life on the order of weeks. A shorter half-life minimizes the radius of influence and potentially increases the number of injection points required.

7.1.2 In-Situ Enhanced Bioremediation

In-situ bioremediation uses microorganisms to degrade organic contaminants in groundwater. A bioremediation solution is injected into the subsurface, and indigenous microorganisms break down contaminants by using them as a food source. The Ecology UIC Program requires that injection wells be registered. The bioremediation process can be aerobic or anaerobic (with or without oxygen), typically resulting in production of carbon dioxide and water for the aerobic process; and methane, hydrogen gas, sulfide, elemental sulfur, and dinitrogen gas for anaerobic processes. Specific bioremediation substrates considered applicable to the Site include emulsified oil substrate (EOS) and 3-D microemulsion. Both produce anaerobic conditions in the subsurface. Results of groundwater sampling indicate that biodegradation occurs naturally in the Shallow Zone with detection of PCE degradation products (Tables 3 and 4). Based on these data, it is likely that bioremediation would be effective in the Deep Zone with injections of bioremediation substrates to stimulate the anaerobic biodegradation process and create suitable conditions. The silty soil and low-permeability conditions of the Shallow Zone are not suited for injection.

EOS consists predominantly of emulsified food-grade soybean oil, with lesser amounts of sodium lactate, food additives, emulsifiers, and preservatives. EOS provides food for the microorganisms and stimulates biodegradation activity through enhanced anaerobic bioremediation. EOS is shipped in liquid form, diluted with water, mixed with a vitamin supplement, and injected into the subsurface.

Regenesis, a remediation technology vendor, recommended 3-D Microemulsion (3-DME) for in-situ enhanced bioremediation treatment of Deep Zone groundwater at the Site. 3-DME is a slightly viscous sticky liquid composed of lactic acid and fatty acids connected to a carbon backbone molecule of glycerin. Naturally occurring microorganisms create hydrogen and reducing conditions in the aquifer when they metabolize the lactic and fatty acids, and facilitate the reductive dechlorination of PCE. The combination of lactic acid and fatty acids provides a 3- to 5-year longevity and helps maintain an anaerobic system beneficial to the bacteria responsible for reductive dechlorination.

7.1.3 In-Situ Thermal Treatment

In-situ thermal treatment applies heat to the contaminated subsurface to destroy or volatilize contaminants. As the contaminant changes into a gas phase, its mobility increases, and the gas can be extracted through collection wells. The gas may undergo aboveground treatment if necessary prior to discharge to the atmosphere. Thermal treatment methods considered applicable for the Site include electrical resistive heating and thermal conductive heating.

Electrical resistive heating treatment heats the soil and groundwater by passing electrical current between electrodes installed beneath the floor slab, and heats the subsurface to approximately 100 degrees Celsius to boil groundwater and generate steam. The hot groundwater/steam flushes contaminants from the soil, where they are collected for aboveground treatment by subsurface vent pipes installed as part of a vapor extraction system. Heating tends to create cracks in the soil, facilitating vapor collection and recovery. As part of the remedial technology screening process, Farallon solicited a proposal from Thermal Remediation Services Inc. for this in-situ thermal treatment technology.

Electro-Thermal Dynamic Stripping Process is an enhancement to electrical resistive heating that uses water injected at the electrodes. Each electrode is connected to a flow line that allows for water injection. Water enhances conductivity and generates steam for stripping, and is especially beneficial once natural moisture in soil is diminished with heating. Injecting water also aids in controlling groundwater flow. Farallon solicited a proposal from McMillan-McGee Corporation, a thermal treatment contractor based in Calgary, Alberta (McMillan-McGee) for application of this technology at the Site.

Thermal conductive heating, also referred to as in-situ thermal desorption, uses electricity to heat soil by radiation, and conductive heat transfer to enhance the permeability of the soil, allowing for easier flow and removal of vapors and soluble-phase liquids. Heater elements typically ranging between 900 and 1,500 degrees Fahrenheit are placed inside vertical stainless steel pipes spaced to achieve uniform heating and suitable treatment time. Although radiant heat dominates near the elements, conductive heat accounts for the majority of the heat transfer throughout the soil. Heated vapor extraction wells are used to recover contaminant vapors, and groundwater recovery wells are used to capture soluble-phase liquids generated by the heating process. Steam, vapor, and soluble-phase liquid in groundwater generated by the heating process are drawn toward the extraction wells countercurrent to the heat flow for aboveground treatment.

7.1.4 Natural Attenuation

Natural attenuation relies on natural processes to clean up or attenuate contaminated soil and/or groundwater. While natural attenuation occurs at most contaminated sites, there are optimal subsurface conditions that must exist to properly remediate the Site. Attenuation of COCs likely will be slow or incomplete if the proper subsurface conditions do not exist. Monitored natural attenuation is the process of monitoring these conditions to ensure that natural attenuation is occurring. Results of groundwater sampling indicate that anaerobic degradation of PCE is occurring naturally in the Shallow Zone with detection of PCE degradation products (Tables 3 and 4). Monitored natural attenuation is considered a potentially applicable component for cleanup of Shallow and Deep Zone groundwater at the Site.

7.1.5 Source Containment

Source containment options considered most suited to Site conditions include horizontal barriers for containment and mitigation of contaminant migration potential exposure pathways. Physical barriers such as pavement covers or caps over contaminated areas are considered effective for limiting exposure to Site soil contamination, limiting migration of soil vapor, and reducing rainwater infiltration that could mobilize soil contamination from Shallow Zone soil to groundwater.

7.1.6 Institutional and Engineering Controls

As part of institutional and engineering controls, a sub-slab depressurization system could be installed to mitigate potential vapor intrusion to indoor air in existing buildings. A sub-slab depressurization system creates a pressure differential across the building floor slab or crawl space that promotes preferential movement of indoor air down into the subsurface. This is accomplished by extracting a low volume of soil vapor from beneath the slab or crawl space and venting it to the atmosphere at a height above the outdoor breathing zone and away from windows and air supply intakes. Treatment of vapors prior to discharge to the atmosphere may be required.

7.2 TREATABILITY STUDIES

The potential application of chemical oxidation technology and natural attenuation were evaluated in supplementary treatability studies that are described below. Chemical oxidation was evaluated for use in the Deep Zone using both bench- and pilot-scale testing. Natural attenuation was evaluated using computer modeling with data collected from the Site. Treatability studies were warranted at the Site because Site conditions pose several key challenges to cleanup, including:

- The presence of a source area beneath the Dry Cleaner Building with high concentrations of PCE in Shallow Zone. No DNAPL has been encountered, although its presence is probable in isolated pockets.
- The presence of predominantly silty soil in the Shallow Zone combined with the shallow depth of groundwater, which precludes the use of typical in-situ remedies such as soil vapor extraction, air sparging, and chemical oxidation.
- The presence of a dissolved-PCE groundwater plume exceeding the MTCA Method A cleanup level of 5 µg/l, extending to an estimated depth of approximately 50 feet bgs.
- The presence of numerous subsurface utilities, a traffic arterial and other streets, an alley, and adjacent off-Site buildings in a mixed commercial/residential urban area that poses access limitations and remedial design considerations.
- Possible coordination of cleanup with property redevelopment.

Treatability studies were conducted to evaluate performance, determine process sizing, and estimate costs in sufficient detail to evaluate and screen specific remediation technologies applicable to Site conditions. Treatability studies were conducted at a bench-scale level and a full pilot-scale level depending on the specific technology evaluated. Before the proposed chemical oxidant injection test described below was conducted, the results of the RI field program were evaluated to refine the treatability testing protocol to be implemented.

Injection of chemical oxidants or substances to accelerate biodegradation as a source control measure in the Deep Zone beneath the dry cleaning equipment source area at the Site is considered to be the most practical and cost-effective technically feasible alternative for existing Site conditions and operations. Both bench- and field-scale pilot testing were conducted to evaluate the efficacy of chemical oxidation, and included physical parameters testing and an oxidant injection test. The bench- and field-scale pilot testing was used to:

- Assess the potential dosage of potassium permanganate required to oxidize COCs to a nonhazardous state (chloride, carbon dioxide, water). Potassium permanganate was selected for the initial pilot test because it is likely to be the most technically viable and cost-effective oxidant based on available Site data and the technology screening. Bench-scale tests for hydrogen peroxide-activated persulfate also were conducted to assess potential dosage as an alternate chemical oxidant.
- Assess the time required for the oxidation reaction to go to completion (i.e., to expend all oxidant).
- Assess the potential for formation of undesirable by-products.
- Develop a preliminary design for full-scale implementation of the technology.

In addition to the oxidant injection test, groundwater modeling was performed to assess aquifer characteristics and contaminant fate and transport. The following sections provide a summary of the scope of work for the chemical oxidant injection testing and groundwater modeling completed for the FS.

7.2.1 Chemical Oxidation Bench-Scale Test

Hydrogen peroxide-activated persulfate and potassium permanganate were selected as the two oxidants to complete a soil oxidant demand (SOD) test. Saturated soil samples were collected from the Deep Zone at the boring for monitoring well MW-11. Well MW-11 was selected because it is in an up-gradient area outside the Deep Zone PCE plume, but is considered representative of the soil types in the Deep Zone beneath the source area. Permanganate is considered a better oxidant relative to hydrogen peroxide-activated persulfate for chlorinated ethenes.

In a typical SOD test, batches of soil from the site and the chemical oxidant are combined, and the oxidant concentration is measured. The amount of chemical oxidant used is reported as SOD. However, the method for measuring persulfate concentrations is not accurate in the presence of hydrogen peroxide due to interference from hydrogen peroxide used in the activation process. Therefore, a different method was required to complete a SOD test on hydrogen peroxide-activated sodium persulfate. Farallon contracted OnSite Environmental Inc., a Washington State-accredited laboratory, to conduct SOD tests on soil for both potassium permanganate and hydrogen peroxide-activated sodium persulfate. Working with OnSite Environmental Inc., Farallon developed a SOD test for hydrogen peroxide-activated persulfate by analyzing the TOC content of a soil sample before and after treatment. The rationale for this methodology is that the reduction in TOC content after treatment would approximate the SOD for hydrogen peroxide-activated sodium persulfate. To validate this method, the permanganate SOD was determined using both standard and modified testing methods.

OnSite Environmental Inc. completed three SOD tests. The laboratory analytical report for the pre-treatment soil, permanganate-treated soil, and hydrogen peroxide-activated sodium persulfate-treated soil TOC analyses is provided in Appendix G. The standard SOD test for permanganate indicated a 490 mg/kg demand, while the TOC version of the SOD test indicated a 300 mg/kg demand. The hydrogen peroxide-activated persulfate test indicated a 90 mg/kg SOD. The SOD test results indicated the SOD was sufficiently low to proceed to pilot testing.

Because permanganate does not require an activator, it is an easier injection application to implement in the field than hydrogen peroxide-activated sodium persulfate. In addition, permanganate has a half-life in the subsurface environment that is on the order of months, while the activated persulfate half-life is on the order of weeks. The longer half-life allows the permanganate to travel farther along the groundwater flow path, which will in turn require fewer injection wells. Although the material costs for permanganate are higher than those for activated persulfate, permanganate is the preferred chemical oxidant due to its longer half-life in the subsurface environment and the lower capital costs associated with fewer required injection wells. The Ecology UIC Program has facilitated permitting for materials injected into the subsurface for remediation purposes, including potassium permanganate. Injection of potassium permanganate could cause exceedance of the secondary Maximum Contaminant Level for manganese in groundwater. Based on the UIC rule, results from the SOD testing, theoretical full-scale cost estimates, and ease of implementation, potassium permanganate was selected to complete an in-situ chemical oxidation pilot test at the Site.

7.2.2 Chemical Oxidation Pilot Test

The chemical oxidation pilot test was conducted on March 8, 2007 using Deep Zone monitoring wells MW-7 and MW-14 for injection (Figures 8 and 11). The results from the aquifer pump test, two-dimensional modeling, and bench-scale testing were used to calculate oxidant injection concentrations and develop a schedule for monitoring during the chemical oxidation pilot test. A single-batch injection of approximately 150 gallons of 2.5 percent potassium permanganate solution was used for the chemical oxidation pilot test. Approximately 60 gallons of the solution was injected into monitoring well MW-7, and 90 gallons was injected into monitoring well MW-14 over an 8-hour period. A copy of the UIC registration authorizing the injection of permanganate for the chemical oxidant pilot test is included in Appendix G.

Following injection, visual monitoring in both the injection wells and selected down-gradient monitoring wells was conducted to evaluate travel times, effectiveness, and potential preferential migration pathways. Groundwater samples were periodically collected over a period of 43 days from Shallow Zone monitoring well MW-4 and Deep Zone monitoring wells MW-7, MW-9, MW-10, MW-12, MW-13, and MW-14 using a disposable polyethylene bailer (Figures 7 and 8). The groundwater samples were observed for the characteristic purple color of the potassium permanganate solution. With the exception of wells MW-7 and MW-14 used for injection, no purple coloring was observed during the monitoring period. After 1 month, groundwater in monitoring well MW-14 was no longer purple, although groundwater in monitoring well MW-7 remained purple after 43 days.

At the end of the 43-day monitoring period on April 20, 2007, groundwater samples were collected from the injection and monitoring wells and submitted for laboratory analysis for

HVOCs and other parameters to assess the effectiveness of the oxidant. Two additional groundwater monitoring events were conducted at the Site in November 2008 and May 2010. A summary of the results of the groundwater monitoring and assessment of the oxidant effectiveness is provided below.

- PCE concentrations in groundwater samples collected from monitoring well MW-7 decreased from a high of 7,000 µg/l prior to injection to 2.5 µg/l 43 days after the permanganate treatment (Table 4). TCE concentrations were reduced from 16 µg/l to non-detect at the laboratory PQL during that period of time. PCE was the only HVOC detected in the groundwater sample collected from monitoring well MW-7 43 days after the pilot test. PCE was detected at concentrations of 18 and 12 µg/l in groundwater samples collected from monitoring well MW-7 in November 2008 and May 2010, respectively. TCE was detected at concentrations of 0.69 and 0.49 µg/l in November 2008 and May 2010, respectively. No other HVOCs were detected in monitoring well MW-7 in May 2010.

- PCE concentrations in groundwater samples collected from monitoring well MW-14 decreased from 0.99 µg/l prior to injection to non-detect at the laboratory PQL after the permanganate treatment (Table 4). Two monitoring events have occurred since the 43-day monitoring period. HVOCs were not detected at concentrations at or above the laboratory PQLs in groundwater samples collected at monitoring well MW-14 for the most-recent sampling event in May 2010.

- Groundwater samples collected from down-gradient Deep Zone monitoring wells MW-9, MW-10, MW-12, and MW-13 did not show any appreciable changes in PCE concentration during the 43-day monitoring period following the pilot-test injection (Table 4). Based on the monitoring observations, groundwater analytical results, SOD testing, and the estimated groundwater seepage velocity in the Deep Zone of approximately 0.26 foot per day, it appears that the permanganate had not migrated to the down-gradient monitoring wells as of the May 2010 monitoring event.

The overall results of the pilot test indicate that permanganate is an effective oxidant for reducing the high concentrations of PCE in Deep Zone groundwater that have been identified at monitoring wells MW-7 and MW-14.

7.2.3 Two-Dimensional Modeling

Groundwater modeling was conducted using a two-dimensional computer model to screen select remediation technologies for cleanup at the Site. The computer model BIOCHLOR is an EPA-approved two-dimensional model used for screening purposes. The groundwater modeling was used to simulate the fate and transport of PCE and its degradation compounds from the dry cleaning equipment source area in both the Shallow and Deep Zones over time. The purpose of this modeling was to estimate the length and concentration of the plume emanating from the Site, assuming both a continuous (DNAPL) source pre-remediation and decaying (dissolved-phase PCE) post-remediation source concentrations. The results of this modeling effort were used also to further refine the conceptual Site model, to support the evaluation of potentially feasible remediation technologies for the Site, and to estimate the restoration time frame down-gradient following source remediation.

BIOCHLOR is a relatively simplistic model that assumes that conditions within the aquifer are homogeneous. The groundwater modeling for pre-remediation scenarios was performed assuming a non-decaying (continuous) DNAPL source in the Shallow Zone at the dry cleaning equipment source area, and a non-decaying, dissolved-phase PCE source in the Deep Zone beneath the dry cleaning equipment source area. A decaying source term was used for post-remediation scenarios because the majority of PCE source mass will be removed. The model inputs such as retardation and longitudinal dispersivity were set for the Shallow and Deep Zones to allow a stable solution with simulated concentrations that would correspond with the current PCE concentrations detected in groundwater using an arbitrary 30- to 40-year time frame for a simulated release. The time actual hazardous substance releases occurred at the Site is unknown, but presumably was after 1958, when dry cleaning operations using PCE began at the Site, and before dry cleaning operations terminated in 1977. The BIOCHLOR input parameters and output results for the Shallow and Deep Zone modeling are included in Appendix F.

7.2.3.1 Pre-Remediation Modeling

Simulation 1—Shallow Zone, Pre-Remediation*:* A non-decaying source concentration of 160,000 µg/l was used to model the Shallow Zone (Appendix F). This concentration of PCE is the highest detected in the reconnaissance groundwater sample collected from boring SB-1 at the dry cleaning equipment source area. This concentration approximates the solubility of PCE in groundwater, which indicates that DNAPL is present. To be conservative, no biotransformation of PCE was simulated. The following modeling inputs were used to simulate the fate and transport of PCE from the dry cleaning equipment source area in Shallow Zone groundwater:

- A value for hydraulic conductivity of 0.038 foot per day ($1.3x10^{-5}$ centimeters per second), which is the geometric mean hydraulic conductivity estimated from the slug tests performed in Shallow Zone wells MW-4, MW-5, and MW-15.
- A modeled PCE plume length of 200 feet.
- A hydraulic gradient of 0.01 based on observed water levels in the Shallow Zone.
- Effective porosity of 0.25 (typical value for unconsolidated sediments).
- A retardation factor of 7.13 for the Shallow Zone. This retardation factor is the default retardation value for PCE specified in BIOCHLOR.
- No biotransformation was assumed to occur during the simulations to provide a conservative estimate of PCE migration.
- A calibration point of 5 µg/l at 65 feet, which is the approximate distance from boring SB-1 to down-gradient monitoring well MW-15.

The modeling results simulate a PCE concentration of 5 µg/l at approximately 70 feet down-gradient of the source after 40 years in the Shallow Zone. This corresponds with the estimated down-gradient extent of the dissolved-PCE plume in Shallow Zone groundwater (Figure 7).

Simulation 2—Deep Zone, Pre-Remediation*:* A non-decaying source concentration of 3,765 µg/l was used as the initial concentration for the Deep Zone (Appendix F).

This is the average concentration of PCE detected in Deep Zone groundwater (prior to the chemical oxidant pilot test conducted in 2007) in monitoring well MW-7, located immediately down-gradient of the dry cleaning equipment source area. The following modeling inputs were used to simulate the fate and transport of PCE from the dry cleaning equipment source area in Deep Zone groundwater:

- A value for hydraulic conductivity of 0.81 foot per day ($2.9x10^{-4}$ centimeters per second), which was obtained during model calibration to observed PCE concentrations down-gradient of the source area. Although this value is lower than the average hydraulic conductivity estimated from the aquifer pump test performed in Deep Zone monitoring well MW-11, it is not unreasonable given the observed aquifer heterogeneity.
- A modeled PCE plume length of 200 feet.
- A hydraulic gradient of 0.003 based on observed water levels in the Deep Zone.
- Effective porosity of 0.25 (typical value for unconsolidated sediments).
- A retardation factor of 1.5, which is lower than the default retardation value for PCE specified in BIOCHLOR. The lower retardation value was selected to provide a conservative estimate of PCE migration and attenuation in the Deep Zone.
- No biotransformation was assumed to occur during the simulations to provide a conservative estimate of PCE migration.
- A calibration point of 5 µg/l at 85 feet, which is the approximate distance from boring SB-1 to the estimated down-gradient extent of the 5 µg/l PCE isoconcentration contour shown on Figure 8.

Using the inputs listed above, the modeling results show a PCE concentration of 5 µg/l at 85 feet after 10 years in the Deep Zone. This corresponds with the current estimated down-gradient extent of the dissolved-PCE plume in Deep Zone groundwater (Figure 8) assuming that PCE released at the dry cleaning equipment source area took 20 to 40 years to migrate vertically downward through the silt and silty sand of the Shallow Zone.

7.2.3.2 Post-Remediation Modeling

Additional modeling was conducted to estimate restoration time frames with the reduction of PCE mass in the Shallow and Deep Zones following implementation of the preferred remedial alternative, including thermal treatment and chemical oxidation to the specified remediation levels for groundwater, discussed in Section 6.5.2. The BIOCHLOR modeling inputs for the post-remediation scenarios described below are included in Appendix F.

Simulation 3—Shallow Zone, Post-Remediation*:* A decaying source concentration of 163 µg/l was used to model the Shallow Zone on the Dry Cleaner Building Property (Appendix F). This concentration of PCE is the highest detected in a reconnaissance sample collected from Shallow Zone boring GP-6 approximately 20 feet south and up-gradient of the proposed thermal treatment area for the dry cleaning equipment source. The following modeling inputs were used to simulate the fate and transport of PCE in Shallow Zone groundwater from boring GP-6 to the Dry Cleaner Building Property boundary following completion of thermal treatment:

- A value for hydraulic conductivity of 0.038 foot per day (1.3×10^{-5} centimeters per second), which is the geometric mean hydraulic conductivity estimated from the slug tests performed in Shallow Zone wells MW-4, MW-5, and MW-15.
- A hydraulic gradient of 0.01 based on observed water levels in the shallow zone.
- Effective porosity of 0.25 (typical value for unconsolidated sediments).
- A modeled plume length of 75 feet, which is the distance from boring GP-6 to the down-gradient property boundary.
- A retardation factor of 7.13 for the Shallow Zone. This is the default retardation value for PCE specified in BIOCHLOR.

- o No biotransformation was assumed to occur during the simulations to provide a conservative estimate of PCE migration.

- o Longitudinal dispersivity of 8 feet, which is approximately 10 per cent of the modeled plume length of 75 feet. Transverse dispersivity of 0.7 foot (10 per cent of longitudinal). Vertical dispersivity is assumed to be negligible.

The modeling results simulate a post-remediation reduction in PCE concentration in Shallow Zone groundwater from 163 µg/l at boring GP-6 to 5 µg/l at approximately 10 feet down-gradient of GP-6 about 10 years after thermal treatment in the Shallow Zone is completed. This result means the groundwater cleanup level is predicted to be attained at the proposed conditional point of compliance on the down-gradient Dry Cleaner Building Property boundary, approximately 75 feet down-gradient of boring GP-6, within 10 years after thermal treatment.

Simulation 4—Deep Zone, Post-Remediation*:* A decaying source concentration of 20 µg/l was used to model the Deep Zone (Appendix F). This is the remediation level assumed for Deep Zone groundwater following completion of chemical-oxidant injection at the dry cleaning equipment source area and down-gradient plume in the right-of-way. The following modeling inputs were used to simulate the fate and transport of PCE from the dry cleaning equipment source area in Deep Zone groundwater:

- o A value for hydraulic conductivity of 0.81 foot per day ($2.9x10^{-4}$ centimeters per second), which was obtained during model calibration to observed PCE concentrations down-gradient of the source area. Although this value is lower than the average hydraulic conductivity estimated from the aquifer pump test performed in Deep Zone monitoring well MW-11, it is not unreasonable given the observed aquifer heterogeneity.

- o A modeled PCE plume length of 200 feet.

- o A hydraulic gradient of 0.003 based on observed water levels in the Deep Zone.

- Effective porosity of 0.25 (typical value for unconsolidated sediments).
- No biotransformation was assumed to occur during the simulations to provide a conservative estimate of PCE migration.
- Longitudinal dispersivity of 11 feet, which was selected using the modified Xu and Eckstein method provided in BIOCHLOR based on a plume length of 200 feet. Transverse dispersivity of 1.1 feet (10 per cent of longitudinal). Vertical dispersivity is assumed to be negligible.
- A retardation factor of 1.5, which is lower than the default retardation value for PCE specified in BIOCHLOR. The lower retardation value was selected to provide a conservative estimate of PCE migration and attenuation in the Deep Zone.

Modeling results predict a reduction in PCE concentration from the 20 µg/l remediation level to below the MTCA Method A groundwater cleanup level of 5 µg/l across the entire Deep Zone groundwater plume after approximately 35 years. The modeling result is the basis for assuming that implementation of chemical oxidant injection followed by monitored natural attenuation will result in attainment of the groundwater cleanup level for Deep Zone groundwater at the Site within 35 years.

Simulation 5—Shallow Zone, Right-of-Way Area, Post-Remediation*:* Modeling was conducted also to simulate the expected reduction in PCE concentrations in Shallow Zone groundwater in the right-of-way down-gradient of the dry cleaning equipment source area following completion of the proposed thermal treatment (Appendix F). Modeling was performed using most of the same hydrogeologic inputs as those for Simulation 1, but with a decaying source concentration of 4,100 µg/l, which corresponds to the PCE concentration detected in the most-recent groundwater sample collected from monitoring well MW-6, located down-gradient of the thermal treatment area. A lower transverse dispersivity value (2.5 feet) was used to account for the decreased simulated plume length (calculated using the modified Xu and Eckstein method provided in BIOCHLOR based on a plume length of 30 feet). Also, the model was run twice, once assuming no biotransformation of PCE, and again with conservative assumptions of biotransformation occurring.

Conservative simulations using a reasonable source decay rate indicate that PCE will never exceed the 5 µg/l MTCA Method A groundwater cleanup level 30 feet down-gradient at Shallow Zone monitoring well MW-21. This holds for simulations assuming no biotransformation and for simulations assuming biotransformation using the minimum rate constants for PCE and daughter products provided in BIOCHLOR. Assuming that biotransformation is occurring, the simulated PCE source concentration across the whole PCE plume in the right-of-way down-gradient of the source control area decreases from 4,100 µg/l at monitoring well MW-6 to 5 µg/l across the whole Shallow Zone plume within about 25 years. Approximately 5 or more additional years may be required to achieve preliminary cleanup levels for TCE and vinyl chloride. Natural attenuation progress will be evaluated with a long-term groundwater monitoring program. PCE and related daughter products have not been detected in Shallow Zone groundwater on the down-gradient edge of the right-of-way, and 100-year simulations indicate that PCE and related daughter products will never reach this area.

Based on the modeling data and the moderate anaerobic degradation of PCE occurring in the Shallow Zone at the Site demonstrated by the occurrence of PCE degradation products, it is reasonable to assume that following completion of active remediation, the MTCA Method A cleanup level for PCE will be attained for Shallow Zone groundwater at the Site within a reasonable restoration time frame of 25 to 45 years through natural attenuation processes.

7.2.4 Bench-Scale Resistivity Testing

In February 2011, seven soil samples collected from the Shallow Zone were provided to McMillan-McGee for bench-scale electrical resistivity testing. Methods and results are provided in the McMillan-McGee (2011a) profile, which is included in Appendix H.

The soil samples were provided to McMillan-McGee in continuous core tubes collected proximate to the dry cleaning equipment source area. The objective of the testing was to measure static (ambient temperature) and dynamic (as sample is heated to treatment temperature) resistivity of Shallow Zone soil to determine whether contaminated Shallow Zone soil is suitable for application of the thermal treatment technology proposed by McMillan-McGee known as Electro-Thermal Dynamic Stripping Process (ET-DSP). Electrical resistivity testing is important to thermal treatment design and is the basis for specifying general power and power control requirements for the treatment, including voltage and current operating conditions, operating strategy, and other field-scale considerations.

Soil samples tested by McMillan-McGee for static electrical resistivity were collected from borings SB-26 through SB-28, SB-35, and SB-36, and for dynamic electrical resistivity from borings SB-26 and SB-36. Results from the bench-scale resistivity testing are described below.

Soil electrical resistivity at ambient temperature ranged from 53.7 to 87.6 ohm-meters, with an average of about 68 ohm-meters. These results indicate low electrical resistance, and are within the ideal range for application of ET-DSP.

It is common for electrical resistivity to drop as the soil mass is heated by a factor of about 3. Bench-scale testing entailed heating the soil sample from 9.4 degrees Celsius (ambient temperature) to 93.3 degrees Celsius. Results of dynamic electrical resistivity testing simulating electrical resistivity that would occur as the soil is heated to treatment temperatures during thermal treatment indicate that electrical resistivity will drop to 19.7 ohm-meters, a factor of about 3.14, during heating to treatment temperature.

Results of bench-scale electrical resistivity testing indicate that with appropriate moisture control, Shallow Zone soil will be fully treatable using ET-DSP thermal treatment technology. Design of the thermal treatment system will consist of a custom electrode layout for electrical heating combined with a multi-phase extraction strategy. The electrodes will be evenly spaced with extraction wells situated within the electrode array to achieve high extraction rates. A water circulation system capable of injection at each electrode to maintain soil moisture at the appropriate level is required to maintain electrical resistivity within the effective range for application of ET-DSP.

7.2.5 Thermal Treatment Numerical Modeling and Conceptual Design

Using the results from electrical resistivity testing and results from the subsurface investigation at the Site provided by Farallon, a numerical computer model was developed to simulate thermal treatment at the Site and to develop a conceptual design that will achieve cleanup goals. Results of electrical resistivity testing are summarized in the preceding section and are presented in the McMillan-McGee (2011a) simulation study, which is included in Appendix H, Remedial Alternative Conceptual Design Details. Numerical computer simulation of the thermal treatment is presented in the McMillan-McGee (2011b) study, which is included in Appendix H. McMillan-McGee (2011b) assumes thermal treatment from 5 to 20 feet bgs. This concept was subsequently updated to include an area from 0 to 20 feet bgs to be treated using double electrodes. The updated layout is presented in the McMillan-McGee (2012) cost estimate, and is shown on Figure H-1 (Appendix H).

The objective of the numerical simulation was to develop a subsurface model of the Site using ET-DSP technology in conjunction with a multi-phase extraction system. ET-DSP technology supplements and expedites thermal resistivity heating with convective heat transfer and stripping of contaminants with volatilized water vapor (steam) using secondary permeability created when steam temperatures are achieved. The model was used to develop a conceptual design and operating strategy for the thermal treatment system.

The thermal treatment area consists of approximately 5,600 square feet, with treatment to a depth of 20 feet bgs, which comprises a treatment volume of approximately 3,700 cubic yards of soil. The conceptual design assumes that a mass of about 520 pounds of PCE will be extracted, and that the Dry Cleaner Building will be demolished, leaving the concrete floor slab as a working surface, which will act as an insulating layer to help retain heat in the subsurface during thermal treatment and facilitate the capture of volatilized vapor. Thermal treatment will enhance the permeability of the silty soil, and facilitate the capture of volatilized PCE from the heated zones. The vapor extraction conceptual design optimizes rapid removal of chemicals from the soil and eliminates the potential for migration of volatilized chemicals from the treatment area. Aggressive extraction is designed at the northwest corner of the treatment area, the dry cleaning equipment source area, where PCE concentrations are highest.

The conceptual design consists of the use of a network of electrodes, extraction wells, and sensor wells shown in plan view on Figure H-1 in Appendix H, with details shown on Figure H-2. A conceptual process flow diagram for the thermal treatment system is shown on Figure H-3. The conceptual design consists of the following primary elements:

- Twenty-one double electrode installations for heating from the ground surface to 20 feet bgs. Eight-inch-diameter electrodes will be installed in 10-inch-diameter borings advanced to 21 feet bgs using sonic drilling techniques. Borings will be backfilled with granular graphite mixed with sand. The electrode borings will have surface seals of bentonite and grout up to the concrete slab. The electrode system will be used to uniformly heat the soil mass to an operating temperature of 95 degrees Celsius over a heat-up period of 60 to 75 days, and to maintain this temperature over a treatment period of about 180 days to achieve remediation levels. The electrode installations include water injection and return lines to maintain soil moisture so dynamic electrical resistivity is maintained in the optimal range. It is assumed that this outcome can be achieved without injecting electrolytes.
- Ten single electrode installations for heating from 5 to 20 feet bgs. The single electrode installations will be similar to those for double electrodes.
- Twenty-five multi-phase extraction wells will be used to extract water and volatilized PCE vapors from the subsurface. Permeability of the silty soil will be enhanced as the subsurface is heated to boiling temperatures and steam is generated. Eight-inch-diameter borings will be advanced to 21 feet bgs for installation of 4-inch-diameter stainless steel extraction wells screened from 5 to 20 feet bgs using 0.010-inch slotted screen. The extraction well borings will have surface seals of bentonite and grout up to the concrete slab.

- Six sensor wells fitted with thermal sensors will be constructed in 6-inch-diameter boreholes and in 2-inch-diameter fiberglass well casing. The sensor well borings will have surface seals of bentonite and grout up to the concrete slab.
- Five new Shallow Zone monitoring wells will be installed for compliance groundwater monitoring within the thermal treatment area during thermal treatment. Thermal treatment will necessitate decommissioning of the existing polyvinyl chloride monitoring wells within or proximate to the thermal treatment area, including monitoring wells MW-3 through MW-5, MW-7, and MW-8. Monitoring well MW-20 was decommissioned during implementation of the interim action at the Hearthstone Property. The five new monitoring wells will be constructed using 2-inch-diameter stainless steel casing and screens to withstand high-temperature conditions and will be sealed with bentonite and grout up to the concrete slab. Compliance monitoring will include collecting soil samples from up to 30 locations and up to three monitoring events using push-probe soil sampling methodology.
- Extraction and treatment equipment consists of blowers and granular activated carbon treatment units with liquid discharge to the sanitary sewer and vapor discharge to the atmosphere after receipt of required permits.
- The extraction wells will be tied into a treatment system that can treat liquids at a rate of up to 5 gallons per minute, and vapors up to 150 standard cubic feet per minute (scfm) extracted from the subsurface.

  Recovered liquids will first be treated through a three-phase coalescing separator. The separator is designed to separate light and heavy fractions of contamination from water at elevated temperatures, polishing the liquid waste stream before discharge.

  The numerical modeling and conceptual design estimated the vapor extraction rate per well for achieving mass recovery to be 6.7 scfm, with a total vapor flow of about 107 scfm. The estimated maximum vacuum needed to achieve the vapor flow rates is about 8 inches of mercury.

- The power distribution system will provide assumed peak input power of 15.88 kilowatts to each electrode, and average electrode power of 10.24 kilowatts for the duration of the project. Power will be provided from a power drop from a utility pole to the power distribution system consisting of two 10-kilowatt units to provide three-phase power to each electrode. The total input energy assumed to be needed for 180 days of operation is about 1,510 megawatt hours.

The thermal treatment system conceptual design includes provisions for continuous remote data monitoring of the temperature and depth of the treatment area, which will allow operators to respond in real time to subsurface conditions as they are revealed. The data will be available in real time on a dedicated project webpage. These data will be used to ensure that target temperatures are achieved and maintained in the soil, and that heat transfer to the ground surface is safely controlled. Power distribution system units will provide power to the electrodes and will be capable of independent power control to each electrode, and monitoring of the current, voltage, and power via the Internet. Electrical conductivity of the soil and heat transfer by convection will be maintained at all electrodes using the water control system. Water injection to each electrode will average about 0.075 gallon per minute during heating. The extraction rate will be adjusted to maintain hydraulic control, which typically will be 1.02 times the injection rate. As the average temperature increases, the electrical resistance of the soil decreases, and consequently the energy input rate decreases. When the average input power does not change significantly, it is an indication that the maximum temperature of the soil has been reached, after which electrical resistivity will continue to decrease, and therefore input power will be reduced.

7.3 ALTERNATIVE DEVELOPMENT AND DESCRIPTION

The cleanup technologies derived from the technology screening (Table 9) that are deemed most feasible for Site conditions were used to develop a suite of Site-wide cleanup alternatives intended to achieve the RAOs for the affected media of concern in the Shallow and Deep Zones at the Site. Based on Site-specific conditions, the most-practicable cleanup approach for the Site will involve a source reduction and/or removal action in the Shallow Zone focused on the dry cleaning equipment source area, where greater than 90 percent of the PCE mass at the Site is contained in soil; in-situ treatment in the Deep Zone; and long-term monitoring to confirm that natural attenuation of residual COCs is occurring in soil and groundwater. Institutional controls will be required where COCs remain in media at concentrations greater than applicable remediation and/or cleanup levels following completion of active remediation.

A total of six cleanup alternatives were developed as part of the FS for portions of the Site, which include the Dry Cleaner Building Property and areas down-gradient of both the Dry Cleaner Building Property and the Hearthstone Property. Cleanup Alternative 1 would be implemented if no development of the Dry Cleaner Building Property was to occur and the Dry Cleaner Building were to remain as an operational facility. Alternatives 2 through 6 may be implemented in conjunction with or independently of development of the Dry Cleaner Building Property. To date there is no plan to develop the Dry Cleaner Building Property.

The FS considered the following six cleanup alternatives for the Dry Cleaner Building Property and the down-gradient areas in the Woodlawn Avenue Northeast and 4th Avenue Northeast rights-of-way affected by releases of COCs at the Site:

- Cleanup Alternative 1: Institutional and Engineering Controls, Monitored Natural Attenuation.
- Cleanup Alternative 2: Shallow-Zone In-Situ Thermal Treatment, Excavation of Shallow-Zone Soil, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls.
- Cleanup Alternative 3: Shallow-Zone In-Situ Thermal Treatment, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls.
- Cleanup Alternative 4: In-Situ Thermal Treatment Shallow Zone and Deep Zone, Excavation of Shallow-Zone Soil, Monitored Natural Attenuation, Institutional Controls.
- Cleanup Alternative 5: Excavation of Shallow-Zone Soil, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls.
- Cleanup Alternative 6: Excavation of Shallow- and Deep-Zone Soil (baseline).

Alternatives 1 and 6 represent the least and most permanent solutions, respectively. WAC 173-340-350(8)(c)(ii) requires that the FS include at least one permanent cleanup action alternative to serve as a baseline against which other alternatives are evaluated for the purpose of determining whether the cleanup action selected is permanent to the maximum extent practicable. In accordance with WAC 173-340-200, a permanent solution is one for which cleanup standards can be met without further action being required at the Site other than approved disposal of any residue from the treatment of hazardous substances. Alternative 6 includes excavation of Shallow and Deep Zone soil where PCE exceeds the MTCA Method A cleanup level on the Dry Cleaner Building Property and down-gradient in the rights-of-way, and serves as a baseline for this FS. However, Alternative 6 is not considered implementable, as explained below, due to the required closure of Woodlawn Avenue Northeast for at least 2 months for implementation.

Cost estimates are provided for each alternative, developed to an appropriate level for FS evaluation purposes, including alternative comparison and disproportionate cost analysis. More-refined cost estimates will be generated for the selected alternative as part of the design process. While the actual construction activities associated with the cleanup alternatives presented and evaluated in the FS would be the same whether remediation is conducted in conjunction with or independently of a development project at the Dry Cleaner Building Property, it is financially advantageous to conduct Cleanup Alternatives 2, 4, 5, and 6 in conjunction with a development project that includes excavation for underground parking, as cleanup costs would be –shared” with costs for development.

Estimated cleanup costs for each cleanup alternative are presented in the following sections of the FS and in Tables 10, 12, and 13 as if the cleanup action was performed concurrently with development of the Dry Cleaner Building Property (i.e., base costs). The estimated costs for conducting Cleanup Alternatives 1 and 3 would be the same regardless of whether cleanup is conducted in conjunction with development of the Dry Cleaner Building Property or independently. However, Cleanup Alternatives 2, 4, 5, and 6, and the estimated base costs for these cleanup alternatives, assume a concurrent development project at the Dry Cleaner Building Property.

Estimated typical construction costs that would be incurred during earthwork associated with development of an uncontaminated property are shown separately as incremental costs in Tables 10 and 13. For soil removal work under Cleanup Alternatives 2, 4, 5, and 6, the base costs are for managing and disposing of contaminated soil or water. Incremental costs for not conducting remediation in conjunction with development of the Dry Cleaner Building Property include costs for worker safety, shoring, excavation, dewatering, transporting and disposal of excavated materials, and backfilling the excavation that would otherwise be necessary for soil removal and/or development of an uncontaminated property.

For example, the estimated base cost to perform Cleanup Alternative 5 is $2,644,100 (Remediation Project Total Cost in Table 10). The estimated incremental cost provided in Table 10 that would be incurred if remediation is not conducted in conjunction with development of the Dry Cleaner Building Property is about $1,000,000. Therefore, the estimated total cost for implementing Cleanup Alternative 5 independent of a development project is about $3,644,100.

A second incremental cost for purposes of the FS and the disproportionate cost analysis is shown for Cleanup Alternatives 2, 3, 4, and 5 in Tables 10 and 13 for estimated costs associated with applying Shallow Zone active cleanup elements (e.g., thermal treatment, excavation) outside the Dry Cleaner Building Property boundary in the rights-of-way.

The estimated incremental cost provided in Table 10 for applying Shallow Zone active cleanup elements in the rights-of-way for Cleanup Alternative 5 (i.e., excavation) is about $2,000,000. Therefore, the estimated total cost for implementing Cleanup Alternative 5 independent of a development project and including Shallow Zone excavation in the rights-of-way is about $5,644,100.

The base and incremental costs are compared to environmental benefits for purposes of the disproportionate cost analysis in Section 7.4.3.2.

7.3.1 Basic Assumptions and Cleanup Approach

The basic assumptions used to develop the cleanup alternatives and cost estimates for implementation, and to evaluate the cleanup alternatives include the following:

- Cleanup Alternative 1 assumes that no development of the Dry Cleaner Building Property is planned for the foreseeable future. The evaluation assumes that Alternatives 2 through 6 may occur concurrently with or separate from development.

- Although no development currently is planned at the Dry Cleaner Building Property, if remediation associated with Cleanup Alternatives 2 through 6 is conducted in conjunction with a development project, the likely development for the property is a multi-story mixed-use building constructed either slab-on-grade or with underground parking, which is based on the highest and best use of the property determined by comparable properties proximate to the Site. Construction of underground parking will require shoring presumably extending to the property lines of the Dry Cleaner Building Property, excavation and dewatering, and soil disposal off the Site.
- It is assumed that remediation will consist of the following common work elements:
  - Demolition of the Dry Cleaner Building;
  - Removal of the USTs decommissioned in-place north of the Dry Cleaner Building in the Woodlawn Avenue Northeast right-of-way and beneath the floor slab of the Dry Cleaner Building;
  - Implementation of remedial technologies and processes to achieve cleanup requirements as described for the cleanup alternative (e.g., thermal treatment, subsurface injections of chemical oxidants or bioremediation stimulants, excavation of contaminated material);
  - Management of contaminated materials per MTCA and other applicable local, state, and federal regulations, including:
    - Transport and off-Site disposal of contaminated soil;
    - Treatment and disposal of contaminated water from dewatering operations; and
    - Adherence to applicable health and safety measures.
  - Compliance monitoring, including long-term monitoring of groundwater.

Cleanup Alternatives 2 through 6 focus on active remediation of the dry cleaning equipment source area, where greater than 90 percent of the PCE mass is contained in soil. The thermal treatment area is the area where thermal treatment would occur for the alternatives that include thermal treatment technology (Cleanup Alternatives 2, 3, and 4). The thermal treatment area is described in Section 7.3.5.

Farallon (2013b) summarized technical discussions between Ecology and the PLPs on whether active remediation in the down-gradient rights-of-way to achieve a shorter restoration time frame is practicable. Farallon and Ecology agreed that implementation of the preferred cleanup alternative for the Site will include a post-source-control down-gradient Shallow Zone chemical oxidation pilot test followed by confirmational compliance monitoring and a possible contingency action according to a general decision tree provided by Farallon (2013b). Procedures and decision points will be developed in detail in the Engineering Design Report for implementation of the preferred cleanup alternative. Post-source-control application of chemical oxidant to address residual PCE in the Shallow Zone beneath Woodlawn Avenue Northeast is included under Cleanup Alternatives 2, 3, 4, and 5, discussed in the sections that follow.

Other assumptions were made during evaluation of the six cleanup alternatives, which are included in their descriptions below and in Section 7.4, Evaluation of Alternatives. The six cleanup alternatives selected for evaluation for the Site are described in further detail in the following sections.

7.3.2 Cleanup Alternative 1: Institutional and Engineering Controls, Monitored Natural Attenuation

Cleanup Alternative 1 assumes that development at the Dry Cleaner Building Property will not occur in the foreseeable future, and the existing building will remain in place. Cleanup Alternative 1 would include a combination of institutional and engineering controls, monitored natural attenuation, and deferred remediation measures required under an environmental covenant. Alternative 1 assumes that the existing Dry Cleaner Building and the decommissioned USTs will remain in-place. A sub-slab depressurization system would be installed to mitigate potential vapor intrusion into the Dry Cleaner Building.

7.3.2.1 Implementation

Institutional controls would be implemented at the Dry Cleaner Building Property to ensure the long-term maintenance of risk management procedures in accordance with WAC 173-340-440. Institutional controls for the Dry Cleaner Building Property would include:

- Deed restrictions to prohibit domestic use of groundwater at the Dry Cleaner Building Property and in adjacent rights-of-way.
- Provisions for 35 years of compliance monitoring of groundwater.
- Implementation and ongoing maintenance of engineering controls, including but not limited to maintenance of physical barriers and a sub-slab depressurization system to mitigate potential vapor intrusion into the Dry Cleaner Building.
- An Environmental Media Management Plan to govern the handling of potentially contaminated media during future work on the Dry Cleaner Building Property and/or beneath the adjacent rights-of-way of Woodlawn Avenue Northeast and 4th Avenue Northeast.
- An environmental covenant requiring remedial measures when the Dry Cleaner Building Property is developed in the future.

The engineering control that would be implemented under Cleanup Alternative 1 includes a sub-slab depressurization and vapor collection system installed under the existing Dry Cleaner Building. The purpose of the system would be to mitigate the potential for exposure via the vapor intrusion pathway for protection of indoor air quality. A system monitoring program would ensure continued proper operation and maintenance of the sub-slab depressurization system.

Long-term compliance groundwater monitoring for natural attenuation of PCE and other HVOCs in groundwater down-gradient of the Site would be necessary. The available data indicate that moderate degradation of PCE is occurring in the Shallow Zone and that only limited lateral migration at relatively low concentrations has occurred in Deep Zone groundwater. Compliance groundwater monitoring would be conducted at approximately eight groundwater monitoring wells (four Shallow Zone and four Deep Zone wells) proximate to the dry cleaning equipment and the Hearthstone Property source areas at up- and down-gradient locations to satisfy the requirements under MTCA for monitored natural attenuation.

7.3.2.2 Time Frame and Estimated Cost

Institutional and engineering controls would be implemented during Year 1. The long-term compliance groundwater monitoring is assumed to occur on an annual basis for Years 1 through 10, and every 2 years thereafter for Years 11 through 35. A breakdown of estimated costs for the specific components of Cleanup Alternative 1 is provided in Table 10.

Capital Cost:	$224,100[2]
Ongoing Periodic and Future Costs:	$173,000
Total:	$397,100 (estimated range: $357,000 – $437,000)

7.3.3 Cleanup Alternative 2: In-Situ Thermal Treatment Shallow Zone, Excavation of Shallow Zone Soil, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls

Cleanup Alternative 2 includes a combination of in-situ and ex-situ remediation technologies to reduce the highest concentrations of PCE in the dry cleaning equipment source area to attain MTCA Method A soil and groundwater cleanup levels using thermal treatment, followed by removal and disposal off the Site of the treated soil and surrounding untreated Shallow Zone soil within the Dry Cleaner Building Property. Cleanup Alternative 2 also includes compliance groundwater monitoring for natural attenuation in areas down-gradient of the dry cleaning equipment and the Hearthstone Property source areas. Institutional and engineering controls would be implemented to ensure that ongoing protection measures function as intended.

[2] Cleanup Alternative 1 capital costs for active treatment site preparation, construction, and remediation:
Sub-slab depressurization system construction and operations and maintenance: $130,000

7.3.3.1 Implementation

Cleanup Alternative 2 assumes that the existing Dry Cleaner Building would be demolished, leaving only the concrete floor slab, and that the decommissioned USTs would be removed from the Woodlawn Avenue Northeast right-of-way and from beneath the Dry Cleaner Building floor slab after completion of thermal treatment. The concrete floor slab would be retained as a work surface, and as a cover system preventing exposure to contamination and infiltration of rainfall. The floor slab also would facilitate collection of HVOCs volatilized during thermal treatment, and would insulate remediation workers from potential stray electrical current during operation of the thermal treatment system.

The treatment goal for Cleanup Alternative 2 would be to attain the MTCA Method A cleanup level for soil and the MTCA Method A cleanup level for groundwater in the Shallow Zone within the treatment areas, rather than the higher soil and groundwater remediation levels identified in Section 6.5.2, Remediation Levels. Treatment to achieve the lower MTCA Method A cleanup levels for soil and groundwater would require an additional 3 to 4 months of treatment time and theoretically would remove only an additional 5 percent of the estimated residual PCE at the Site (from a 92 to a 97 percent reduction). Thermal treatment also would reduce PCE in the rights-of-way within and proximate to the thermal treatment area.

In contrast to using thermal treatment to attain remediation levels (Cleanup Alternative 3), there is substantial uncertainty whether the thermal treatment can achieve the MTCA Method A cleanup levels for soil and groundwater, even with the increased costs associated with a longer treatment duration. Further, although Alternative 2 would achieve a more-stringent soil cleanup level, achieving cleanup standards throughout the entire rights-of-way still would rely on natural attenuation processes occurring over the long-term. After thermal treatment, soil excavated from the Dry Cleaner Building Property would be suitable for disposal at a Subtitle D permitted facility with a contained-out determination from Ecology.

Once the Dry Cleaner Building has been demolished, a temporary construction wall would be erected around the perimeter of the Dry Cleaner Building Property, including the Woodlawn Avenue Northeast street parking area adjoining the north property boundary. It is assumed that the alley west-adjacent to the Dry Cleaner Building Property would remain open. The in-situ thermal treatment system would comprise an approximately 5,600-square-foot treatment area on the northwest portion of the Dry Cleaner Building proximate to the dry cleaner equipment source area as shown on Figure 14. The thermal treatment area is coincident with the estimated maximum extent of Shallow Zone soil with concentrations of PCE exceeding the 2 mg/kg remediation level (i.e., the source area that contains the majority of PCE mass predominately contributing contamination to groundwater). Concentrations of PCE in soil outside the thermal treatment area, associated with minor sources referenced in Section 3.1.3, currently are below the proposed remediation level.

Reduction and removal of PCE and other HVOCs would be accomplished by thermal treatment of soil and groundwater to depths of approximately 20 feet bgs and using a shallow soil vapor extraction system to recover HVOC vapors generated during thermal treatment. The plan view and process flow diagrams for Shallow Zone thermal treatment using the thermal conductivity technology ET-DSP are shown in Appendix H.

Following completion of the in-situ thermal treatment in the Shallow Zone, confirmation soil and groundwater sampling would be performed to confirm compliance with cleanup standards in the Shallow Zone within the treatment area. The criteria for compliance sampling, including sampling depths and frequency, would be finalized in the Compliance Monitoring Plan. For the purposes of the FS, it is assumed that two performance monitoring events would occur. Soil samples would be collected at up to 10 locations within the thermal treatment area using a direct-push drill rig. Groundwater samples would be collected from up to five stainless steel monitoring wells installed within the thermal treatment area.

A pilot test for chemical oxidation will be performed post-source control in the Shallow Zone immediately down-gradient of the thermal treatment area, possibly in the excavation resulting from the removal of the USTs. Groundwater compliance monitoring following the pilot test will measure the efficacy of Shallow Zone chemical oxidation treatment down-gradient of the area of source control and possibly trigger a contingency action according to a general decision tree provided by Farallon (2013b), with procedures and decision points to be developed in detail in the Engineering Design Report prepared for the preferred cleanup alternative.

Once soil and groundwater remediation is confirmed in the Shallow Zone within the thermal treatment area, in-situ treatment of the Deep Zone would occur using chemical oxidation or bioremediation. Either a chemical oxidant or a biological degradation substrate would be injected into Deep Zone groundwater beneath the dry cleaning equipment source area and down-gradient into the Woodlawn Avenue Northeast right-of-way. This alternative assumes that 18 injection wells and two injection events would be necessary to treat contaminants at depths of between 20 and 45 feet bgs and achieve cleanup standards in the Deep Zone. The layout of injection wells is shown in Appendix H.

A number of chemical oxidants were considered for use in the Deep Zone at the Site, including potassium permanganate and a modified Fenton's reagent composed of hydrogen peroxide and a chelated iron catalyst. The final selection of chemical oxidant would be completed during preparation of the Cleanup Action Plan. The results of the 2007 chemical oxidation bench- and pilot-scale testing conducted for the Deep Zone indicate that a potassium permanganate solution can effectively remediate PCE concentrations in Deep Zone groundwater. For chemical oxidation, approximately 3,700 pounds of potassium permanganate would be required with a SOD value of 0.3 mg/kg.

Cleanup Alternative 2 includes removal of Shallow Zone soil at the Dry Cleaner Building Property to a maximum depth of 15 feet bgs, including shoring and dewatering, to achieve the MTCA Method A soil cleanup level protective of groundwater. PCE concentrations in soil outside the thermal treatment area and within the Dry Cleaner Building Property currently are below the 2 mg/kg remediation level, and considerably below the MTCA Method B soil cleanup level protective of direct contact exposure, and this soil may be disposed of along with thermally-treated soil at a Subtitle D facility under a contained-out determination from Ecology.

Extending thermal treatment across the entire Dry Cleaner Building Property offers no benefit with regard to reducing post-treatment excavation and disposal costs because even if thermally treated, residual concentrations of PCE would remain requiring disposal at a Subtitle D facility under a contained-out determination. Section 7.4.3 presents the results of the disproportionate cost analysis demonstrating that extending the thermal treatment area to treat contamination in street rights-of-way where PCE concentrations exceed MTCA Method A groundwater cleanup levels is not practicable. The disproportionate cost analysis also discusses how thermal treatment across the entire Dry Cleaner Building Property is not cost-effective. After thermal treatment, Shallow Zone groundwater extracted to dewater the excavation is not expected to require additional treatment prior to discharge to the sanitary sewer. Because PCE concentrations in post-treatment soil will be considerably below the MTCA Method B soil cleanup level protective of direct contact exposure, additional protective measures and special soil-handling requirements during excavation would be minimal, although compliance monitoring during excavation would be conducted.

Long-term compliance groundwater monitoring for natural attenuation of PCE and other HVOCs in groundwater down-gradient in the Woodlawn Avenue Northeast right-of-way would be necessary. The available data indicate that moderate degradation of PCE is occurring in the Shallow Zone under anaerobic conditions, and that only limited lateral migration at relatively low concentrations has occurred in Deep Zone groundwater. Compliance groundwater monitoring would be conducted at approximately eight groundwater monitoring wells (four Shallow Zone wells and four Deep Zone wells) proximate to the dry cleaning equipment and the Hearthstone

Property source areas, including up- and down-gradient locations, to satisfy the requirements under MTCA for monitored natural attenuation.

Institutional controls would be implemented at the Dry Cleaner Building Property to ensure the long-term maintenance of risk-management procedures in accordance with WAC 173-340-440. Institutional controls would include deed restrictions to prohibit domestic use of groundwater at the Dry Cleaner Building Property and adjacent rights-of-way, and to provide for continued monitoring of groundwater. An Environmental Media Management Plan would be developed to govern handling of potentially contaminated media during future construction work both on the property and in the rights-of-way where soil and/or groundwater exceeding applicable cleanup levels may be encountered.

The use of engineering controls for management of vapor intrusion at the Dry Cleaner Building Property is not anticipated for Alternative 2 because the existing building would be demolished, and Shallow Zone thermal treatment (and future excavation as part of property redevelopment) would remove the majority of PCE mass in the Shallow Zone, effectively mitigating the risk for vapor intrusion into a future building. New construction may require use of a vapor barrier and/or a protective sub-slab depressurization system. Engineering controls for areas down-gradient of the Dry Cleaner Building Property are not anticipated. The potential for vapor intrusion into the commercial building down-gradient at 6869 Woodlawn Avenue Northeast, north of the Dry Cleaner Building, is unlikely because the building currently has open-air parking at the ground surface level, which would prevent vapors from intruding into the first floor of the building structure. In addition, the subsurface lithology in the Shallow Zone is predominantly silt, which retards migration of vapor-phase contaminants.

Although the exposure pathway for soil vapor intrusion to indoor air likely will be eliminated with the completion of thermal treatment for Cleanup Alternative 2 because the majority of PCE mass in the Shallow Zone will be reduced or removed, engineering controls, including but not limited to physical barriers such as building foundations and/or vapor barriers, may be required for new construction to mitigate potential vapor intrusion from residual PCE concentrations in soil or groundwater.

7.3.3.2 Time Frame and Estimated Cost

The time frame for implementation of Cleanup Alternative 2 and for compliance monitoring is provided below along with a cost estimate summary. A detailed breakdown of estimated costs for the specific components of Cleanup Alternative 2 is provided in Table 10. The estimated cost presented below assumes that Cleanup Alternative 2 occurs in conjunction with a development project. Table 10 provides estimates of the incremental cost if remediation is not conducted in conjunction with a development project, and the incremental cost if active Shallow Zone remediation is extended into the rights-of-way.

Shallow Zone:	Year 1: Less than 12 months
Deep Zone:	Year 1 and possibly Year 2: Less than 12 months after completion of Shallow Zone treatment
Compliance groundwater monitoring:	Years 1 through 5: Annual monitoring of four Deep Zone monitoring wells. Years 10 through 35: Monitoring of four Deep Zone wells every 5 years
	Years 1 through 10: Annual monitoring of four Shallow Zone monitoring wells, including two wells at the conditional point of compliance on the down-gradient property boundary of the Dry Cleaner Building Property

	Years 15 to 35: Monitoring of four Shallow Zone wells every 5 years in the right-of-way of Woodlawn Avenue Northeast to demonstrate natural attenuation
Capital Cost:	$3,694,200[3]
Ongoing Periodic and Future Costs:	$ 105,000
Total:	$3,799,200
	(estimated range: $3,420,000 - $4,180,000)

7.3.4 Cleanup Alternative 3: In-Situ Thermal Treatment Shallow Zone, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls

Similar to Cleanup Alternative 2, Cleanup Alternative 3 requires demolition of the Dry Cleaner Building and removal of the decommissioned USTs, and includes in-situ thermal treatment to reduce the highest concentrations of PCE in the dry cleaning equipment source area and achieve cleanup standards. Similar to Cleanup Alternative 2, Cleanup Alternative 3 includes a post-source control pilot test for chemical oxidation in the Shallow Zone immediately down-gradient of the thermal treatment area according to a general decision tree provided by Farallon (2013b). Pilot test procedures and decision points would be developed in detail in the Engineering Design Report prepared for the preferred cleanup alternative. Institutional and engineering controls would mitigate potential future exposure risks and require ongoing monitoring. The main differences between Cleanup Alternatives 2 and 3 are: Cleanup Alternative 3 uses remediation levels for Shallow and Deep Zone treatment; and Cleanup Alternative 2 does not include post-treatment excavation. If future development of the Dry Cleaner Building Property requires excavation for foundations and/or an underground parking

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[3] Cleanup Alternative 2 capital costs for active treatment site preparation, construction, and remediation:

Shallow Zone—		
	Thermal treatment:	$1,480,000
	Excavation:	$424,000
	Pilot test:	$26,600
Deep Zone—		
	Chemical oxidation or bioremediation:	$226,000

facility, soil with residual concentrations of PCE would be subject to a contained-out determination and disposal at an appropriate facility.

Cleanup Alternative 3 includes Shallow Zone thermal treatment to achieve a 2 mg/kg remediation level that is considerably below the MTCA Method B soil cleanup level for PCE, and would result in removal of more than 90 percent of the PCE mass from the Site, rather than achieving the lower MTCA Method A soil cleanup level targeted for Cleanup Alternatives 2 and 4. In addition, Cleanup Alternative 3 uses remediation levels for PCE in groundwater, including 100 µg/l in the Shallow Zone within the thermal treatment area, and 20 µg/l in the Deep Zone. Because this alternative would achieve a PCE soil cleanup level protective of the direct contact exposure pathway and includes collection of empirical data to demonstrate that groundwater is not adversely affected by residual PCE in soil, it does not include soil removal and disposal. However, if excavation is required for future development, excavated soil would be suitable for disposal as contained-out soil where residual concentrations of PCE are present in soil. As for Cleanup Alternative 2, long-term compliance groundwater monitoring for natural attenuation would occur down-gradient in the Woodlawn Avenue Northeast and 4th Avenue Northeast rights-of-way.

7.3.4.1 Implementation

Cleanup Alternative 3 implementation of thermal treatment in the Shallow Zone, and chemical oxidation or biological treatment in the Deep Zone is the same as for Cleanup Alternative 2, with the exception that the duration of treatment under Alternative 3 will be shorter using the higher remediation levels rather than the lower MTCA Method A soil cleanup level used under Alternative 2. Subsurface injection in the Deep Zone would occur after thermal treatment has been completed. Figure 14 shows the thermal treatment area for the Shallow Zone. Appendix H provides details of the components of the conceptual design, including the proposed thermal treatment system and the Deep Zone injection plan.

7.3.4.2 Time Frame and Estimated Cost

The time frame for implementation of Cleanup Alternative 3 and for compliance monitoring is provided below along with a cost estimate summary. A detailed breakdown of estimated costs for the specific components of Cleanup Alternative 3 is provided in Table 10. Table 10 provides an estimate of the incremental cost if active Shallow Zone remediation is extended into the rights-of-way.

Shallow Zone:	Year 1: Less than 8 months
Deep Zone:	Year 1 and possibly Year 2: Less than 24 months after completion of Shallow Zone treatment
Compliance groundwater monitoring:	Shallow Zone monitoring in four wells--Year 1: quarterly, Years 2 and 3: semi-annually, Years 4 through 10: annually, then every 5 years through Year 35 to demonstrate natural attenuation in the right-of-way of Woodlawn Avenue Northeast. Deep Zone monitoring in four wells--Years 1 through 10: annually, then every 5 years through Year 35 to demonstrate natural attenuation in the right-of-way of Woodlawn Avenue Northeast.
Capital Cost:	$2,593,400[4]
Ongoing Periodic and Future Costs:	$ 105,000

[4] Cleanup Alternative 3 capital costs for active treatment site preparation, construction, and remediation:

Shallow Zone—

Thermal treatment:	1,270,000
Pilot test:	$26,600

Deep Zone—

Chemical oxidation or bioremediation:	$162,000

Total:	$2,698,400 (estimated range: $2,430,000 - $2,970,000)

7.3.5 Cleanup Alternative 4: In-Situ Thermal Treatment Shallow Zone and Deep Zone, Excavation of Shallow Zone Soil, Monitored Natural Attenuation, Institutional Controls

Cleanup Alternative 4 includes institutional and engineering controls similar to those under Cleanup Alternatives 2 and 3 and also requires demolition of the Dry Cleaner Building and removal of the decommissioned USTs in the Woodlawn Avenue Northeast right-of-way. Similar to Cleanup Alternatives 2 and 3, Cleanup Alternative 4 includes a post-source control pilot test for chemical oxidation in the Shallow Zone immediately down-gradient of the thermal treatment area according to a general decision tree provided by Farallon (2013b). Pilot test procedures and decision points would be developed in detail in the Engineering Design Report prepared for the preferred cleanup alternative. However, in contrast to Cleanup Alternatives 2 and 3, thermal treatment under Cleanup Alternative 4 is extended vertically to include the Deep Zone at the Dry Cleaner Building Property where residual concentrations of PCE exceed preliminary cleanup levels. Similar to Cleanup Alternative 2, Cleanup Alternative 4 assumes that thermal treatment will achieve MTCA Method A soil and groundwater cleanup levels for PCE. Similar to Cleanup Alternative 2 and in contrast with Cleanup Alternative 3, Alternative 4 assumes excavation of Shallow Zone soil with PCE in excess of the MTCA Method A soil cleanup level. Soil will be disposed of at a Subtitle D facility under a contained-out determination from Ecology. Cleanup Alternative 4 does not use remediation levels.

7.3.5.1 Implementation

Implementation of thermal treatment under Cleanup Alternative 4 is the same as that under Cleanup Alternatives 2 and 3, with the exception that the thermal electrodes would be installed to greater depths in areas where PCE concentrations in Deep Zone groundwater within the thermal treatment area exceed the preliminary cleanup level. Shallow Zone excavation would require compliance monitoring and disposal of soil containing residual PCE concentrations at a Subtitle D permitted landfill under a contained-out determination from Ecology. Consistent with Cleanup Alternative 2, Alternative 4 assumes that 100 percent of the Shallow Zone soil excavated outside the thermal treatment area would require disposal at a Subtitle D permitted facility, and that wastewater generated during dewatering would not require pre-treatment prior to discharge to the sanitary sewer. Figure 14 shows the thermal treatment area; Appendix H provides details of the components of the conceptual design.

Consistent with Cleanup Alternatives 1, 2, and 3, institutional controls would be implemented under Alternative 4 to monitor conditions and mitigate future possible exposure risks.

7.3.5.2 Time Frame and Estimated Cost

The time frame for implementation of Cleanup Alternative 4 and for compliance monitoring is provided below along with a cost estimate summary. A detailed breakdown of estimated costs for the specific components of Cleanup Alternative 4 is provided in Table 10. The estimated cost presented below assumes that Cleanup Alternative 4 occurs in conjunction with a development project. Table 10 provides estimates of the incremental cost if remediation is not conducted in conjunction with a development project, and the incremental cost if active Shallow Zone remediation is extended into the rights-of-way.

Shallow and Deep Zone (Dry Cleaner Building Property Only):	Year 1: Less than 12 months
Compliance groundwater monitoring:	Years 1 through 5: Annual monitoring of four Deep Zone monitoring wells Years 10 through 35: Monitoring of four Deep Zone wells every 5 years Years 1 through 10: Annual monitoring of four Shallow Zone monitoring wells, including two wells at the conditional point of compliance on the down-gradient

	property boundary of the Dry Cleaner property
	Years 15 to 35: Monitoring of four Shallow Zone wells every 5 years in the right-of-way of Woodlawn Avenue Northeast to demonstrate natural attenuation
Capital Cost:	$4,272,000[5]
Ongoing Periodic and Future Costs:	$ 105,000
Total:	$4,377,000
	(estimated range: $3,940,000 - $4,810,000)

7.3.6 Cleanup Alternative 5: Excavation of Shallow Zone Soil, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls

Cleanup Alternative 5 includes excavation without prior treatment of Shallow Zone soil at the Dry Cleaner Building Property where concentrations of PCE in soil exceed the cleanup standards. Cleanup Alternative 5 also includes Deep-Zone oxidation or bioremediation, and monitored natural attenuation along with implementation of institutional and engineering controls as described under Cleanup Alternative 2, and also requires demolition of the Dry Cleaner Building and removal of the decommissioned USTs. Similar to Cleanup Alternatives 2, 3, and 4, Cleanup Alternative 5 includes a post-source control pilot test for chemical oxidation in the Shallow Zone immediately down-gradient of the thermal treatment area according to a general decision tree provided by Farallon (2013b). Pilot test procedures and decision points would be developed in detail in the Engineering Design Report prepared for the preferred cleanup alternative.

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[5]Cleanup Alternative 4 capital costs for active treatment site preparation, construction, and remediation:

Shallow and Deep Zones—

Thermal treatment:	$1,960,000
Excavation:	$424,000
Pilot test:	$26,600

7.3.6.1 Implementation

Excavation of Shallow Zone soil will require that the Dry Cleaner Building be demolished, that appropriate shoring be placed to protect excavation sidewalls and utilities, and that dewatering occur, with discharge to the sanitary sewer according to a King County Industrial Waste Discharge Authorization.

Excavation is assumed to require removal and disposal of approximately 9,950 tons of soil to a depth of 20 feet bgs, which comprises Remediation Areas 1, 2, and 3 shown on Figure 16. Excavation included under Cleanup Alternatives 2, 3, and 4 assumed a 15-foot-deep excavation, as the soil would be thermally treated to a depth of 20 feet prior to excavation. Excavation of the approximately 550 tons of soil between the depths of 15 and 20 feet at the bottom of the Shallow Zone will occur in Areas 1a and 1b in the dry cleaning equipment source area where PCE occurs through the total depth of the Shallow Zone. It is assumed that a separate shoring system will be installed for the approximately 1,750-square-foot excavation from 15 to 20 feet bgs. Groundwater in the Deep Zone is under pressure, and excavation into the base of the Shallow Zone is expected to require significantly more dewatering as groundwater from the Deep Zone rises into the excavation. Once the deeper excavation is completed to the base of the Shallow Zone, it is assumed that the excavation will be backfilled with low-permeability control density fill to the base of the 15-foot-deep excavation to diminish the amount of Deep Zone groundwater rising into the 15-foot-deep excavation.

The excavated soil containing PCE would be disposed of off the Site at an approved transport, storage, and disposal facility as follows:

- Approximately 80 percent (7,750 tons) of the excavated soil is assumed to contain PCE below the current 14 mg/kg contained-out threshold and would be disposed of as nonhazardous at an approved Subtitle D landfill under a contained-out determination from Ecology (Remediation Areas 2 and 3);
- Approximately 10 percent (1,010 tons) of the excavated soil is assumed to contain PCE exceeding the current 14 mg/kg contained-out threshold (Remediation Area

1b) and would be disposed of as a dangerous waste at an approved Subtitle C landfill; and

- Approximately 10 percent (1,190 tons) of the excavated soil from the dry cleaning equipment source area is assumed to contain PCE concentrations exceeding the 60 mg/kg criterion (Remediation Area 1a) for disposal at a Subtitle C landfill, and would require treatment off the Site prior to disposal at a Subtitle C landfill.

Removal and disposal of untreated soil has a higher cost than in-situ thermal treatment followed by removal and disposal (Cleanup Alternative 4) because of the substantial volume of untreated soil that would be classified as dangerous waste.

Groundwater extracted to dewater the excavation is expected to require treatment prior to discharge to the sanitary sewer. Implementation of Deep-Zone chemical oxidation or biological treatment is the same as under Cleanup Alternatives 2 and 3.

As with Cleanup Alternatives 2, 3, and 4, a pilot test for chemical oxidation will be performed post-source control in the Shallow Zone immediately down-gradient of the excavation area, possibly in the excavation resulting from the removal of the USTs. Groundwater compliance monitoring will measure the efficacy of Shallow Zone chemical oxidation treatment down-gradient of the area of source control and possibly trigger contingency action according to a general decision tree provided by Farallon (2013b), with procedures and decision points to be developed in detail in the Engineering Design Report for the preferred cleanup alternative.

Components of the conceptual design for Cleanup Alternative 5 are provided in Appendix H. As with Alternatives 1, 2, 3, and 4, institutional controls would be implemented to monitor conditions and to mitigate future possible exposure risks.

7.3.6.2 Time Frame and Estimated Cost

The time frame for implementation of Cleanup Alternative 5 and for compliance monitoring is provided below along with a cost estimate summary. A detailed breakdown of estimated costs for the specific components of Cleanup Alternative 5 is provided in Table 10. The estimated cost presented below assumes that Cleanup Alternative 5 occurs in conjunction with a development project. Table 10 provides estimates of the incremental cost if remediation is not conducted in conjunction with a development project, and the incremental cost if active Shallow Zone remediation is extended into the rights-of-way.

Shallow Zone:	Year 1: Less than 2 months
Deep Zone:	Year 1 and possibly Year 2: Less than 12 months after completion of Shallow Zone excavation
Compliance groundwater monitoring:	Years 1 through 5: Annual monitoring of four Deep Zone monitoring wells Years 10 through 35: Monitoring of four Deep Zone wells every 5 years
	Years 1 through 10: Annual monitoring of four Shallow Zone monitoring wells, including two wells at the conditional point of compliance on the down-gradient property boundary of the Dry Cleaner property
	Years 15 to 35: Monitoring of four Shallow Zone wells every 5 years in the right-of-way of Woodlawn Avenue Northeast to demonstrate natural attenuation

Capital Cost:	$2,490,100[6]
Ongoing Periodic and Future Costs:	154,000
Total:	$2,644,100
	(estimated range: $2,290,000 - $2,800,000)

7.3.7 Cleanup Alternative 6: Excavation of Shallow and Deep Zone Soil

Cleanup Alternative 6 is considered to have the highest degree of permanence of the alternatives presented in this FS. Cleanup Alternatives 2 through 5 use technologies that are considered permanent where they are applied, yet retain some reliance on implementation of institutional and engineering controls to protect future potential receptors from residual contamination on the Dry Cleaner Building Property and adjacent areas in the rights-of-way. Cleanup Alternative 6 does not require use of institutional or engineering controls or long-term groundwater monitoring because the preliminary cleanup levels would be attained at the standard points of compliance for all affected media in both the Shallow and Deep Zones.

7.3.7.1 Implementation

Excavation of Shallow Zone soil on the Dry Cleaner Building Property will require that the Dry Cleaner Building be demolished and the decommissioned USTs be removed, that appropriate shoring be placed to protect excavation sidewalls and utilities, and that dewatering occur, with discharge to the sanitary sewer according to a King County Industrial Waste Discharge Authorization. Excavation of soil in the Deep Zone on the Dry Cleaner Building Property and of soil in the Shallow and/or Deep Zone down-gradient of the dry cleaning equipment and Hearthstone Property source areas also would occur, with additional shoring of excavation sidewalls and underground utilities and operation of a larger dewatering system required. Based on available data, the excavation depth generally would extend to 15 feet bgs on the Dry Cleaner Building Property. In the dry cleaning equipment source area and down-gradient into the

[6]Cleanup Alternative 5 capital costs for active treatment site preparation, construction, and remediation:

Shallow and Deep Zones—

Excavation:	1,500,000
Pilot test:	$26,600
Chemical oxidation or bioremediation:	$226,000

Woodlawn Avenue Northeast and 4th Avenue Northeast rights-of-way, excavation would extend as deep as 50 feet bgs. Actual depths and the lateral extent would be determined during performance monitoring.

Based on available data, the assumed overall soil excavation would total approximately 23,500 tons, which includes Remediation Areas 1 through 6 shown on Figure 16. The excavated soil containing PCE would be disposed of off the Site at an approved treatment or disposal facility as follows:

- Approximately 90 percent (20,300 tons) of the excavated soil is assumed to contain PCE below the 14 mg/kg contained-out threshold and would be disposed of as nonhazardous waste at an approved Subtitle D landfill under a contained-out determination from Ecology (Remediation Areas 2, 3, part of 4, 5, and 6);
- Less than about 10 percent (2,000 tons) of the excavated soil is assumed to contain PCE exceeding the 14 mg/kg contained-out threshold and would be disposed of at an approved Subtitle C landfill (Remediation Areas 1b and part of 4);
- Less than about 5 percent (1,200 tons) of the excavated soil from the dry cleaning equipment source area is assumed to contain PCE concentrations exceeding the 60 mg/kg criterion for disposal as dangerous waste at a Subtitle C landfill and would require treatment off the Site prior to disposal at a Subtitle C landfill (Remediation Area 1a).

Cleanup Alternative 6 would require closure of Woodlawn Avenue Northeast and, to a lesser extent, 4th Avenue Northeast for the duration of the excavation in the rights-of-way, which could range from 1 to 2 months. Some excavation would be conducted also beneath the sidewalk on the north side of the Woodlawn Avenue Northeast right-of-way, but is not expected to extend onto the property at 6869 Woodlawn Avenue Northeast (Figure 16). Where excavation occurs outside the limits required for redevelopment of the Dry Cleaner Building Property, backfilling and resurfacing would be required. City of Seattle approval for the proposed excavation work within the rights-of-way is unlikely, and the costs for this alternative are disproportionate to the benefits. Based on these data, Cleanup Alternative 6 is not practicable, and therefore not implementable.

7.3.7.2 Time Frame and Estimated Cost

The time frame for implementation of Cleanup Alternative 6 is provided below along with a cost estimate summary. A detailed breakdown of estimated costs for the specific components of Cleanup Alternative 6 is provided in Table 10. The estimated cost presented below assumes that Cleanup Alternative 6 occurs in conjunction with a development project. Table 10 provides estimates of the incremental cost if remediation is not conducted in conjunction with a development project.

Shallow Zone:	Year 1: Less than 2 months
Deep Zone:	Year 1: Less than 2 months after completion of Shallow Zone excavation
Groundwater compliance monitoring:	Not required
Capital Cost:	$7,978,400[7]
Ongoing Periodic and Future Costs:	$ 34,800
Total:	$8,013,200 (estimated range: $7,210,000 - $8,810,000)

7.4 EVALUATION OF ALTERNATIVES

This section presents the evaluation of Cleanup Alternatives 1 through 6 developed in Section 7.3, Alternative Development and Description, to address contamination at the Dry Cleaner Building Property and areas down-gradient of both the dry cleaning equipment and the Hearthstone Property source areas. The evaluation was conducted in accordance with the requirements set forth in MTCA, as established in WAC 173-340-350 through 173-340–370.

[7] Cleanup Alternative 6 capital costs for active treatment site preparation, construction, and remediation:
Shallow and Deep Zones—
Excavation: 4,820,000

The evaluation of potentially feasible remedial alternatives for the Dry Cleaner Building Property also considered Site-specific conditions, including the distribution of PCE in the affected media and hydrogeologic conditions affecting contaminant fate and transport and exposure summarized in Section 5, Conceptual Site Model; results of treatability studies, including computer modeling presented in Section 7.2 (Treatability Studies); potential impacts to current and/or future use of the Dry Cleaner Building Property; the presence of underground utilities; and adjacent land uses.

The following key assumptions were used in the evaluation of cleanup alternatives:

- PCE is a valid indicator hazardous compound for the COCs at the Site, and implementation of cleanup alternatives that are successful at meeting the cleanup objectives for PCE would be successful also for other COCs (PCE breakdown products) throughout the Site.
- The distribution of PCE in soil and groundwater described in the conceptual site model (Section 5) has been defined sufficiently to support the evaluation of potential remediation technologies.
- The cleanup standards identified in Section 6.5 will be attained.
- Natural attenuation is occurring in rights-of-way adjacent to the dry cleaning equipment and Hearthstone Property source areas. Where natural attenuation is relied upon to achieve cleanup standards within a reasonable restoration time frame, monitoring will be conducted and evaluated per protocols in EPA (1998), including collection of environmental samples to enable characterization of degradation processes and evaluation of restoration time frame based on empirical data.
- Engineering controls may be required to mitigate the potential vapor intrusion pathway for protection of indoor air quality in the Dry Cleaner Building if redevelopment does not occur and the existing building is not removed (Cleanup Alternative 1), or if future development includes a new slab-on-grade building (i.e., no excavation for a subsurface parking structure).

- Implementation of institutional controls at the Site will be necessary to address residual contamination in the subsurface following active remediation to ensure long-term maintenance of risk-management procedures in accordance with WAC 173-340-440. Institutional controls would: include deed restrictions prohibiting domestic use of groundwater beneath the Site; provide for continued monitoring of groundwater; and provide for maintenance of engineering controls, if required. In addition, an Environmental Media Management Plan would be developed to govern the handling of potentially contaminated media during future redevelopment or utility work, as necessary.

7.4.1 Evaluation Process

The FS considered the requirements under WAC 173-340-350 and the criteria defined in WAC 173-340-360 for the screening of potentially feasible cleanup alternatives for the Site. A cleanup alternative must satisfy the following threshold criteria as specified in WAC 173-340-360(2)(a):

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

In addition to meeting the threshold criteria, cleanup actions under MTCA must meet the following additional requirements specified in WAC 173-340-360(2)(b):

- Provide for a reasonable restoration time frame based on the factors provided in WAC 173-340-360(4)(b);
- Use permanent solutions to the maximum extent practicable based on the criteria defined in WAC 173-340-360(3)(f); and
- Consider public concerns raised during public comment on the Cleanup Action Plan (WAC 173-340-600).

The factors used to evaluate the reasonableness of the restoration time frame per WAC 173-340-360(4)(b) include:

- Potential risks to human health and the environment posed by the Site;
- Practicability of achieving a shorter restoration time frame;
- Current use of the Site, surrounding areas, and associated resources that are or may be affected by releases from the Site;
- Availability of alternative water supplies;
- Likely effectiveness and reliability of institutional controls;
- Ability to control and monitor migration of hazardous substances from the Site;
- Toxicity of the hazardous substances at the Site; and
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the Site or under similar Site conditions.

The criteria used to evaluate the degree of permanence to the maximum extent practicable per WAC 173-340-360(3)(f) include:

- Protectiveness: This criterion considers overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, the time required to reduce risk at the facility and attain cleanup standards, risks at the Site resulting from implementing the alternative, and improvement of overall environmental quality.
- Permanence: Permanence addresses the degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of the waste-treatment process, and the characteristics and quantity of treatment residuals generated.
- 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 that hazardous substances are expected to remain on the Site at concentrations that exceed cleanup levels, and the magnitude of residual risk with the alternative in place. The following types of cleanup action components may be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness: reuse or recycling; destruction or detoxification; immobilization or solidification; disposal on or off the Site in an engineered, lined, and monitored facility; isolation or containment with attendant engineering controls on the Site; and institutional controls and monitoring.

- Management of short-term risks: This criterion pertains to the risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks. This criterion also includes risks to workers and customers at businesses adjoining the Dry Cleaner Building Property resulting from implementation of the cleanup alternative.
- Technical and administrative implementability: Implementability includes consideration of whether the alternative is technically feasible, administrative and regulatory requirements, permitting, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with business operations in the Dry Cleaner Building and adjoining business operations.
- Cost: This criterion addresses the cost to implement the alternative, including the cost of construction and anticipated long-term costs. Long-term costs include operation and maintenance, monitoring, and reporting costs.
- Consideration of public concerns: This criterion considers whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, federal and state agencies, or any other organization that may have an interest in or knowledge of the Site.

7.4.2 Evaluation Results

A detailed evaluation of Cleanup Alternatives 1 through 6 using the criteria described above is presented in Table 11, which includes parameters such as the MTCA Composite Benefit Score and the estimated costs used in the disproportionate cost analysis, described in Section 7.4.3. Table 12 provides a summary of the evaluation results, which are described below by evaluation criteria.

7.4.2.1 Protect Human Health and the Environment

According to Section 5.4, Exposure Assessment, the two types of exposure risk associated with the presence of COCs at the Site are terrestrial ecological risk and human health risk. Because the Site qualifies for a TEE exclusion based on WAC 173-340-7491, mitigating the potential human health risk associated with exposure to COCs in indoor air, soil, and groundwater at the Site will be the primary objective of any cleanup action implemented.

Cleanup Alternatives 1 through 6 satisfy the MTCA criterion for protection of human health and the environment. Cleanup Alternative 1 would be implemented if the Dry Cleaner Building Property is not to be developed for the foreseeable future. The existing concrete floor slab of the Dry Cleaner Building serves as a barrier against direct contact with subsurface contamination and reduces the potential for intrusion of vapors into the building interior. Installation of a sub-slab depressurization system is included under Cleanup Alternative 1, which will eliminate the potential for vapor intrusion into the interior of the Dry Cleaner Building and inhalation by workers. Institutional controls would further reduce potential exposure by prohibiting domestic use of groundwater and requiring ongoing maintenance of the sub-slab depressurization system and creation of an Environmental Media Management Plan for handling potentially contaminated media during future construction activities. Under Cleanup Alternative 1, subsurface contamination will continue to attenuate naturally over time and would be monitored using a long-term groundwater monitoring program.

Cleanup Alternatives 2 through 6 provide additional protection to human health by actively reducing subsurface contamination using a combination of in-situ technologies (thermal treatment and chemical oxidation or bioremediation) and/or excavation. Active remedial measures focus on reducing levels of COCs in the dry cleaning equipment source area, thereby reducing risks from residual contamination at the Site. Alternatives 2 through 5 include the institutional controls used under Alternative 1 to further reduce exposure risks.

7.4.2.2 Comply with Cleanup Standards

Active remedial measures under Cleanup Alternatives 2 through 5 are designed to ultimately achieve cleanup standards within a reasonable restoration time frame by focusing on remediation of subsurface contamination at the Dry Cleaner Building Property. Cleanup Alternatives 2, 3, 5, and 6 actively treat the Deep Zone in the rights-of-way. Cleanup Alternatives 2 through 5 rely on monitored natural attenuation to achieve cleanup levels in the Shallow Zone of the rights-of-way. Cleanup Alternative 6 is designed to achieve preliminary cleanup levels in adjacent public rights-of-way in the short term. Compliance with cleanup standards will occur under Alternative 1, but only over a much-longer time period to allow natural processes to attenuate subsurface contamination.

7.4.2.3 Comply with State and Federal Laws

In addition to the preliminary cleanup levels required under MTCA, numerous laws and associated regulations influence how a particular remedial action is implemented. Permitting by various agencies, substantive standards promulgated by state and local agencies, best management practices, workplace safety, and off-site waste disposal practices are some of the aspects that must be formally addressed in the design and implementation phases of a cleanup action to ensure compliance with applicable laws. None of the alternatives contains elements that cannot be designed and implemented in compliance with these laws.

7.4.2.4 Provide for Compliance Monitoring

Compliance monitoring refers to the collection, analysis, and reporting of environmental data to assess the short- and long-term effectiveness of a cleanup action and whether protection is being achieved in accordance with cleanup objectives. A Compliance Monitoring Plan describing standard field techniques and laboratory analytical methods will be developed in conjunction with the Engineering Design Report. All of the remedial alternatives presented include comprehensive compliance monitoring programs to fulfill this requirement. Long-term compliance monitoring under Cleanup Alternatives 1 through 5 will include testing for PCE, PCE degradation products, and natural attenuation parameters, and progress of natural attenuation will be evaluated per EPA (1998) protocol.

7.4.2.5 Provide for a Reasonable Restoration Time Frame

A reasonable restoration time frame is another requirement for evaluating alternatives. MTCA prefers alternatives that can be implemented in a shorter period of time while equivalent in other respects (e.g., permanence, implementation risks to the community, environment, cost).

Restoration time frame is the time required to meet cleanup standards (i.e., to meet all cleanup levels in all media at all points of compliance). Under MTCA, nine factors are used to determine whether a cleanup action provides for a reasonable restoration time frame (Section 7.4.1, Evaluation Process). Cleanup Alternatives 2 through 6 offer a reasonable restoration time frame under MTCA. Considering applicable MTCA factors for evaluating the reasonableness of a restoration time frame, Alternative 6 would require the shortest time to achieve cleanup standards via excavation and off-Site disposal. In-situ technologies will require a slightly longer restoration time frame in treatment areas. The restoration time frame for Alternative 1 is the longest and would achieve cleanup standards with natural attenuation of the dry cleaning equipment source area and down-gradient in the rights-of-way only after many years. Cleanup Alternatives 1 through 5 rely on natural attenuation processes to achieve cleanup standards, especially in the Shallow Zone of the rights-of-way, where active remedial measures are impracticable (Sections 7.1, Evaluation of Feasible Remediation Technologies, and 7.4.3, Disproportionate Cost Analysis). A restoration time of 25 to 35 years for the rights-of-way is considered reasonable, considering the following:

- Potential risks to human health and the environment posed by the Site will be low after treatment of the dry cleaning equipment source area. An environmental covenant requiring protective measures would effectively and reliably limit exposure to residual contamination.
- Active remedial measures that could achieve a shorter restoration time frame for the Shallow Zone of the rights-of-way are impracticable to implement (Sections 7.1, Evaluation of Feasible Remediation Technologies, and 7.4.3, Disproportionate Cost Analysis).
- Shallow Zone groundwater is not considered to be a potable water supply, and municipal water is provided to this area of the city. Contamination from the Site is bounded and has migrated only a limited distance down-gradient of the source areas on the Dry Cleaner Building Property and the Hearthstone Property.
- Empirical evidence confirms that moderate anaerobic degradation of PCE is occurring under current conditions, and a long-term compliance groundwater monitoring program will enable demonstration of natural attenuation over time.

7.4.2.6 Use Permanent Solutions to the Maximum Extent Practicable

MTCA specifies that when a cleanup action is selected, preference is to be given to actions that are permanent to the maximum extent practicable. Multiple cleanup approaches are possible for the Site. Active treatment approaches such as those under Alternatives 2 through 6 offer the greatest degree of permanence by actively reducing the mass of contaminants to achieve cleanup standards.

Selecting a remedy that is permanent to the maximum extent practicable at the Site includes consideration of the results of a disproportionate cost analysis per WAC 173-340-360(3)(e). A permanent cleanup action achieves cleanup standards without further action at the Site, reducing or eliminating the need for long-term monitoring, maintenance, or institutional controls. Costs would be disproportionate to benefits if the incremental costs of an alternative over that of a lower-cost (less-permanent) alternative exceed the incremental degree of benefits (protection) achieved. A disproportionate cost analysis was conducted for cleanup alternatives considered for the Dry Cleaner Building Property and is described in Section 7.4.3.

7.4.2.7 Consider Public Concerns

Community concerns are considered by Ecology in the selection of cleanup actions and are formally obtained during required Public Notice and Participation periods, which will occur with submittal of the Draft Cleanup Action Plan. Public concerns will be considered in the selection and implementation of the cleanup alternative for the Dry Cleaner Building Property.

7.4.3 Disproportionate Cost Analysis

The purpose of disproportionate cost analysis is to facilitate selection of the cleanup alternative that provides the highest degree of permanence to the maximum extent practicable. The disproportionate cost analysis conducted considered the following variations of the cleanup alternatives and incremental estimated cost associated with each of them:

- Cleanup Alternatives 2 through 6 are implemented independently of development at the Dry Cleaner Building Property; and
- Cleanup Alternatives 2 through 5 are extended into the rights-of-way down-gradient of the dry cleaning equipment and Hearthstone Property source areas.

The disproportionate cost analysis for the Site was conducted according to the methodology provided by Ecology (2009a) per WAC 173-340-360(3)(e). The cleanup alternative evaluation presented in Table 11 is provided in a format suggested by Ecology (2009a). Table 11 presents a semi-quantitative assessment of the MTCA criteria for permanence to the maximum extent practicable (WAC 173-340-360[3][f]). A numeric score ranging from 0 to 10 is assigned for each of the criteria based on best professional judgment. The higher the score, the more favorable the criterion evaluation is under MTCA. The criteria scores are weighted according to

Ecology (2009a) suggestions and as indicated in Table 11. A MTCA Composite Benefit Score is calculated for each alternative by summing the mathematical product of the criterion score times the weighting factor, and provides a quantitative measure of environmental benefit that would be realized with implementation of a cleanup alternative. For example, if the weighting factors for the six criteria are Protectiveness–30 percent, Permanence–20 percent, Long-Term Effectiveness–20 percent, Short-Term Effectiveness–10 percent, Implementability–10 percent, and Public Concerns–10 percent, with scores for each of these criteria of 7.5, 7, 6, 3, 7, and 6, respectively, the MTCA Composite Benefit Score is calculated as: (7.5)(0.3) + (7)(0.2) + (6)(0.2) + (3)(0.1) + (7)(0.1) + (6)(0.1) = 6. A score of 6 represents moderate environmental benefit on a scale of 0 to 10, with 10 having the highest environmental benefit.

Table 11 provides details regarding the basis for the scoring and the estimated costs for the six cleanup alternatives that are provided in more detail in Table 10. The disproportionate cost analysis is further summarized in Table 13 which includes MTCA Composite Benefit Scores and the estimated cost for implementing each cleanup alternative if conducted concurrently with a development project (base cost) and incremental costs for conducting the two variations summarized above. Figure 15 graphically presents the results of the disproportionate cost analysis. The red bars on Figure 15 indicate the environmental benefit offered by the cleanup alternative as measured by the MTCA Composite Benefit Score using the left axis of the graph. The blue bars reflect cost estimates using the right axis of the graph. The darkest blue bar represents the cost estimate for the cleanup alternatives phased with development of the Dry Cleaner Building Property. The two blue bars of lighter shades show the two variations of the cost estimate, including: the cleanup alternative cost if cleanup is not conducted in conjunction with development; and the cost for extending the cleanup approach laterally into the adjacent rights-of-way. The incremental benefit of implementing an alternative per the description in Section 7.4.1, Evaluation Process, may be discerned relative to incremental costs.

The primary conclusions of the disproportionate cost analysis are summarized below.

7.4.3.1 Cleanup Alternative 6 is Impracticable

The cost for implementing Cleanup Alternative 6, Excavation of Shallow and Deep Zone Soil on the Dry Cleaner Building Property and adjacent rights-of-way, is disproportionate to the environmental benefits that would be achieved, and is considered to be impracticable under MTCA. The risks of implementing Cleanup Alternative 6 are significant, given the deep excavation, shallow groundwater conditions, proximity to a high-traffic urban area, and the presence of numerous underground utilities, including water, storm sewer, sanitary sewer, and natural gas in the excavation area. Further, obtaining City of Seattle approval for excavation to depths of 50 feet bgs in the public right-of-way requiring closure of a major traffic arterial for up to 2 months is highly unlikely especially if possible future PCE exposure can be managed with less disruption and less risk to underground utilities by other means. Cleanup Alternative 6 is considered to be impracticable under MTCA because of the unsatisfactory evaluation results for implementability and short-term risk management combined with the very high relative cost. If conducted concurrently with a development project, the cost is nearly 300 percent of the cost of the alternative offering the highest MTCA Composite Benefit Score (Cleanup Alternative 3) and about 60 percent of the environmental benefit. Table 11 provides additional rationale for considering Cleanup Alternative 6 to be impracticable.

7.4.3.2 Conducting Remediation Independently from Development is Impracticable for Cleanup Alternatives 2, 4, 5, and 6

For cleanup alternatives 2, 4, 5, and 6, the incremental cost for removal of contaminated soil not conducted in conjunction with development of the Dry Cleaner Building Property is disproportionate to the environmental benefit that would be achieved and is considered to be impracticable under MTCA. First, while soil removal will entail excavation of soil containing PCE concentrations exceeding the MTCA Method A soil cleanup level protective of groundwater, it will not necessarily reduce the estimated restoration time frame for groundwater in the adjacent rights-of-way. Empirical demonstration of protection of groundwater can be made if cleanup does not achieve the MTCA Method A soil cleanup level.

Second, estimates of incremental costs for not phasing soil removal in conjunction with development is about $1,000,000 (Table 10; Figure 15). The incremental cost for

Cleanup Alternatives 5 and 6 is about $1,000,000 (a premium of about 40 and 10 percent, respectively). The incremental cost for Cleanup Alternatives 2 and 4 is about $1,100,000 (a premium of about 30 percent).

Estimates for incremental costs for removal of contaminated soil solely for purpose of remediation (i.e., excavation not conducted in conjunction with development of the Dry Cleaner Building Property) were derived from work that typically would be conducted as part of a development project budget. Removal of soil for remediation will require extensive shoring and dewatering systems, and special handling of excavated soil and groundwater generated during dewatering. Worker protective measures would be required. These activities and measures would be required also for removal of soil for development purposes. Removal of soil for remediation without concurrent property development will necessitate import of clean fill that would be compacted and stabilized until such time as the Dry Cleaner Building Property is sold or developed. The eventual development of the Dry Cleaner Building Property likely will include extensive excavation for an underground parking structure, which would require excavation and off-Site disposal of the clean fill previously imported during the remedial activities. These incremental costs can be either avoided or paid for as development activities if soil removal is performed in conjunction with development.

7.4.3.3 Additional Active Remediation in Rights-of-Way is Impracticable

Cleanup Alternatives 2, 3, and 5 include active remediation in the Deep Zone using chemical oxidation or bioremediation. This section discusses the impracticability of extending Shallow Zone thermal treatment and excavation into the rights-of-way.

The Shallow Zone thermal treatment area shown on Figure 14 extends about 15 feet into the Woodlawn Avenue Northeast right-of-way and about 5 feet into the alley west of the Dry Cleaner Building Property. The IRAWP describes a removal action that extends as far as about 10 feet north of the Hearthstone Property into the Woodlawn Avenue Northeast right-of-way. The IRAWP indicates that excavation in the Woodlawn Avenue Northeast right-of-way will be 8 feet bgs. The incremental cost for extending Shallow Zone thermal treatment and excavation components of Cleanup Alternatives 2 through 6 farther into the rights-of-way of Woodlawn Avenue Northeast and 4th Avenue Northeast is disproportionate to the environmental benefit that would be achieved, and is therefore considered to be impracticable under MTCA.

As discussed in Section 7.1, Evaluation of Feasible Remediation Technologies, the low-permeability conditions of the Shallow Zone are not suited to in-situ technologies that rely on distribution by injection or extraction of materials (e.g., air sparge/vapor extraction, chemical oxidation, enhanced bioremediation). Injecting chemical oxidants or bioremediation substrates is not technically feasible unless injection occurs using very close spacing due to the low permeability of Shallow Zone soil, which would be cost prohibitive and high risk due to the presence of numerous underground utilities in the rights-of-way. However, as indicated in Section 7.1 and per Ecology request, after remediation of source material at the Dry Cleaner Property, pilot testing, including application of chemical oxidant, will be conducted to evaluate the feasibility of in-situ treatment to address residual PCE in the Shallow Zone beneath Woodlawn Avenue Northeast. Farallon (2013b) outlined the general approach for post-source control pilot testing, details of which will be provided in the Engineering Design Report.

Implementation of thermal treatment or excavation would require extended closure of Woodlawn Avenue Northeast, a major traffic arterial with frequent bus service, and re-routing of traffic. The City of Seattle likely would not approve such a closure or thermal treatment and/or excavation close to underground utilities, particularly given the potential for damage, the relative low mass of contamination (compared to the source area) remaining in this area, and that PCE exposure can be managed by other means with less disruption and risk to underground utilities. Conducting deep excavations under Cleanup Alternative 6 in a traffic arterial proximate to underground utilities in a densely populated urban area is disruptive and potentially dangerous, and would require special protective measures. Shallow and Deep Zone soil removal in the rights-of-way would require extensive shoring and dewatering facilities, and special handling of removed soil and groundwater. Worker protective measures and compliance monitoring also would be required. Underground utilities, including natural gas, water, and sewer, would require shoring. Upon completion of excavation activities, clean fill would have to be imported, compacted, and stabilized, and the roadways reconstructed.

Unless the pilot test described above demonstrates that in-situ treatment will be effective, it appears the limited environmental benefits of extending groundwater remediation farther into Shallow Zone rights-of-way do not warrant the incremental costs, especially considering that current and future environmental risks can be managed effectively. Domestic use of groundwater can be restricted. Risk to future workers can be managed with health and safety measures. The rights-of-way are paved, limiting human exposure and infiltration of rainfall and subsequent mobilization of contamination to groundwater. In addition, groundwater contamination is not migrating laterally. Shallow Zone soil is dense and fine-grained, with low groundwater transmissivity, limiting the potential for future contaminant migration down-gradient. Following active remediation of the source areas, natural attenuation processes occurring in the Shallow Zone would continue to reduce residual concentrations of PCE and associated degradation products over time, as demonstrated by the post-remediation BIOCHLOR modeling described in Section 7.2.3, Two-Dimensional Modeling.

Cleanup Alternatives 1 through 5 include provisions for developing and implementing an Environmental Media Management Plan for future construction and maintenance projects in the rights-of-way. This approach to managing risks from contamination in the rights-of-way is considered to be protective, effective, and implementable.

The estimated incremental costs for extending active treatment into the rights-of-way range from about $2,000,000 for Cleanup Alternative 5 (a premium of more than 75 percent) to $3,500,000 for Cleanup Alternative 4 (a premium of about 80 percent). Based on information available at this time, the remediation options for soil and groundwater in the rights-of-way are not practicable under MTCA when the cost and implementability constraints are compared to the environmental benefits.

7.4.3.4 Ancillary Conclusions of the Disproportionate Cost Analysis

Considering the results of the disproportionate cost analysis, several ancillary conclusions may be drawn with regard to the cost effectiveness of particular elements of the six cleanup alternatives.

Thermal treatment of the entire Dry Cleaner Building Property under Cleanup Alternatives 2, 3, and 4 is not cost-effective. Thermal treatment over the entirety of the Dry Cleaner Building Property (i.e., including the area outside the thermal treatment area shown on Figure 14) was not considered as an element of any of the cleanup alternatives. The thermal treatment area encompasses the area where PCE in the Shallow Zone exceeds the 2 mg/kg soil remediation level and the MTCA Method A groundwater cleanup level. The thermal treatment area encompasses the area of the Deep Zone where PCE in soil and groundwater exceeds MTCA Method A cleanup levels on the Dry Cleaner Building Property. In the Shallow Zone, while current groundwater concentrations exceed the MTCA Method A groundwater cleanup level over most of the Dry Cleaner Building Property, soil data from samples collected outside the thermal treatment area indicate that PCE in soil is below the MTCA Method B soil cleanup level protective of direct contact exposure and likely will not exceed the 14 mg/kg contained-out threshold; thus the soil would be suitable for off-Site disposal under a contained-out determination from Ecology if excavation occurs as part of development of the Dry Cleaner Building Property.

An additional approximately $800,000 would be required to thermally treat the Shallow Zone outside the proposed thermal treatment area and within the Dry Cleaner Building Property to achieve MTCA Method A cleanup levels for soil and groundwater under Cleanup Alternatives 2 and 4. The incremental cost for thermal treatment of approximately 4,300 square feet of the Shallow Zone outside the thermal treatment area is not commensurate with the environmental benefit of achieving MTCA Method A cleanup levels, considering the following:

- The total PCE mass in the area outside the thermal treatment area is only approximately 6 percent of the total estimated residual PCE mass (about 93 percent of which is adsorbed to soil);
- Data indicate that concentrations of PCE in soil outside the thermal treatment area are below the MTCA Method B cleanup level protective of direct contact exposure, and possible exposure to contaminated soil and groundwater at the Site is limited and can be controlled; and
- If the Dry Cleaner Building Property is developed with underground parking, Shallow Zone soil excavated from the Dry Cleaner Building Property would require special handling and disposal under a contained-out determination from Ecology and would be just as costly to dispose of as if it were not thermally treated.

Thermally treating groundwater and soil to concentrations below remediation levels is not cost effective. Up to approximately 4 additional months of treatment is estimated to be required to achieve MTCA Method A cleanup levels for soil and groundwater using thermal treatment. Operation and maintenance costs for thermal treatment of the Shallow Zone are approximately $30,000 per month, increasing treatment cost by approximately $120,000 for the additional 4 months. The incremental cost of achieving MTCA Method A cleanup levels as opposed to remediation levels for soil and groundwater is not commensurate with the environmental benefit, considering the limited potential for exposure to contaminated materials at the Site, which can be controlled, and the significantly lower level of confidence that thermal treatment in the Shallow Zone can achieve MTCA Method A cleanup levels for soil and groundwater. Further, although achieving a more-stringent soil cleanup level within the thermal treatment area may be slightly more protective of groundwater in the rights-of-way within and proximate to the thermal treatment area in the short-term, natural attenuation processes still would be relied upon to achieve cleanup standards in untreated areas of the rights-of-way. In addition, disposal costs associated with treated soil would not be reduced because soil excavated during future development still would require a contained-out determination and disposal at a Subtitle D facility.

Achieving PCE concentrations in groundwater less than the remediation level (Cleanup Alternatives 2 and 4) is more cost-effectively achieved using monitored natural attenuation and institutional controls (Cleanup Alternative 3).

Thermally treating the Deep Zone is not cost effective. The cost of thermally treating the Deep Zone within the thermal treatment area is approximately $500,000 (Cleanup Alternative 4). Deep Zone in-situ treatment with chemical oxidation or bioremediation, including the Woodlawn Avenue Northeast right-of-way (Cleanup Alternatives 2, 3, and 5), will cost an estimated $200,000. Use of chemical oxidation or bioremediation is technically feasible and a more cost-effective remedial approach for the Deep Zone than is thermal treatment. The permeable Deep Zone conditions are amenable to dispersing injected materials, and favorable chemical oxidation pilot test indicates that this technology will be effective.

7.4.3.5 Cleanup Alternative 3 is the Most-Practicable Cleanup Alternative

The disproportionate cost analysis indicates that the most-practicable cleanup approach is to thermally treat the source area in the Shallow Zone as under Cleanup Alternatives 2 and 3. The cleanup alternative with the highest MTCA Composite Benefit Score and the second lowest relative cost is Cleanup Alternative 3. Of the six cleanup alternatives evaluated, Cleanup Alternative 3 is considered to have the highest degree of permanence under MTCA to the maximum extent practicable, and the cost estimate for Cleanup Alternative 3 is the same whether it is performed in conjunction with development or independently. Cleanup Alternative 2 has a comparable MTCA Composite Benefit Score, but a cost of about $1,100,000 more than Cleanup Alternative 3 assuming cleanup in conjunction with a development project. Cleanup Alternative 5 has only a slightly lower MTCA Composite Benefit Score than Cleanup Alternative 3, and implemented in conjunction with a development project has an estimated cost about $54,000 less than Cleanup Alternative 3. Because of its slightly higher MTCA Composite Benefit Score and because no development project currently is being planned at the Dry Cleaner Building Property, Cleanup Alternative 3 is considered to be the preferred cleanup alternative for the Dry Cleaner Building Property and the adjacent rights-of-way, and is described in more detail in Section 8, Preferred Cleanup Alternative.

8.0 PREFERRED CLEANUP ALTERNATIVE

Based on the results of the FS, Cleanup Alternative 3 (In-Situ Thermal Treatment Shallow Zone, Deep-Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls) is the preferred cleanup alternative for the Dry Cleaner Building Property and adjacent Woodlawn Avenue Northeast and 4th Avenue Northeast rights-of-way. Cleanup Alternative 3, like Cleanup Alternatives 2, 4, and 5, includes primary elements of Cleanup Alternative 1 (Institutional and Engineering Controls, Monitored Natural Attenuation) to mitigate risks from residual contamination. Cleanup Alternative 3 includes post-source control pilot testing of chemical oxidant in the Shallow Zone at the down-gradient edge of the source control area and provisions for possible additional contingency action in the right-of-way per details to be developed in the Engineering Design Report for the preferred cleanup alternative. Cleanup Alternatives 2, 3, and 5 provide the highest environmental benefit of all six cleanup alternatives. Cleanup Alternative 3 is considered the most technically feasible cost-effective alternative of the five active remediation alternatives considered, based on cost estimates assuming that remediation will not be conducted concurrently with a development project on the Dry Cleaner Building Property. Cleanup Alternative 3 satisfies the requirements of MTCA and the terms of the Agreed Order, and significantly reduces risk from Site contamination to the maximum extent practicable by using in-situ treatment technologies to remove (thermal treatment) and destroy (chemical oxidation or bioremediation) Site contamination.

Cleanup Alternatives 2 and 5 provide a level of environmental benefit comparable to that of Cleanup Alternative 3. Cleanup Alternative 2 is significantly more costly than Cleanup Alternative 3 as it includes thermal treatment followed by excavation. Cleanup Alternative 5 does not use thermal treatment prior to excavation of Shallow Zone soil. Excavation is least costly and most practicable with a concurrent development project, but no development project is planned at this time. If there were a concurrent development project, Cleanup Alternative 5 would be slightly less costly than Cleanup Alternative 3 for a comparable environmental benefit.

As described in Section 5.5, Conceptual Site Model Summary, PCE mass estimates based on available data indicate that the majority of PCE mass at the Site (i.e., greater than 90 percent) is contained in soil on the Dry Cleaner Building Property, less than 10 percent is present in soil in the rights-of-way, and less than 1 percent is contained in groundwater. This summary excludes the PCE mass in soil and groundwater related to the source area on the Hearthstone Property because the approved removal action presented in the IRAWP for the Hearthstone Property implemented in 2011 and 2012 addressed cleanup of the Hearthstone Property source area.

Based on the distribution of PCE at the Site, Cleanup Alternative 3 focuses on active remediation of PCE in the Shallow Zone of the Dry Cleaner Building Property and portions of the Woodlawn Avenue Northeast right-of-way, and PCE in the Deep Zone across the Site. Thermal treatment will extend approximately 15 feet into the Woodlawn Avenue Northeast right-of-way, and approximately 5 feet into the alley west of the Dry Cleaner Building Property. Nonetheless, Cleanup Alternative 3 includes the pilot test described above to evaluate the potential effectiveness of chemical oxidation in the Shallow Zone right-of-way.

Implementation of Cleanup Alternative 3 to achieve PCE remediation levels in soil and groundwater is estimated to result in a reduction of the total mass of PCE at the Site of over 90 percent. This estimate includes a greater than 90 percent reduction of PCE within the thermal treatment area, and a greater than 70 percent reduction of PCE in the Woodlawn Avenue Northeast right-of-way. A summary of estimated PCE reduction resulting from implementation of Cleanup Alternative 3 is provided below.

	Soil	Groundwater	Shallow Zone	Deep Zone	Inside Thermal Treatment Area	Outside of Thermal Treatment Area
Dry Cleaner Building Property	93%	93%	92%	99%	95%	0.0%
Rights-of-way	73%	50%	59%	94%	74%	71%
	92%	84%	92%		92%	

The last row of the summary table above is the estimated PCE reduction for the Site as a whole, excluding the Hearthstone Property, and not a summation of the percentages above it. For example, PCE would be reduced by approximately 92 percent across the Site, with a reduction of 93 percent on the Dry Cleaner Building Property and 73 percent in the rights-of-way.

According to the BIOCHLOR modeling summarized in Section 7.2.3, Two-Dimensional Modeling, proposed preliminary cleanup levels will be achieved in the Shallow Zone at conditional point of compliance monitoring wells on the down-gradient property boundary of the Dry Cleaner Building Property, within 10 years of completing thermal treatment at the dry cleaning equipment source area. The Shallow Zone is composed of dense silt and silty sand at the Dry Cleaner Building Property and transitions to a dense silt in the Woodlawn Avenue Northeast right-of-way, effectively retarding and limiting contamination migration in the Shallow Zone to within approximately 50 feet down-gradient of the dry cleaning equipment source area. Tables 2 through 4 present empirical data demonstrating that natural attenuation processes are degrading PCE into its daughter products in the Shallow Zone, and Table 5 presents data characterizing geochemical conditions affecting anaerobic dehalogenation in the Shallow and Deep Zones. Modeling results indicate that preliminary cleanup levels will be attained for Deep Zone groundwater within approximately 25 to 35 years following chemical oxidant injection. Modeling results also indicate that PCE in Shallow Zone groundwater down-gradient of the area of source treatment will decrease to below its preliminary cleanup level in a similar time frame.

Cleanup Alternative 3 addresses the primary COC at the Site, PCE, and the other COCs in the three media of concern at the Site: indoor air, soil, and groundwater. Cleanup Alternative 3 is protective of the indoor air inhalation pathway and of direct contact exposure (dermal contact, ingestion) with soil and with groundwater, and the proposed preliminary cleanup level for soil, the MTCA Method A soil cleanup level, is protective of groundwater. Post-remediation groundwater compliance monitoring will provide data empirically demonstrating that groundwater is protected from residual PCE concentrations in soil and that groundwater cleanup levels are attained. Elements of Cleanup Alternative 3 may be conducted either in conjunction with development of the Dry Cleaner Building Property, or independently, although Cleanup Alternative 3 is unlikely to be implemented until a development plan is in place, as it includes demolition of the existing Dry Cleaner Building.

The basis for selecting Cleanup Alternative 3 as the preferred alternative for the Dry Cleaner Building Property and rights-of-way is summarized below. The draft Cleanup Action Plan will provide a scope of work for implementing the preferred cleanup action and for compliance monitoring to document the effectiveness of the cleanup and to ensure that human health and the environment are protected.

8.1 PREFERRED ALTERNATIVE SELECTION

The rationale for selecting Cleanup Alternative 3 as the preferred alternative is based on the results of the evaluation presented in Section 7.4, Evaluation of Alternatives, which was conducted per the requirements set forth in MTCA under WAC 173-340-350 through 173-340–370, and on Farallon's best professional judgment for implementing cleanup technologies at the Site. The results of the FS cleanup alternative evaluation, including a disproportionate cost analysis conducted per WAC 173-340-360(3)(e) with Ecology (2009a) guidance, are presented in Table 11 and summarized in Table 12.

Cleanup Alternative 3 satisfies the MTCA threshold criteria specified in WAC 173-340-360(2)(a) and meets the additional requirements specified in WAC 173-340-360(2)(b). Of the six alternatives evaluated, Cleanup Alternatives 2 and 3 received the highest MTCA Composite Benefit Score (i.e., environmental benefit under MTCA) for permanence to the maximum extent practicable per WAC 173-340-360(3)(f) and Ecology (2009a): 7.8 on a scale of 0 to 10, with 10 representing the highest degree of permanence under MTCA. The basis for the MTCA Composite Benefit Score for Cleanup Alternative 3 is summarized below:

- Protectiveness is considered favorable, with a score of 8 out of 10, reflecting a high degree of certainty that remediation levels will be achieved, some uncertainty with regard to thermal treatment duration in the Shallow Zone on the Dry Cleaner Building Property, and reliance on long-term natural attenuation processes to diminish residual contaminant concentrations and achieve cleanup levels in the Shallow Zone of the rights-of-way.

- Permanence is considered favorable, with a score of 8 out of 10 because of thermal treatment transferring contamination from the subsurface to granular active carbon to an off-Site treatment, recycling, or disposal facility instead of permanent destruction on the Site.
- Long-Term Effectiveness is considered favorable, with a score of 8 out of 10 because of reliance on natural attenuation processes in the Shallow Zone in rights-of-way adjacent to the Dry Cleaner Building Property where thermal treatment would not be conducted.
- Short-Term Risk Management is considered favorable, with a score of 7 out of 10 because of use of high-voltage electricity with thermal treatment in an urban area.
- Implementability is considered favorable, with a score of 8 out of 10 because of complexities relating to permitting/authorization requirements for construction, street use, electrical work, and subsurface injections.
- Public Concerns is considered favorable, with a score of 7 out of 10 because of anticipated public perception of thermal treatment and traffic impacts during work in the rights-of-way.

The results of the disproportionate cost analysis presented in Section 7.4.3 confirm that Cleanup Alternative 3, along with Cleanup Alternative 2, offers the highest environmental benefit of the six alternatives, with an estimated cost of about $2,698,400 regardless of a development project or not. Based on these data, Cleanup Alternative 3 is considered to have the highest degree of practicability. The results of the disproportionate cost analysis are shown on Figure 15 and summarized in Table 13.

Cleanup Alternative 3 meets the requirements set forth in WAC 173-340-370, Expectations for Cleanup Action Alternatives. Cleanup Alternative 3 emphasizes treatment technologies where conditions lend themselves to treatment minimizing reliance on long-term management and control of residual contamination. Cleanup Alternative 3 includes engineering controls, including pavement in rights-of-way to contain contamination in the Shallow Zone that is impracticable to treat or remove, a concrete floor slab for the short-term on the Dry Cleaner Building Property, and a sub-slab depressurization system requirement for future development of the Dry Cleaner Building Property to mitigate future risks from residual contamination that is impracticable to remove. Institutional controls, including restrictions on use of Site groundwater, maintenance of engineering controls and a compliance groundwater monitoring program, and an environmental covenant requiring protective measures during future subsurface activities at the Site, will provide additional protection.

Cleanup Alternative 3 includes a post-source control pilot test of chemical oxidant to the Shallow Zone at the down-gradient edge of the source control area and provisions for possible additional contingency action in the right-of-way per details to be developed in the Engineering Design Report for the preferred cleanup alternative. If the pilot test demonstrates that in-situ treatment is not practicable, Cleanup Alternative 3 will rely on natural attenuation processes for Shallow Zone groundwater in the rights-of-way. In this circumstance, natural attenuation is consistent with WAC 173-340-370(7) because:

- Source control is achieved by treatment of the dry cleaning equipment source area to the maximum extent practicable;
- Residual contamination at the Dry Cleaner Building Property and adjacent rights-of-way does not pose an unacceptable threat to human health or the environment, and safeguards will be implemented to reduce the risk of exposure;
- Empirical evidence confirms that natural biodegradation of PCE is occurring in Shallow Zone groundwater and will continue to occur; and
- Long-term groundwater monitoring will be performed.

Cleanup Alternatives 2 and 5 have MTCA Composite Benefit Scores comparable to that for Cleanup Alternative 3. Assuming a concurrent development project, Cleanup Alternative 2 has an estimated cost about 40 percent greater than that of Cleanup Alternative 3, and Cleanup Alternative 5 has an estimated cost about one percent less than Cleanup Alternative 3. However, no concurrent development project is planned at this time. Cleanup Alternatives 4 and 6 received lower MTCA composite benefit scores and have higher estimated costs. The estimated cost for Cleanup Alternative 6 relative to its MTCA composite benefit score is disproportionately high. Therefore, Cleanup Alternative 6 is considered impracticable to implement.

Cleanup Alternative 1 does not satisfy all of the MTCA threshold requirements because it would not attain preliminary cleanup levels, except over the long-term as contamination attenuates naturally. Cleanup Alternative 1 relies on institutional and engineering controls and ongoing monitoring to protect human health and the environment.

8.2 IMPLEMENTATION

Technical elements, including preliminary cleanup levels, points of compliance, and remediation levels, for the remedial action at the Site are described in Section 6 and are summarized for Cleanup Alternative 3 in Table 14 for each of the potential exposure media at the Site: indoor air, soil, and groundwater. Cleanup Alternative 3 is designed to achieve preliminary cleanup levels at both standard and conditional points of compliance, and will be protective of indoor air inhalation in a future structure when the property is developed. Cleanup Alternative 3 will be protective of direct contact exposure to PCE in soil and groundwater, and the proposed preliminary cleanup level for soil, the MTCA Method A soil cleanup level, is protective of groundwater.

Remediation levels are not specified for indoor air, as the only building on the Site, the Dry Cleaner Building, will be demolished as part of cleanup implementation. Remediation levels are proposed for soil and groundwater. Achieving a 2 mg/kg remediation level for thermal treatment of PCE in soil equates to an approximately 90 percent reduction of PCE mass at the Site, is considerably below the MTCA Method B soil cleanup level protective of direct contact exposure, and will result in soil suitable for contained-out disposal at a Subtitle D facility if future development plans require excavation. Thermal treatment to achieve the lower MTCA Method A soil cleanup level for PCE protective of groundwater is not practicable, as demonstrated by the analysis presented in Section 7.4.3, Disproportionate Cost Analysis. The groundwater remediation level for PCE in the Shallow Zone within the thermal treatment area is 100 µg/l, and in the Deep Zone throughout the Site, 20 µg/l. Remediation levels for PCE in groundwater are based on practicability considerations for the selected treatment technologies. The preliminary cleanup level for PCE in groundwater is the MTCA Method A groundwater cleanup level based on applicable state and federal laws as protective of groundwater.

8.3 CLEANUP ACTION ELEMENTS

Figure 16 shows six areas where remedial technologies will be applied. Areas 1 and 2 are the thermal treatment area where Shallow Zone soil PCE concentrations exceed the 2 mg/kg soil remediation level (i.e., the primary source area). Area 3 is the area within the Dry Cleaner Building Property where PCE concentrations in soil currently are below the 2 mg/kg remediation level, and soil will not be thermally treated because levels are protective of direct contact exposure, and soil with PCE concentrations below 14 mg/kg is suitable for disposal at a Subtitle D permitted facility with an Ecology contained-out designation if future development plans require excavation. Groundwater compliance monitoring will provide empirical data to demonstrate that residual soil concentrations on the Dry Cleaner Building Property will be protective of groundwater following completion of the thermal treatment at conditional point of compliance monitoring wells at the down-gradient Dry Cleaner Building Property boundary. Area 4 is the proximate area of the Woodlawn Avenue Northeast right-of-way where the Shallow and Deep Zones are affected by releases from the dry cleaning equipment source area. Areas 5 and 6 consist of those areas in the rights-of-way where only the Shallow Zone has been affected by releases at the Site.

Although there is no plan for development of the Dry Cleaner Building Property at this time, Cleanup Alternative 3 may be conducted in conjunction with or independently of development. The general sequence of work for implementing Cleanup Alternative 3 is summarized below:

- Demolish the Dry Cleaner Building, leaving the concrete floor slab as a physical barrier to Site contamination and as a work surface;
- Secure the Dry Cleaner Building Property with a construction wall and other measures.
- Thermally treat Shallow Zone soil and groundwater in Areas 1 and 2.

- Remove the decommissioned USTs in the Woodlawn Avenue Northeast right-of-way and beneath the Dry Cleaner Building floor slab.
- Apply a chemical oxidant to the Shallow Zone along the up-gradient edge of the Woodlawn Avenue Northeast right-of-way as a pilot test, and perform performance groundwater monitoring. (Dependent on the results of performance monitoring, additional contingency actions for treatment in the Shallow Zone of the right-of-way may be performed per the Engineering Design Report for the preferred cleanup alternative).
- Treat the affected Deep Zone on the Dry Cleaner Building Property and down-gradient in the Woodlawn Avenue Northeast right-of-way, Areas 1, 2, and 4 with in-situ chemical oxidation or bioremediation using up to 18 injection points and up to two injection events.

Institutional controls will include an environmental covenant to:

- Prohibit use of groundwater at the Site for drinking water;
- Require development and implementation of an Environmental Media Management Plan governing the handling of potentially contaminated media during future construction work on the Dry Cleaner Building Property and in the rights-of-way adjacent to the Dry Cleaner Building Property where soil and/or groundwater exceeding applicable cleanup levels may be encountered;
- Require long-term groundwater compliance monitoring, and monitoring and treatment of groundwater during potential future dewatering associated with construction; and
- Maintain engineering controls.

Engineering controls will include:

- Maintenance of physical barriers (i.e., concrete floor slabs) for protection from indoor air exposure in the existing Dry Cleaner Building or in new construction, which also will include a sub-slab depressurization system; and

- Maintenance of physical barriers (i.e., road pavement) for protection from direct contact with soil and shallow groundwater.

8.3.1 Compliance Monitoring

Compliance monitoring will include the following:

- During thermal treatment: protection, performance, and confirmational soil and groundwater monitoring.
- During Deep-Zone Chemical Oxidation or Bioremediation: protection, performance, and confirmational groundwater monitoring.
- Post remediation: Shallow Zone confirmational compliance monitoring down-gradient of the source control area, to include eight monitoring events through Year 3: quarterly during Year 1, and semiannually during Years 2 and 3. Compliance monitoring will then convert to an annual schedule for Years 4 through 10, and once every 5 years for Years 11 through 35. Shallow Zone compliance groundwater monitoring will be conducted in approximately four Shallow Zone monitoring wells, although additional monitoring locations may be identified in the compliance monitoring plan for Years 1 through 3.

  Long-term groundwater monitoring in the Deep Zone will include approximately four Deep Zone monitoring wells annually for 5 years, and every 5 years for years 10 through 35.

8.3.2 Restoration Time Frame

Thermal treatment of the Shallow Zone will take approximately 8 months to achieve remediation levels. Chemical oxidation or bioremediation in the Deep Zone will require up to 2 additional years to attain the proposed remediation levels. Residual groundwater contamination will require up to 25 to 35 years to naturally attenuate and achieve preliminary cleanup levels in the Deep Zone and in the Shallow Zone.

8.3.3 Contingency Actions

If indoor air in a future structure replacing the Dry Cleaner Building is affected by residual soil or groundwater contamination at the Site, the installed vapor intrusion mitigation measures will be inspected for proper function, and enhanced if necessary. Concrete floors and retaining walls will be inspected for cracking. Sub-grade maintenance may result in breaching the vapor barrier, requiring repairs. If the sub-slab depressurization system is passive, it may be enhanced by applying a vacuum. Other enhancements may include providing additional sub-slab depressurization conduits.

If thermal treatment remediation levels for Shallow Zone soil or groundwater are not achieved during the planned treatment period, the contingency action will be to extend the treatment period or install additional electrodes to the extent practicable. Likewise, if chemical oxidation or bioremediation of Deep Zone soil and groundwater does not achieve remediation levels, the contingency action will be to conduct additional injection events, possibly using additional injection points.

Per Farallon (2013b), with details to be provided in the Engineering Design Report for the preferred cleanup alternative, if post-source control Shallow Zone application of chemical oxidant on the up-gradient edge of the Woodlawn Avenue Northeast right-of-way achieves substantive reduction of PCE in proximate monitoring wells, additional contingency pilot testing of injection of chemical oxidant will be conducted in the Shallow Zone in the Woodlawn Avenue Northeast right-of-way. Per details to be provided in the Engineering Design Report for the preferred cleanup alternative, if the pilot testing is successful, full-scale contingency application of Shallow Zone chemical oxidation in the right-of-way will be evaluated and implemented if it is determined to be implementable and practicable.

Specific design details concerning implementation of the preferred cleanup alternative, the decision process for evaluating whether modifications to the selected approach are warranted, and the monitoring requirements that will be implemented to document effectiveness will be provided in the Engineering Design Report for the preferred cleanup alternative.

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10.0 LIMITATIONS

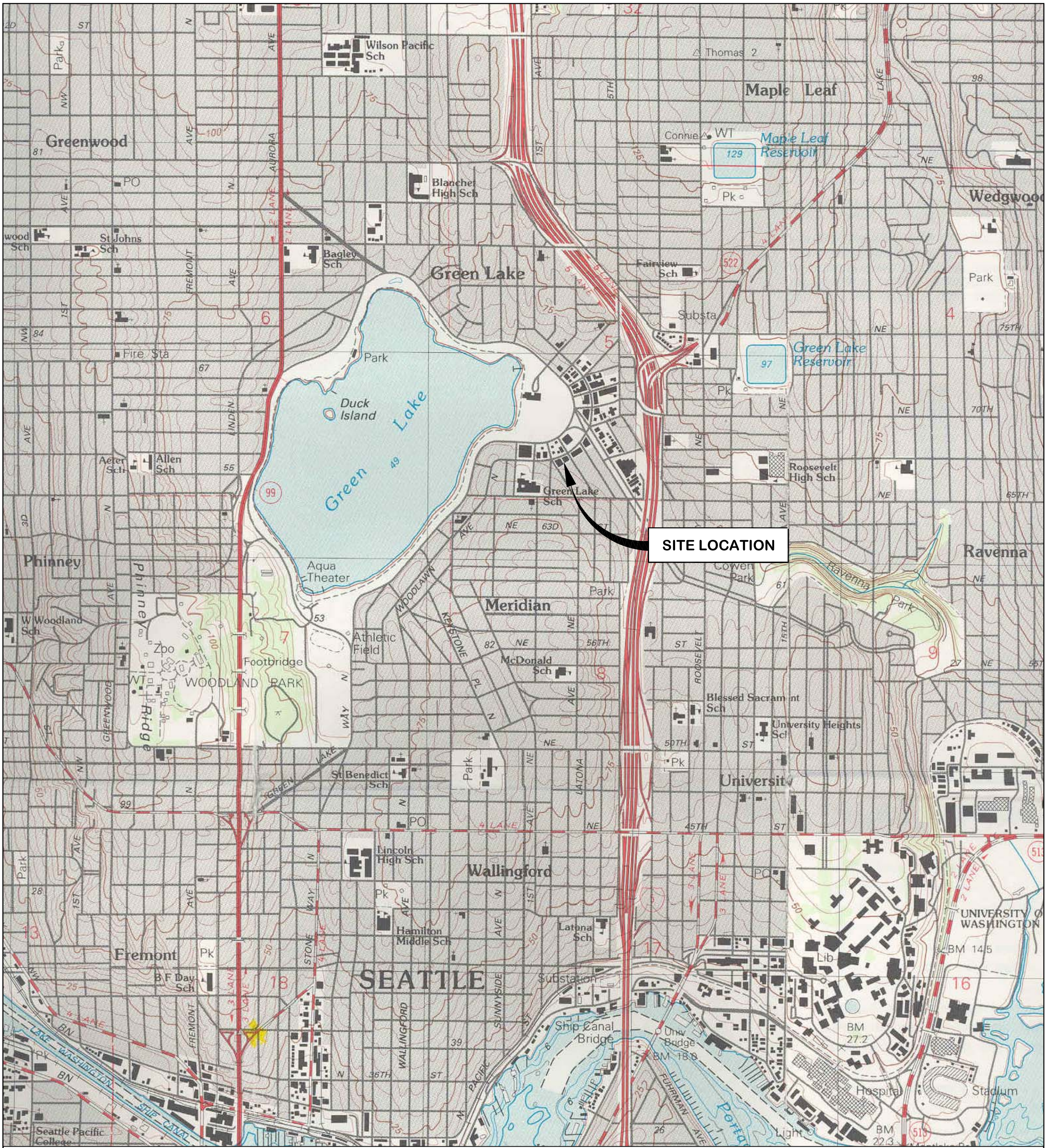
The conclusions and recommendations contained in this report are based on professional opinions with regard to the subject matter. These opinions have been arrived at in accordance with currently accepted hydrogeologic and engineering standards and practices applicable to this location, and are subject to the following limitations.

Certain information used by Farallon in this report has been obtained, reviewed, and/or evaluated from various sources believed to be reliable. Although Farallon's conclusions, opinions, and recommendations are based in part on such information, Farallon's services did not include verification of its accuracy or authenticity. Should such information prove to be inaccurate or unreliable, Farallon reserves the right to amend or revise its conclusions, opinions, and/or recommendations.

FIGURES

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002



REFERENCE: 7.5 MINUTE USGS QUADRANGLE SEATTLE NORTH, WASHINGTON. DATED 1981
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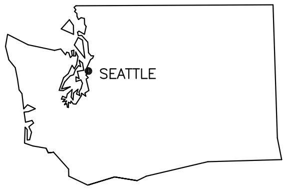
DRAFT



WASHINGTON

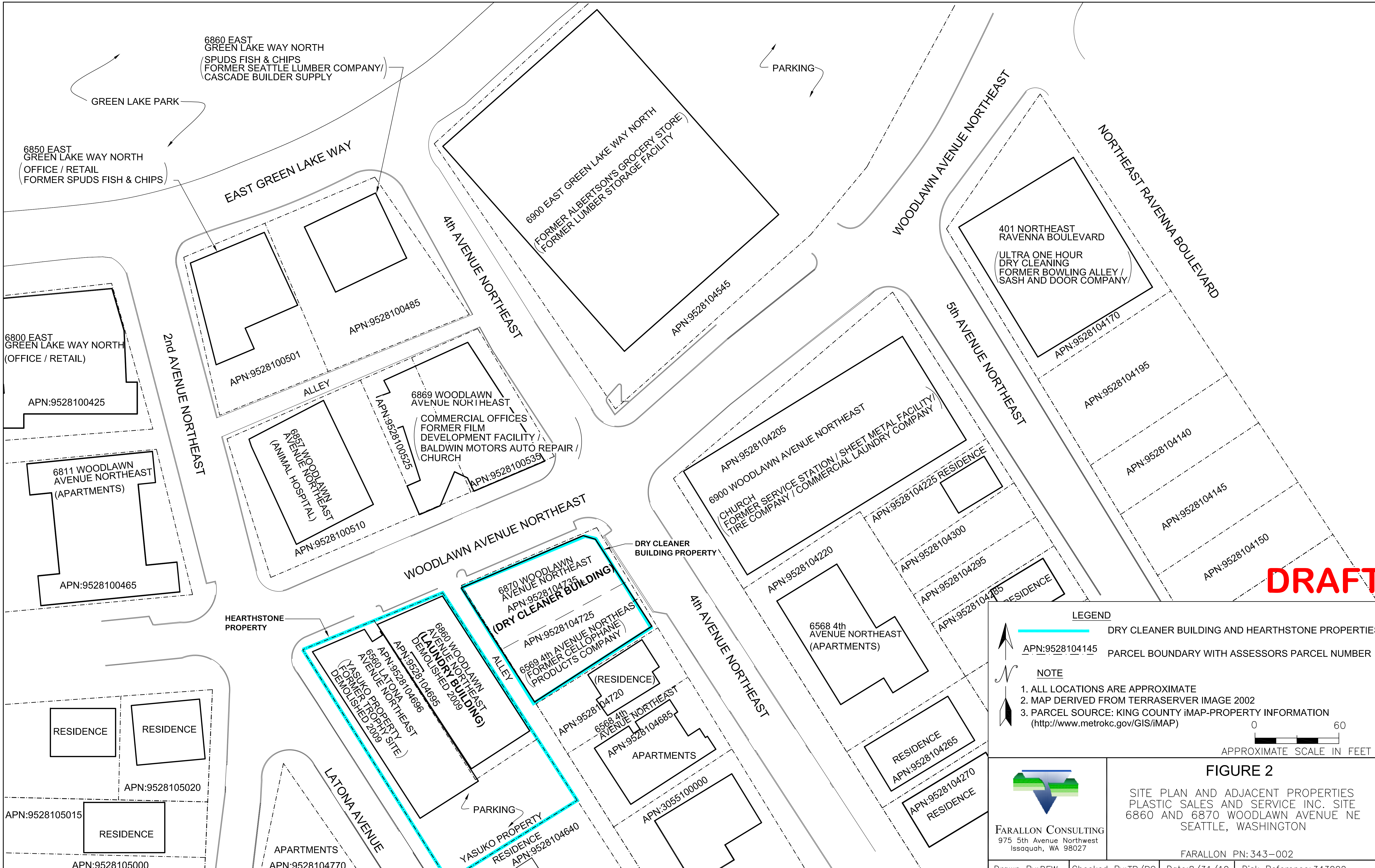
FARALLON CONSULTING
975 5th Avenue Northwest
Issaquah, WA 98027

FIGURE 1

SITE LOCATION MAP
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343–002

Drawn By: DEW	Checked By: TB/RC	Date: 8/31/10	Disk Reference: 343002a



DRAFT

LEGEND

DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES

APN:9528104145 PARCEL BOUNDARY WITH ASSESSORS PARCEL NUMBER

NOTE

1. ALL LOCATIONS ARE APPROXIMATE
2. MAP DERIVED FROM TERRASERVER IMAGE 2002
3. PARCEL SOURCE: KING COUNTY iMAP-PROPERTY INFORMATION (http://www.metrokc.gov/GIS/iMAP)

0 60
APPROXIMATE SCALE IN FEET

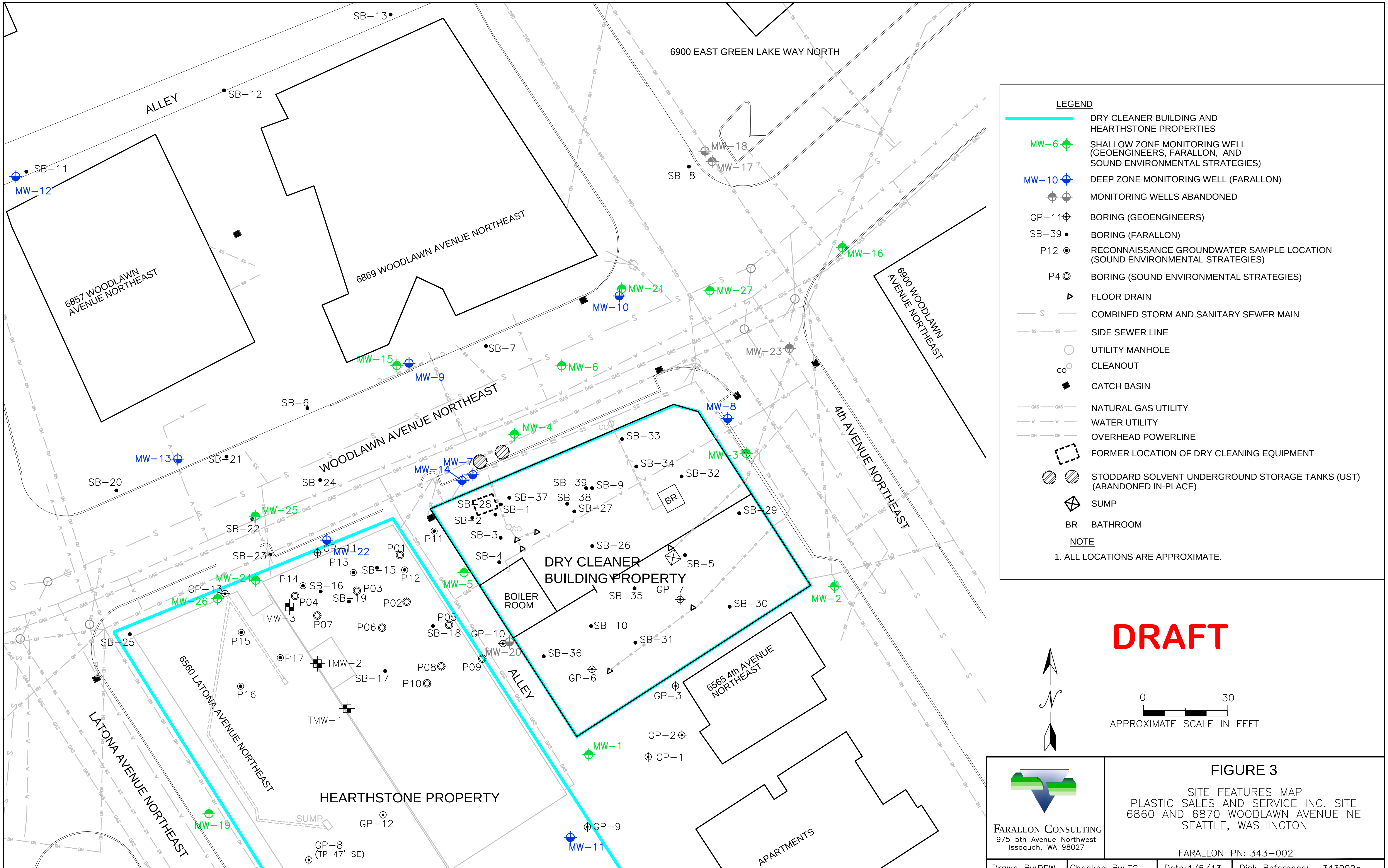
FARALLON CONSULTING
975 5th Avenue Northwest
Issaquah, WA 98027

FIGURE 2

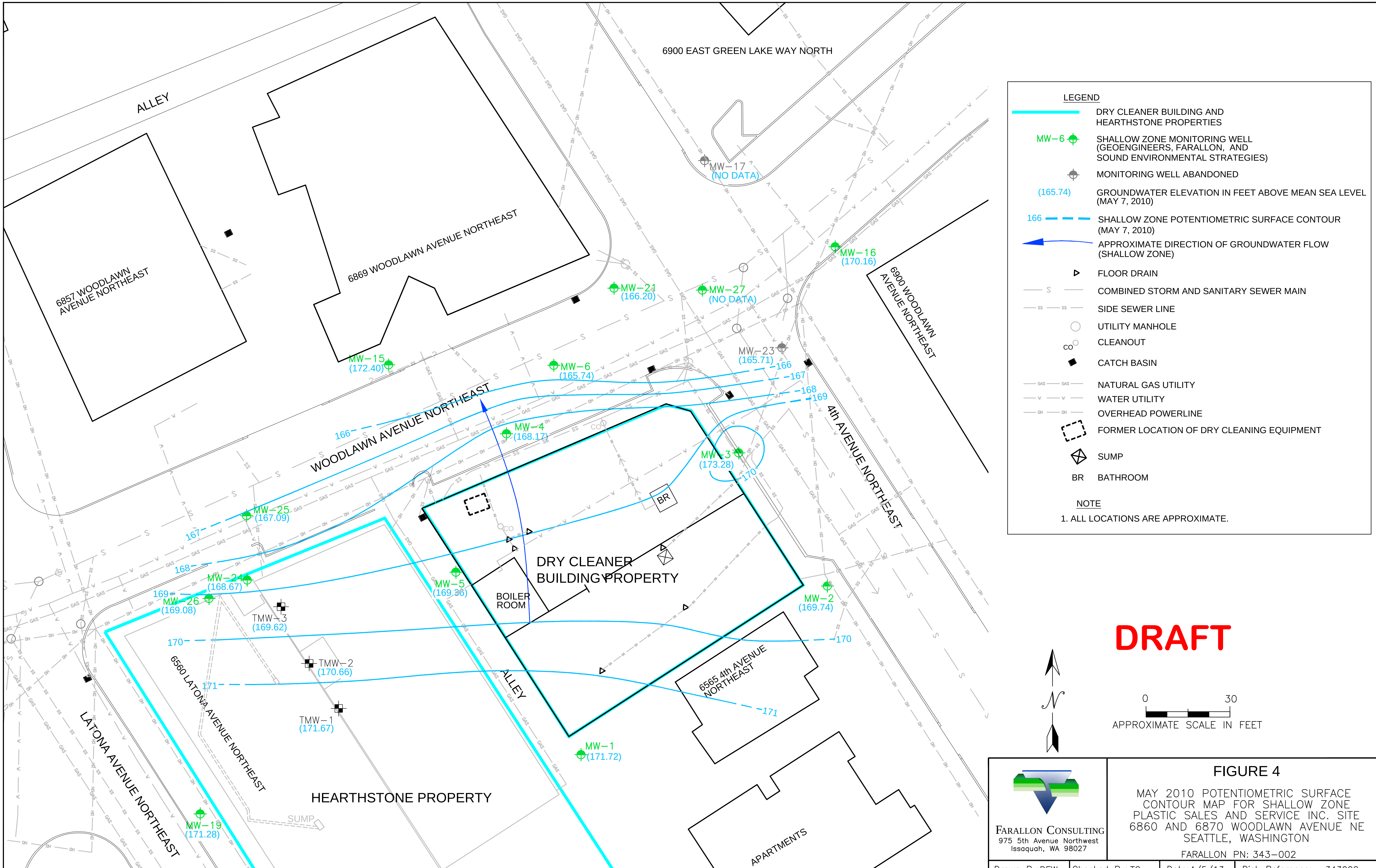
SITE PLAN AND ADJACENT PROPERTIES
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343-002

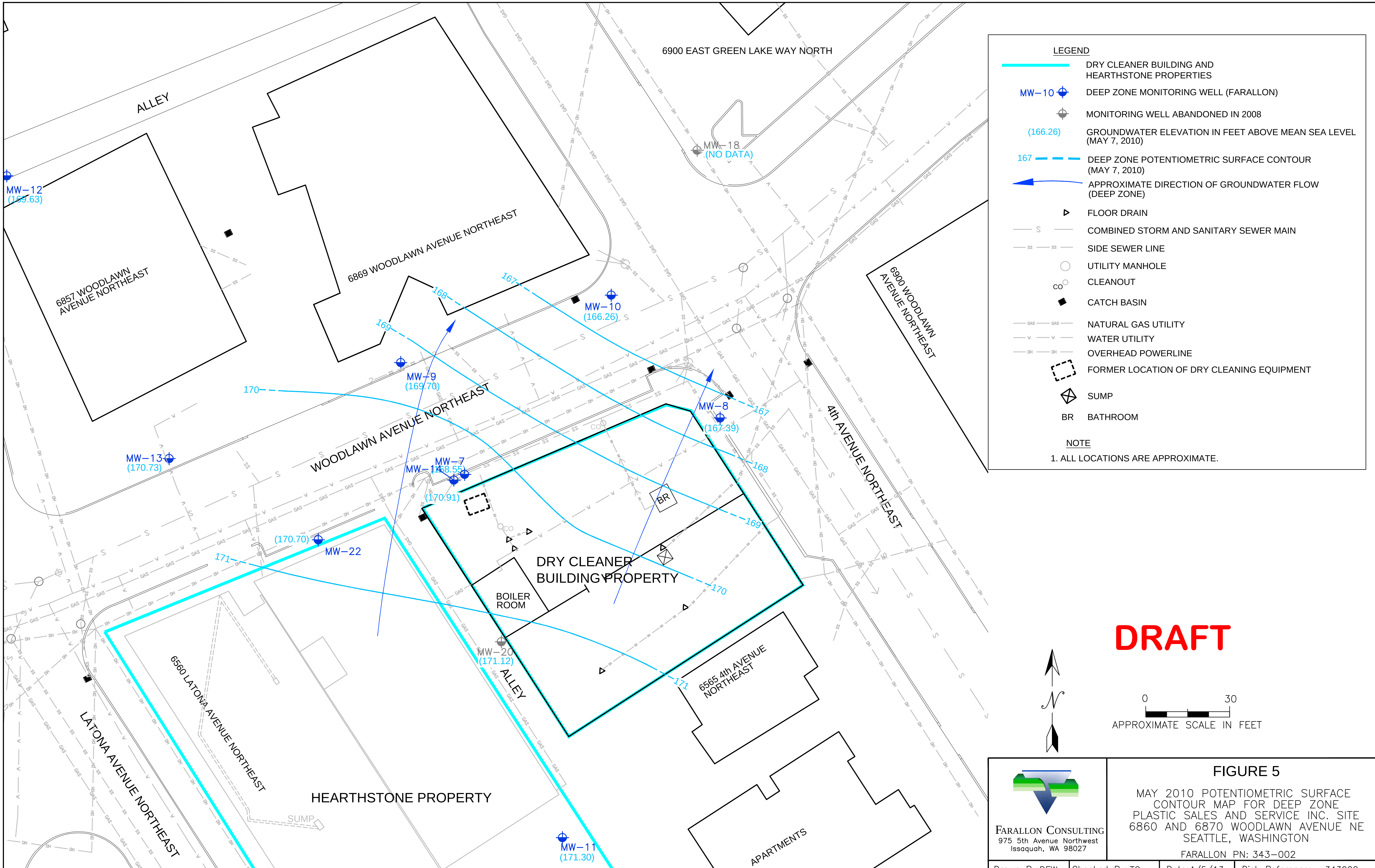
Drawn By: DEW	Checked By: TB/RC	Date: 8/31/10	Disk Reference: 343002a



LEGEND
DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
MW-6 SHALLOW ZONE MONITORING WELL (GEOENGINEERS, FARALLON, AND SOUND ENVIRONMENTAL STRATEGIES)
MW-10 DEEP ZONE MONITORING WELL (FARALLON)
MONITORING WELLS ABANDONED
GP-11 BORING (GEOENGINEERS)
SB-39 BORING (FARALLON)
P12 RECONNAISSANCE GROUNDWATER SAMPLE LOCATION (SOUND ENVIRONMENTAL STRATEGIES)
P4 BORING (SOUND ENVIRONMENTAL STRATEGIES)
FLOOR DRAIN
COMBINED STORM AND SANITARY SEWER MAIN
SIDE SEWER LINE
UTILITY MANHOLE
CO CLEANOUT
CATCH BASIN
NATURAL GAS UTILITY
WATER UTILITY
OVERHEAD POWERLINE
FORMER LOCATION OF DRY CLEANING EQUIPMENT
STODDARD SOLVENT UNDERGROUND STORAGE TANKS (UST) (ABANDONED IN-PLACE)
SUMP
BR BATHROOM
NOTE
1. ALL LOCATIONS ARE APPROXIMATE.
DRAFT
N
0 30
APPROXIMATE SCALE IN FEET
6900 EAST GREEN LAKE WAY NORTH
ALLEY
6857 WOODLAWN AVENUE NORTHEAST
6869 WOODLAWN AVENUE NORTHEAST
6900 WOODLAWN AVENUE NORTHEAST
WOODLAWN AVENUE NORTHEAST
4th AVENUE NORTHEAST
LATONA AVENUE NORTHEAST
6560 LATONA AVENUE NORTHEAST
6565 4th AVENUE NORTHEAST
APARTMENTS
DRY CLEANER BUILDING PROPERTY
BOILER ROOM
BR
HEARTHSTONE PROPERTY
SUMP
SB-13
SB-12
SB-11
MW-12
SB-8
MW-18
MW-17
MW-21
MW-10
MW-27
MW-16
MW-23
SB-7
MW-15
MW-9
MW-6
SB-6
MW-8
MW-4
MW-13
SB-21
MW-7
MW-14
SB-33
SB-34
SB-32
MW-3
SB-20
SB-24
SB-39
SB-9
SB-38
SB-37
SB-27
SB-28
SB-1
SB-2
SB-29
MW-25
SB-22
P11
SB-3
SB-26
SB-4
SB-5
SB-23
GP-11
MW-22
P13
P01
SB-15
P12
MW-24
P14
SB-16
P03
MW-5
GP-7
MW-2
GP-13
MW-26
P04
SB-19
P02
SB-35
SB-30
TMW-3
P07
P06
P05
SB-18
GP-10
SB-10
SB-25
P15
MW-20
SB-31
P17
TMW-2
SB-17
P08
P09
SB-36
P16
P10
GP-6
GP-3
TMW-1
GP-2
MW-1
GP-1
MW-19
GP-12
GP-9
GP-8 (TP 47' SE)
MW-11
FARALLON CONSULTING
975 5th Avenue Northwest
Issaquah, WA 98027
FIGURE 3
SITE FEATURES MAP
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON
FARALLON PN: 343-002
Drawn By:DEW
Checked By: TC
Date:4/5/13
Disk Reference: 343002a



ALLEY
6857 WOODLAWN AVENUE NORTHEAST
6869 WOODLAWN AVENUE NORTHEAST
6900 EAST GREEN LAKE WAY NORTH
6900 WOODLAWN AVENUE NORTHEAST
WOODLAWN AVENUE NORTHEAST
4th AVENUE NORTHEAST
LATONA AVENUE NORTHEAST
6560 LATONA AVENUE NORTHEAST
6565 4th AVENUE NORTHEAST
APARTMENTS
DRY CLEANER BUILDING PROPERTY
HEARTHSTONE PROPERTY
BOILER ROOM
BR
SUMP
ALLEY
MW-17 (NO DATA)
MW-21 (166.20)
MW-27 (NO DATA)
MW-16 (170.16)
MW-23 (165.71)
MW-15 (172.40)
MW-6 (165.74)
MW-4 (168.17)
MW-3 (173.28)
MW-25 (167.09)
MW-24 (168.67)
MW-26 (169.08)
MW-5 (169.36)
MW-2 (169.74)
MW-1 (171.72)
MW-19 (171.28)
TMW-3 (169.62)
TMW-2 (170.66)
TMW-1 (171.67)
166
167
168
169
170
171
LEGEND
DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
MW-6 SHALLOW ZONE MONITORING WELL (GEOENGINEERS, FARALLON, AND SOUND ENVIRONMENTAL STRATEGIES)
MONITORING WELL ABANDONED
(165.74) GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL (MAY 7, 2010)
166 SHALLOW ZONE POTENTIOMETRIC SURFACE CONTOUR (MAY 7, 2010)
APPROXIMATE DIRECTION OF GROUNDWATER FLOW (SHALLOW ZONE)
FLOOR DRAIN
COMBINED STORM AND SANITARY SEWER MAIN
SIDE SEWER LINE
UTILITY MANHOLE
CO CLEANOUT
CATCH BASIN
NATURAL GAS UTILITY
WATER UTILITY
OVERHEAD POWERLINE
FORMER LOCATION OF DRY CLEANING EQUIPMENT
SUMP
BR BATHROOM
NOTE
1. ALL LOCATIONS ARE APPROXIMATE.
DRAFT
N
0 30
APPROXIMATE SCALE IN FEET
FARALLON CONSULTING
975 5th Avenue Northwest
Issaquah, WA 98027
FIGURE 4
MAY 2010 POTENTIOMETRIC SURFACE CONTOUR MAP FOR SHALLOW ZONE
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON
FARALLON PN: 343-002
Drawn By:DEW
Checked By: TC
Date:4/5/13
Disk Reference: 343002a



ALLEY
6900 EAST GREEN LAKE WAY NORTH
6857 WOODLAWN AVENUE NORTHEAST
6869 WOODLAWN AVENUE NORTHEAST
WOODLAWN AVENUE NORTHEAST
6900 WOODLAWN AVENUE NORTHEAST
4th AVENUE NORTHEAST
MW-12 (169.63)
MW-18 (NO DATA)
MW-10 (166.26)
MW-9 (169.70)
MW-8 (167.39)
MW-13 (170.73)
MW-7 (168.55)
MW-14 (170.91)
MW-22 (170.70)
MW-20 (171.12)
MW-11 (171.30)
167
168
169
170
171
DRY CLEANER BUILDING PROPERTY
BOILER ROOM
BR
CO
6565 4th AVENUE NORTHEAST
ALLEY
6560 LATONA AVENUE NORTHEAST
LATONA AVENUE NORTHEAST
HEARTHSTONE PROPERTY
SUMP
APARTMENTS
LEGEND
DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
MW-10 DEEP ZONE MONITORING WELL (FARALLON)
MONITORING WELL ABANDONED IN 2008
(166.26) GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL (MAY 7, 2010)
167 DEEP ZONE POTENTIOMETRIC SURFACE CONTOUR (MAY 7, 2010)
APPROXIMATE DIRECTION OF GROUNDWATER FLOW (DEEP ZONE)
FLOOR DRAIN
COMBINED STORM AND SANITARY SEWER MAIN
SIDE SEWER LINE
UTILITY MANHOLE
CO CLEANOUT
CATCH BASIN
NATURAL GAS UTILITY
WATER UTILITY
OVERHEAD POWERLINE
FORMER LOCATION OF DRY CLEANING EQUIPMENT
SUMP
BR BATHROOM
NOTE
1. ALL LOCATIONS ARE APPROXIMATE.
DRAFT
N
0 30
APPROXIMATE SCALE IN FEET
FARALLON CONSULTING
975 5th Avenue Northwest
Issaquah, WA 98027
FIGURE 5
MAY 2010 POTENTIOMETRIC SURFACE CONTOUR MAP FOR DEEP ZONE
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON
FARALLON PN: 343-002
Drawn By: DEW
Checked By: TC
Date: 4/5/13
Disk Reference: 343002a

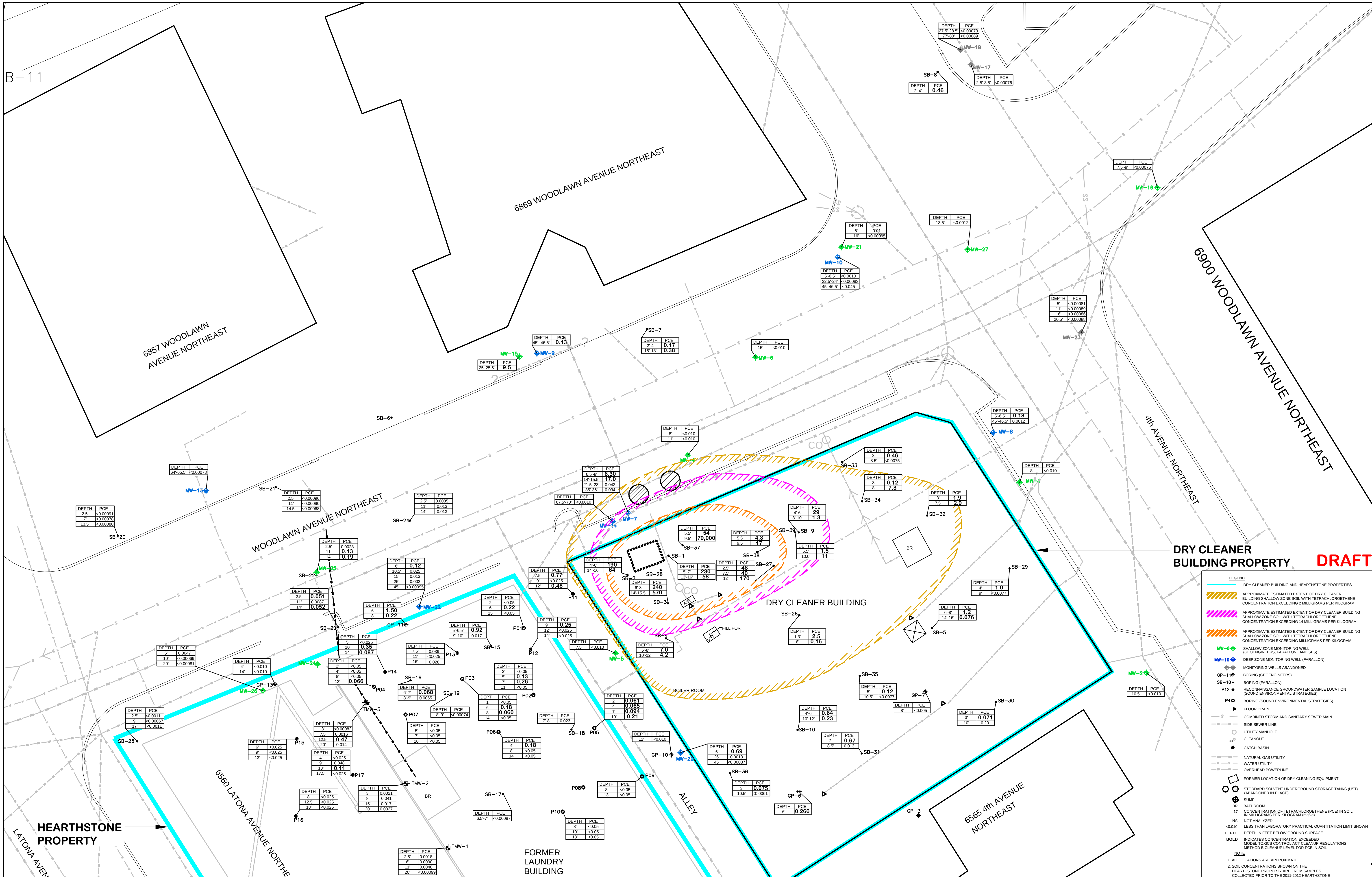


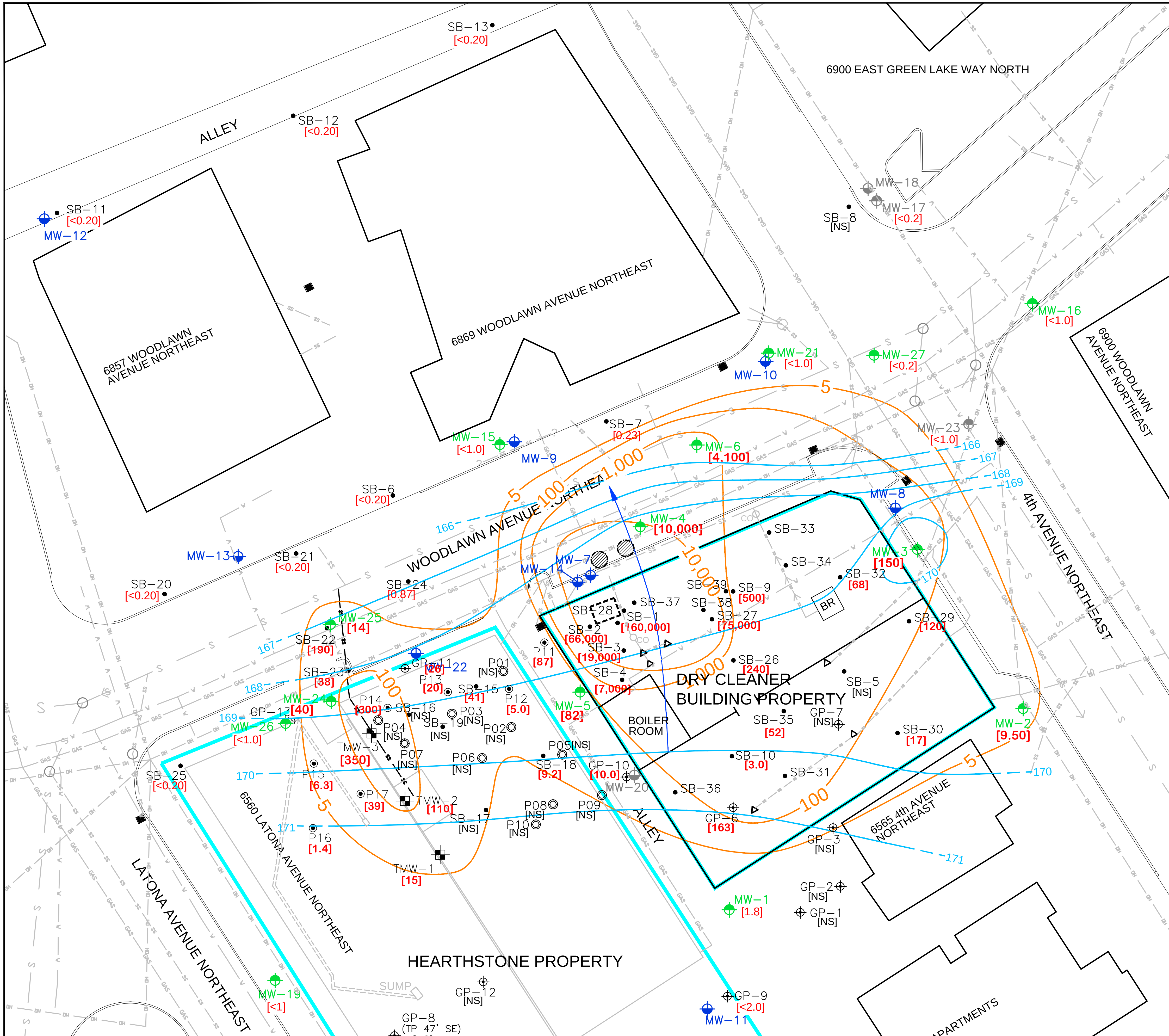
FIGURE 6

SITE PLAN SHOWING PCE CONCENTRATIONS IN SOIL
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343-002

FARALLON CONSULTING
975 5th Avenue Northwest
Issaquah, WA 98027

Drawn By: DEW	Checked By: TC	Date: 11/30/12	Disk Reference: 343002a



LEGEND

- DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
- MW-6 — SHALLOW ZONE MONITORING WELL (GEOENGINEERS, FARALLON, AND SOUND ENVIRONMENTAL STRATEGIES)
- MW-10 — DEEP ZONE MONITORING WELL (FARALLON)
- MONITORING WELLS ABANDONED
- GP-11 — BORING (GEOENGINEERS)
- SB-10 — BORING (FARALLON)
- P12 — RECONNAISSANCE GROUNDWATER SAMPLE LOCATION (SOUND ENVIRONMENTAL STRATEGIES)
- P4 — BORING (SOUND ENVIRONMENTAL STRATEGIES)
- FLOOR DRAIN
- S — COMBINED STORM AND SANITARY SEWER MAIN
- SS — SIDE SEWER LINE
- UTILITY MANHOLE
- CO — CLEANOUT
- CATCH BASIN
- GAS — NATURAL GAS UTILITY
- V — WATER UTILITY
- OH — OVERHEAD POWERLINE
- FORMER LOCATION OF DRY CLEANING EQUIPMENT
- STODDARD SOLVENT UNDERGROUND STORAGE TANKS (UST) (ABANDONED IN-PLACE)
- SUMP
- BR — BATHROOM
- [NS] — NO GROUNDWATER SAMPLE OBTAINED
- [29] — MOST RECENT CONCENTRATION OF TETRACHLOROETHENE (PCE) IN GROUNDWATER IN MICROGRAMS PER LITER (µg/L)
- [<0.2] — LESS THAN LABORATORY PRACTICAL QUANTITATION LIMIT SHOWN
- **BOLD** — INDICATES CONCENTRATION EXCEEDED MODEL TOXICS CONTROL ACT CLEANUP REGULATION METHOD A CLEANUP LEVEL FOR PCE IN GROUNDWATER
- 5 — ISOCONCENTRATION OF PCE IN SHALLOW ZONE GROUNDWATER (µg/L)
- 166.00 — SHALLOW ZONE POTENTIOMETRIC SURFACE CONTOUR (MAY 2010)
- APPROXIMATE DIRECTION OF GROUNDWATER FLOW (SHALLOW ZONE)

NOTE

1. ALL LOCATIONS ARE APPROXIMATE.
2. GROUNDWATER CONCENTRATIONS SHOWN ON THE HEARTHSTONE PROPERTY ARE FROM SAMPLES COLLECTED PRIOR TO THE 2011-2012 HEARTHSTONE PROPERTY INTERIM ACTION

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APPROXIMATE SCALE IN FEET

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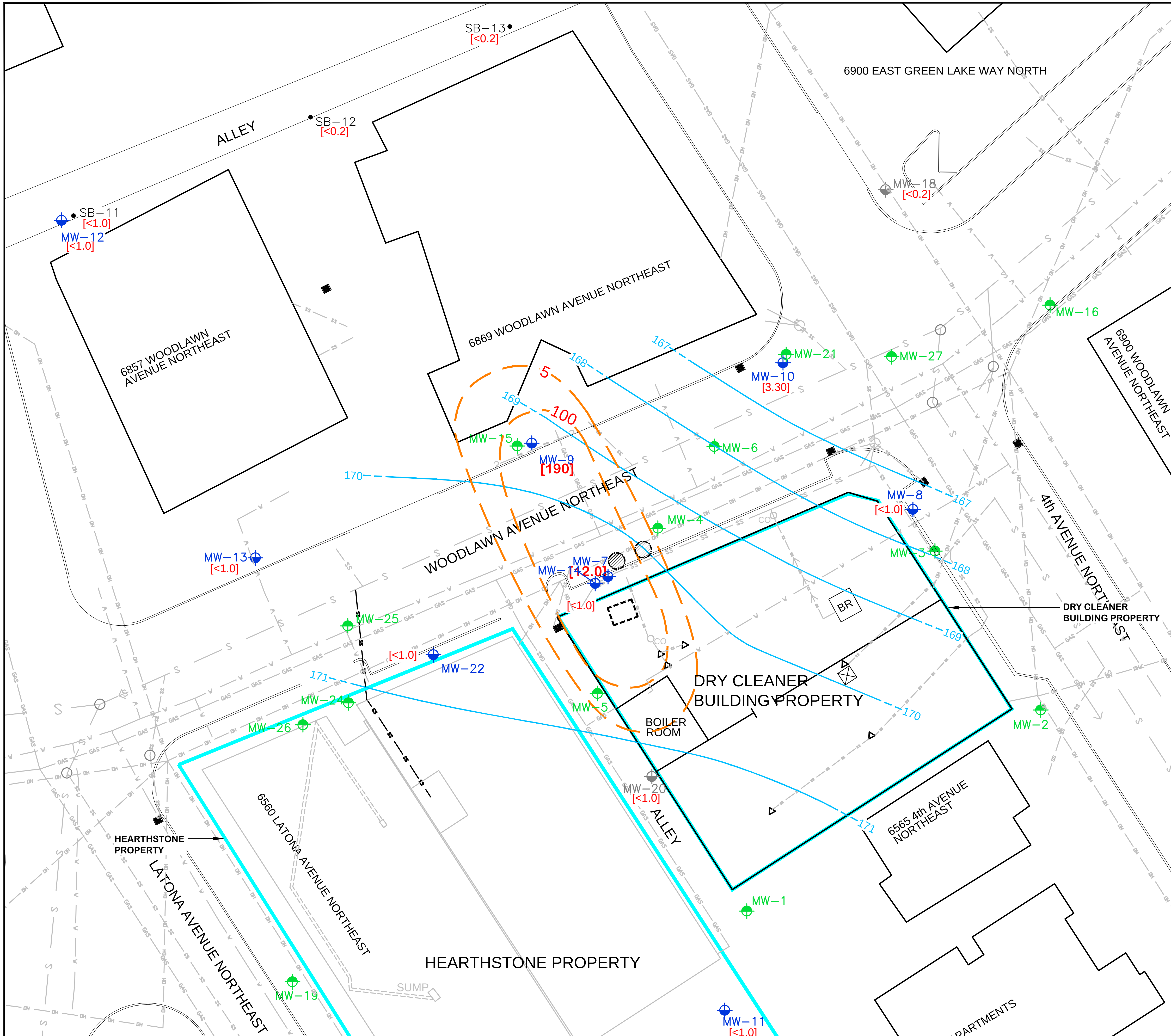
FIGURE 7

SITE PLAN SHOWING
PCE IN SHALLOW ZONE GROUNDWATER
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343-002

Drawn By:DEW	Checked By: TC	Date:4/9/13	Disk Reference: 343002a



LEGEND

- DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
- MW-6 — SHALLOW ZONE MONITORING WELL (GEOENGINEERS, FARALLON, AND SOUND ENVIRONMENTAL STRATEGIES)
- MW-10 — DEEP ZONE MONITORING WELL (FARALLON)
- MONITORING WELL ABANDONED
- FLOOR DRAIN
- S — COMBINED STORM AND SANITARY SEWER MAIN
- SS — SIDE SEWER LINE
- UTILITY MANHOLE
- CO — CLEANOUT
- CATCH BASIN
- GAS — NATURAL GAS UTILITY
- V — WATER UTILITY
- OH — OVERHEAD POWERLINE
- FORMER LOCATION OF DRY CLEANING EQUIPMENT
- STODDARD SOLVENT UNDERGROUND STORAGE TANKS (UST) (ABANDONED IN-PLACE)
- SUMP
- BR — BATHROOM
- [29] — MOST RECENT CONCENTRATION OF TETRACHLOROETHENE (PCE) IN GROUNDWATER IN MICROGRAMS PER LITER (µg/L)
- [<0.2] — LESS THAN LABORATORY PRACTICAL QUANTITATION LIMIT SHOWN
- **BOLD** — INDICATES CONCENTRATION EXCEEDED MODEL TOXICS CONTROL ACT CLEANUP REGULATION METHOD A CLEANUP LEVEL FOR PCE IN GROUNDWATER
- 5 — ISOCONCENTRATION OF PCE IN DEEP ZONE GROUNDWATER (µg/L)
- 166.00 — DEEP ZONE POTENTIOMETRIC SURFACE CONTOUR (MAY 7, 2010)

NOTE

1. ALL LOCATIONS ARE APPROXIMATE.
2. SHALLOW ZONE BORINGS AND RECONNAISSANCE GROUNDWATER SAMPLING LOCATIONS NOT SHOWN

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APPROXIMATE SCALE IN FEET

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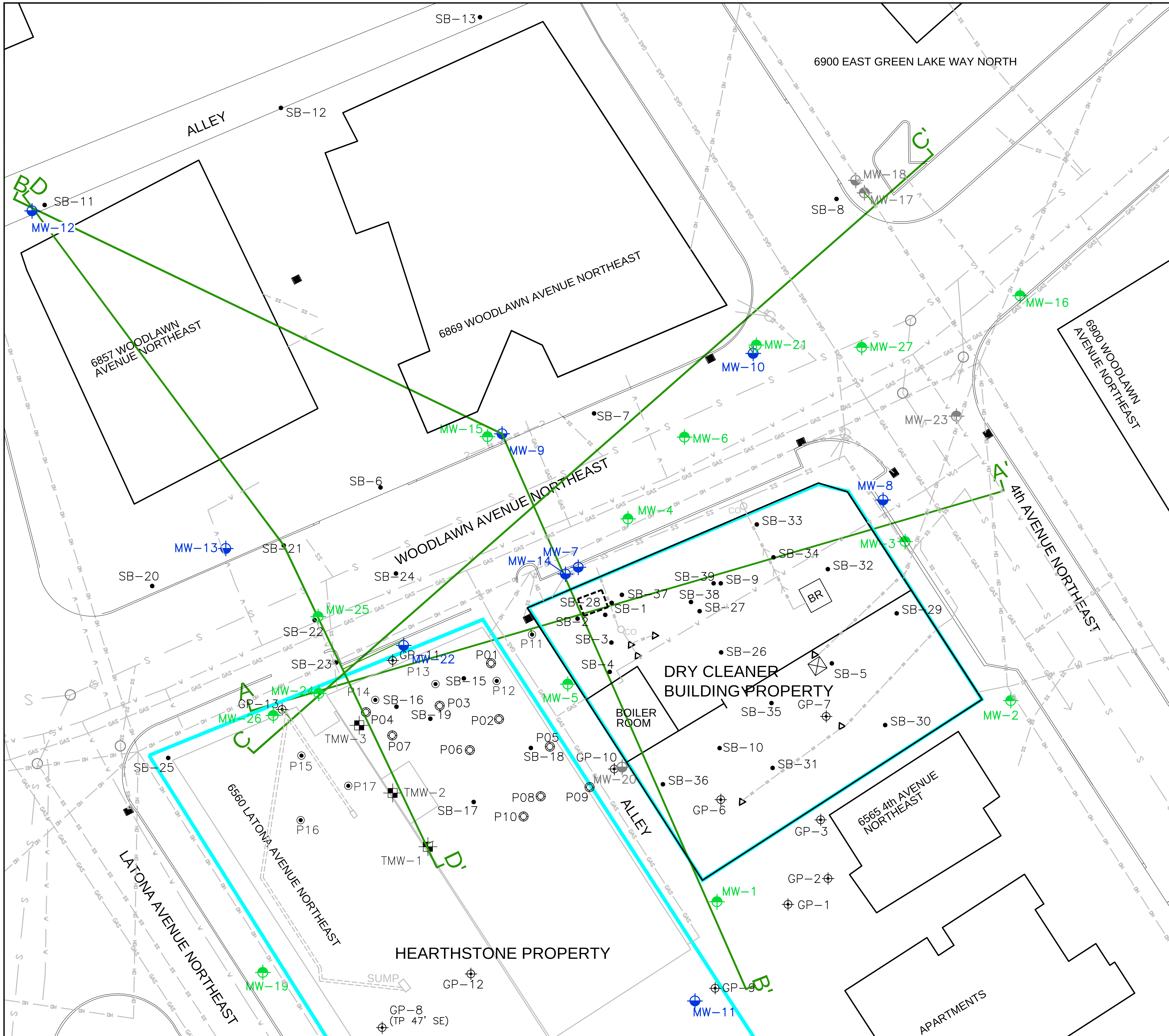
FIGURE 8

SITE PLAN SHOWING
PCE IN DEEP ZONE GROUNDWATER
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343-002

Drawn By:DEW	Checked By: TC	Date:4/9/13	Disk Reference: 343002a



LEGEND

- DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
- A — A' LINE OF CROSS-SECTION
- MW-6 SHALLOW ZONE MONITORING WELL (GEOENGINEERS, FARALLON, AND SOUND ENVIRONMENTAL STRATEGIES)
- MW-10 DEEP ZONE MONITORING WELL (FARALLON)
- MONITORING WELLS ABANDONED
- GP-11 BORING (GEOENGINEERS)
- SB-10 BORING (FARALLON)
- P12 RECONNAISSANCE GROUNDWATER SAMPLE LOCATION (SOUND ENVIRONMENTAL STRATEGIES)
- P4 BORING (SOUND ENVIRONMENTAL STRATEGIES)
- FLOOR DRAIN
- COMBINED STORM AND SANITARY SEWER MAIN
- SIDE SEWER LINE
- UTILITY MANHOLE
- CO CLEANOUT
- CATCH BASIN
- NATURAL GAS UTILITY
- WATER UTILITY
- OVERHEAD POWERLINE
- FORMER LOCATION OF DRY CLEANING EQUIPMENT
- SUMP
- BR BATHROOM

NOTE

1. UTILITY LOCATIONS BASED ON SURVEY PROVIDED BY CITY OF SEATTLE PUBLIC UTILITIES, DATED JUNE 2008

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APPROXIMATE SCALE IN FEET

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FIGURE 9

CROSS-SECTION LINES FOR A-A', B-B', C-C', AND D-D'
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343-002

Drawn By: DEW	Checked By: TC	Date: 4/9/13	Disk Reference: 343002a

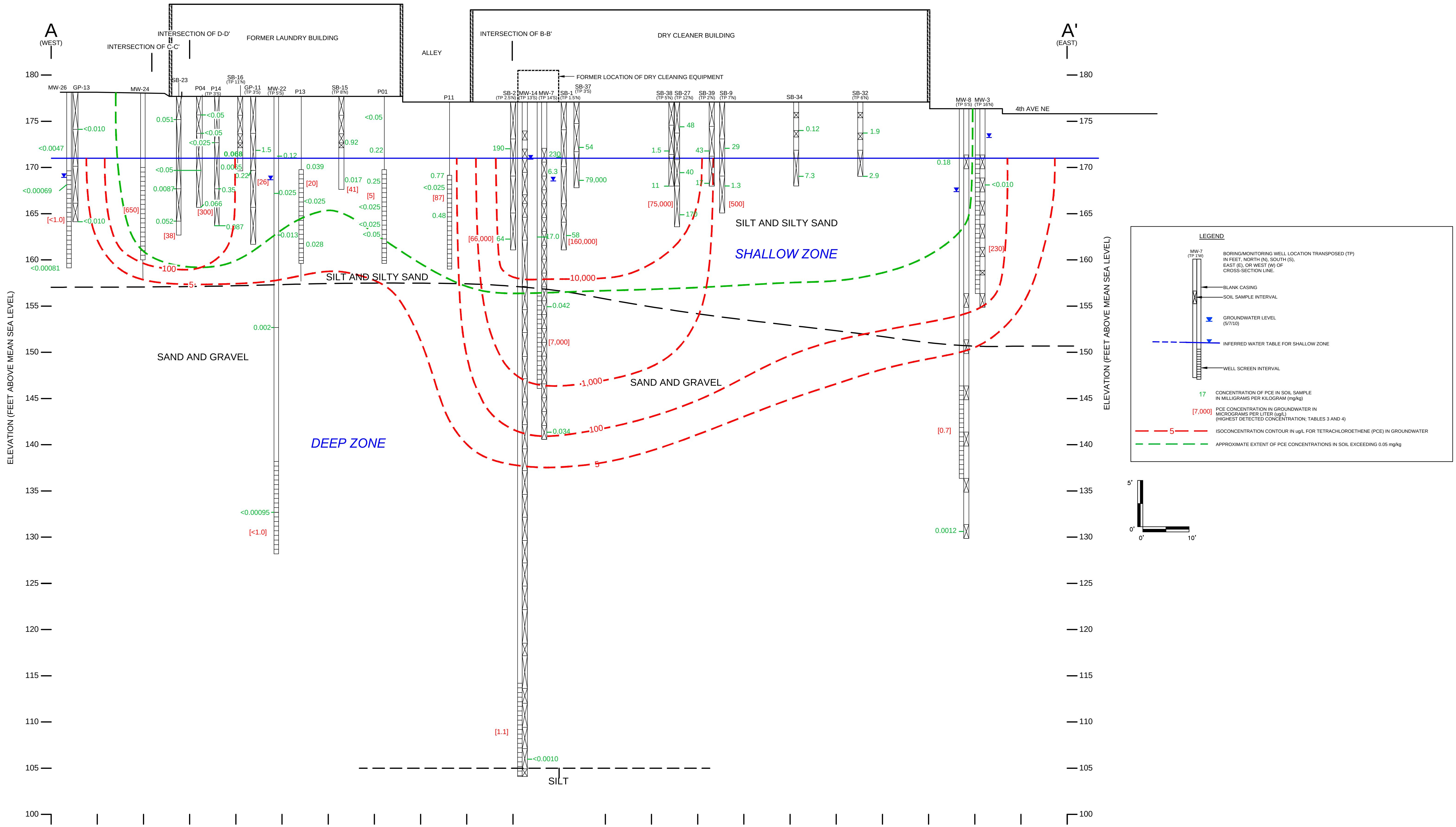

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FIGURE 10
CROSS SECTION A–A'
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

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FARALLON PN: 343-002

Drawn By: DEW | Checked By: TC/RC | Date: 4/9/13 | Disk Reference: CROSECTION

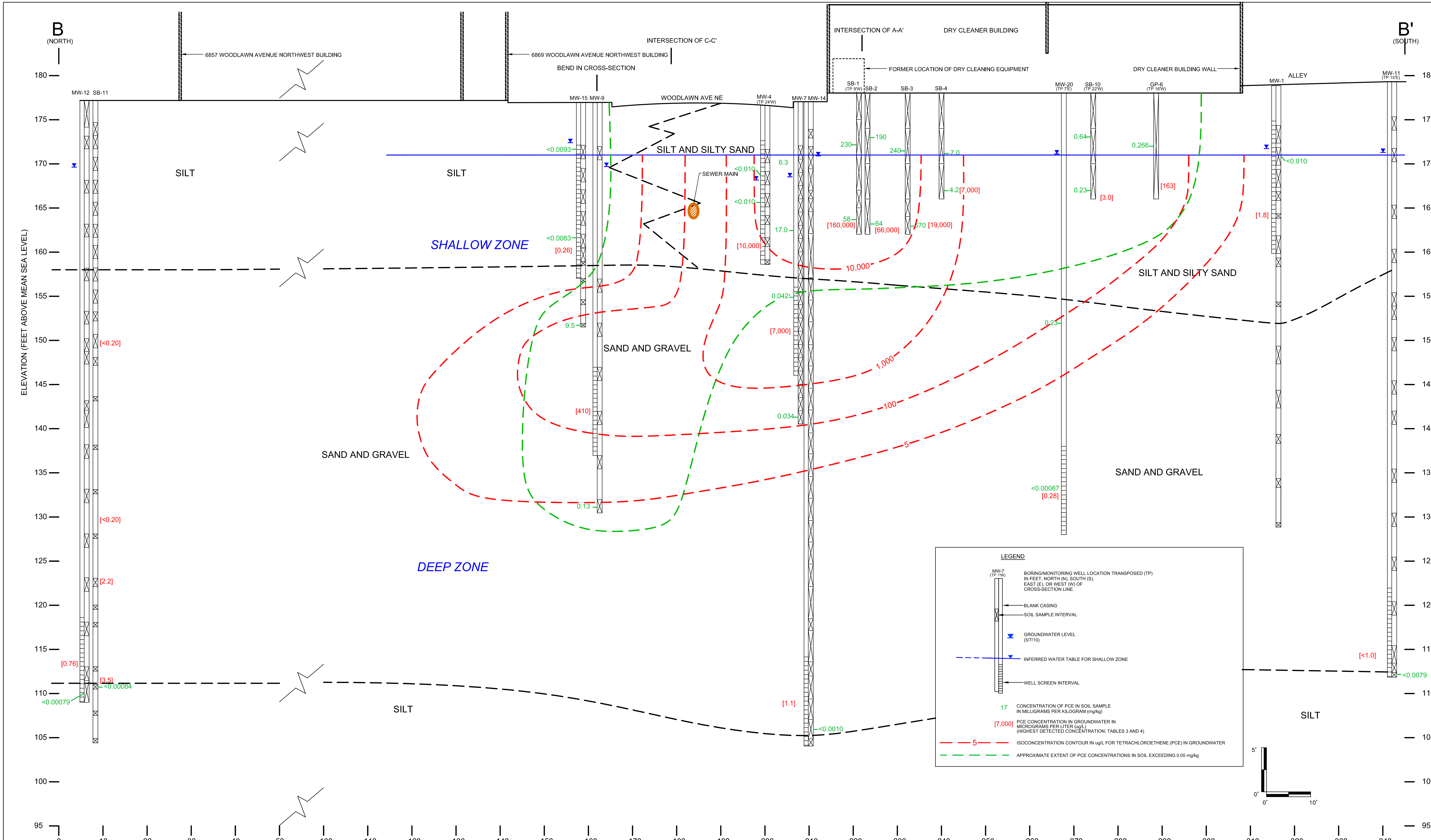

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FIGURE 11

CROSS SECTION B–B'
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343–002

Drawn By: DEW	Checked By: TC/RC	Date: 8/31/10	Disk Reference: CROSECTION

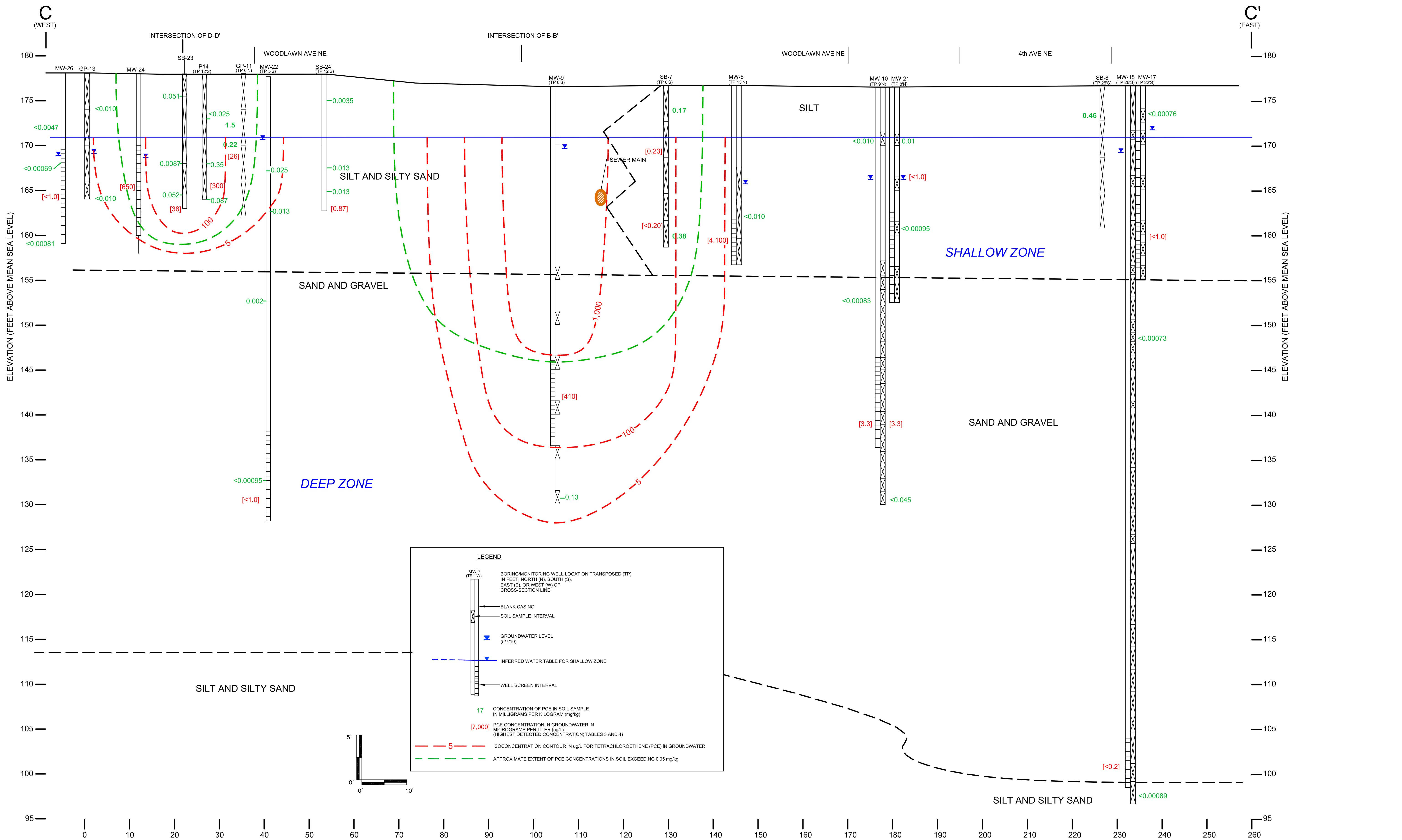

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FIGURE 12

CROSS SECTION C–C'
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343-002

Drawn By: DEW | Checked By: RC | Date: 8/31/10 | Disk Reference: CROSECTION

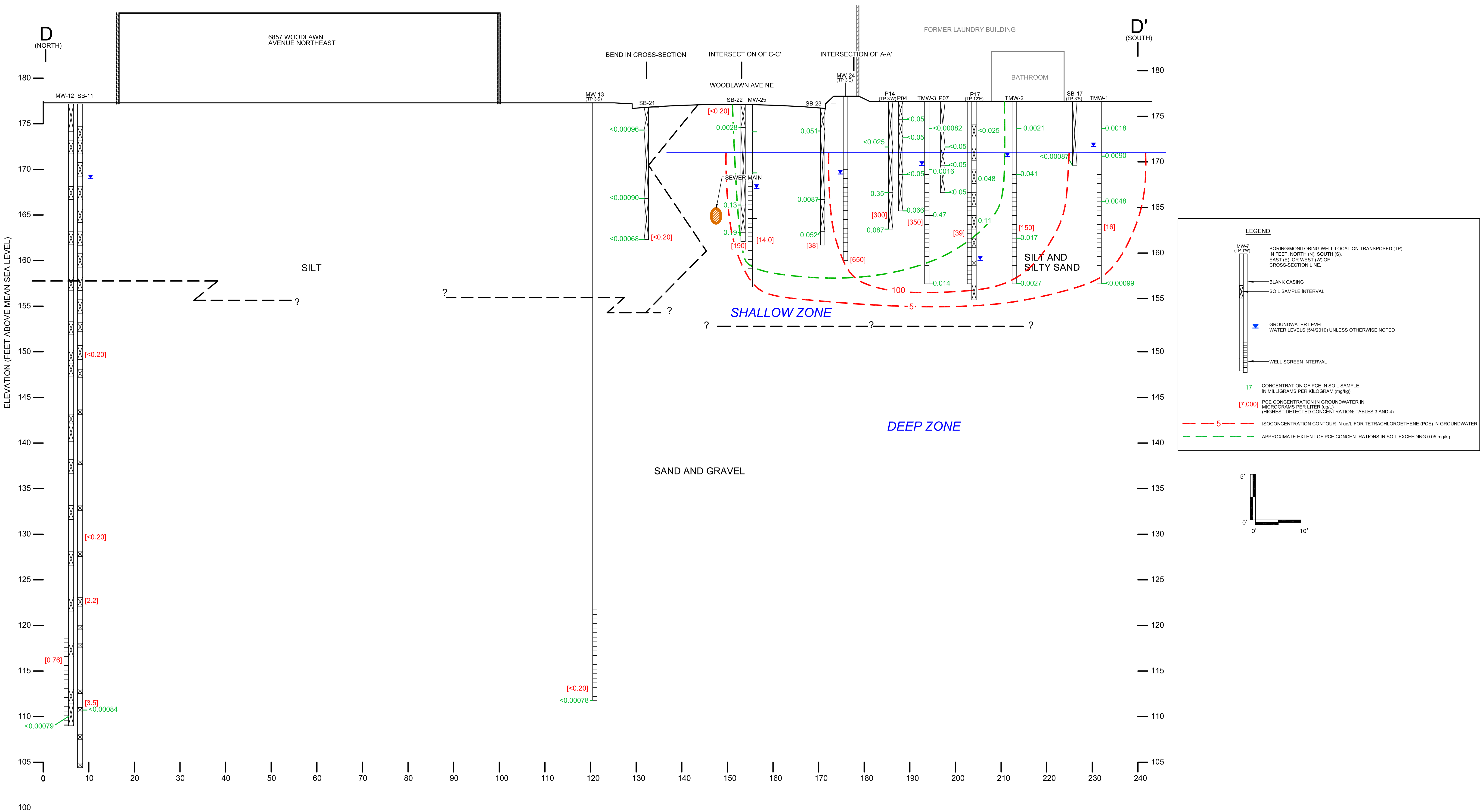

FIGURE 13

CROSS SECTION D–D'
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

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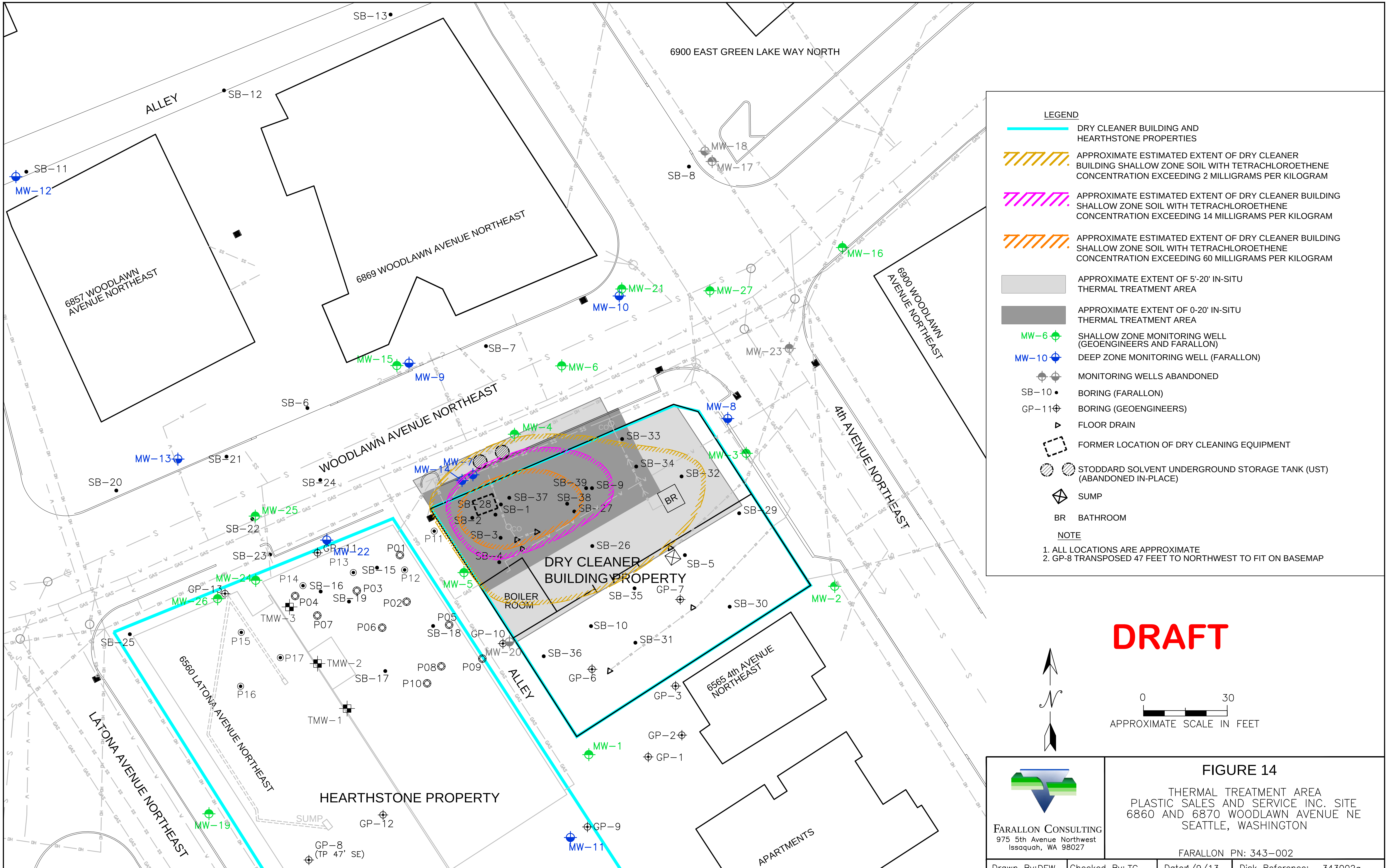
FARALLON PN: 343-002

Drawn By: DEW | Checked By: RC/TC | Date: 8/31/10 | Disk Reference: CROSECTION


LEGEND
DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
APPROXIMATE ESTIMATED EXTENT OF DRY CLEANER BUILDING SHALLOW ZONE SOIL WITH TETRACHLOROETHENE CONCENTRATION EXCEEDING 2 MILLIGRAMS PER KILOGRAM
APPROXIMATE ESTIMATED EXTENT OF DRY CLEANER BUILDING SHALLOW ZONE SOIL WITH TETRACHLOROETHENE CONCENTRATION EXCEEDING 14 MILLIGRAMS PER KILOGRAM
APPROXIMATE ESTIMATED EXTENT OF DRY CLEANER BUILDING SHALLOW ZONE SOIL WITH TETRACHLOROETHENE CONCENTRATION EXCEEDING 60 MILLIGRAMS PER KILOGRAM
APPROXIMATE EXTENT OF 5'-20' IN-SITU THERMAL TREATMENT AREA
APPROXIMATE EXTENT OF 0-20' IN-SITU THERMAL TREATMENT AREA
MW-6 SHALLOW ZONE MONITORING WELL (GEOENGINEERS AND FARALLON)
MW-10 DEEP ZONE MONITORING WELL (FARALLON)
MONITORING WELLS ABANDONED
SB-10 BORING (FARALLON)
GP-11 BORING (GEOENGINEERS)
FLOOR DRAIN
FORMER LOCATION OF DRY CLEANING EQUIPMENT
STODDARD SOLVENT UNDERGROUND STORAGE TANK (UST) (ABANDONED IN-PLACE)
SUMP
BR BATHROOM
NOTE
1. ALL LOCATIONS ARE APPROXIMATE
2. GP-8 TRANSPOSED 47 FEET TO NORTHWEST TO FIT ON BASEMAP
DRAFT
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APPROXIMATE SCALE IN FEET
6900 EAST GREEN LAKE WAY NORTH
ALLEY
6857 WOODLAWN AVENUE NORTHEAST
6869 WOODLAWN AVENUE NORTHEAST
WOODLAWN AVENUE NORTHEAST
6900 WOODLAWN AVENUE NORTHEAST
4th AVENUE NORTHEAST
DRY CLEANER BUILDING PROPERTY
BOILER ROOM
HEARTHSTONE PROPERTY
6560 LATONA AVENUE NORTHEAST
LATONA AVENUE NORTHEAST
6565 4th AVENUE NORTHEAST
APARTMENTS
GP-8 (TP 47' SE)
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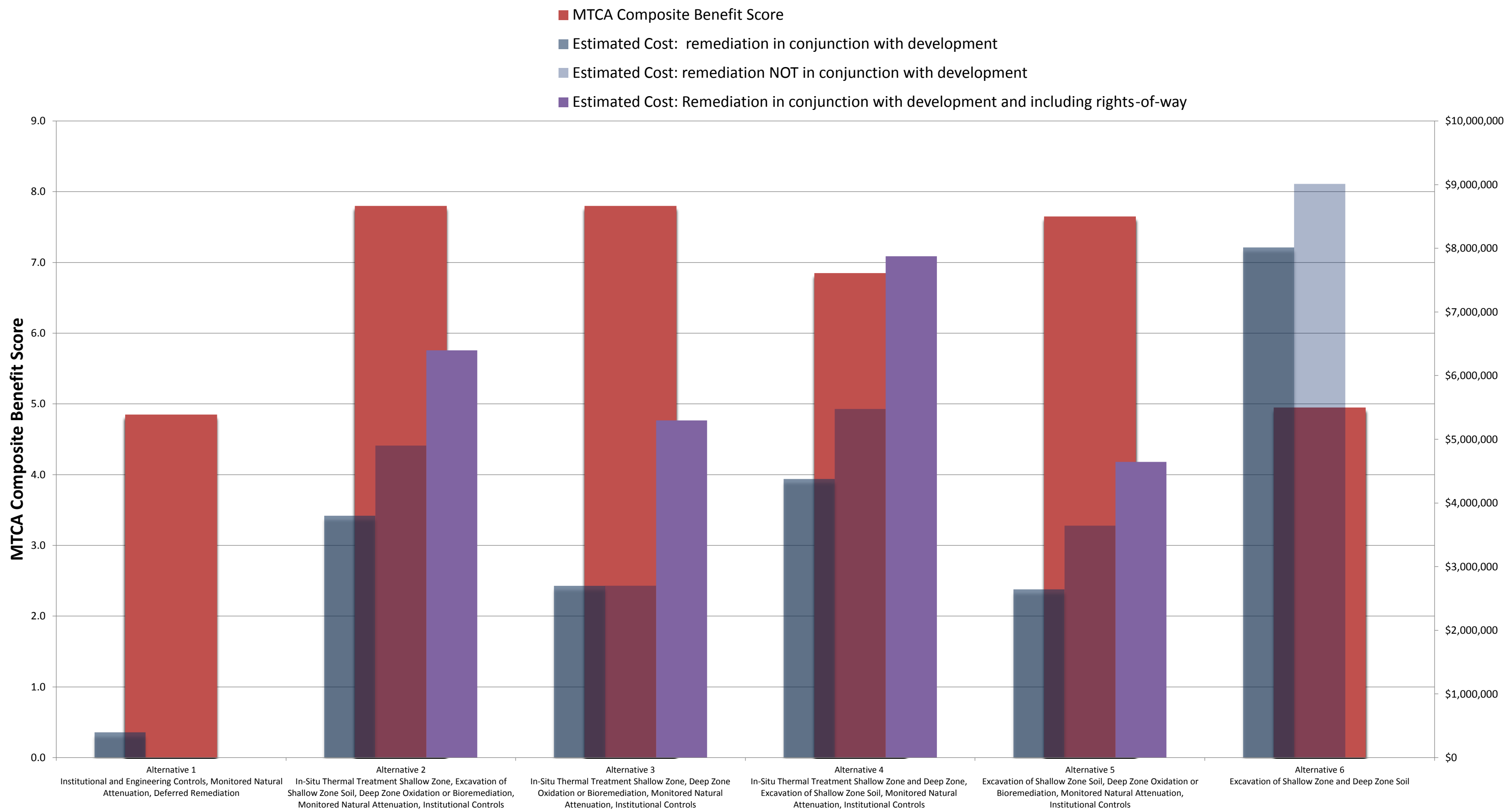
Issaquah, WA 98027
FIGURE 14
THERMAL TREATMENT AREA
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON
FARALLON PN: 343-002
Drawn By:DEW
Checked By: TC
Date:4/9/13
Disk Reference: 343002a

Figure 15
Disproportionate Cost Analysis Details
Plastic Sales Service, Inc. Site
Farallon PN: 343-002



Notes: 1. With Alternative 1, it is assumed that no development will occur in the foreseeable future. 2. Alternative 6 assu mes remediation in the rights-of-way. 3.The estimated costs are based on cost data presented in Table 10 Remedial Alternative Cost Summary. The estimated incremental costs for a. remediation not in conjunction with development, and b. re mediation in conjunction with development and including rights-of-way, are calculated by adding the incremental costs in Table 10 t o the total costs in Table 10.

LEGEND

- DRY CLEANER BUILDING AND HEARTHSTONE PROPERTIES
- MW–6 SHALLOW ZONE MONITORING WELL (GEOENGINEERS, FARALLON, AND SOUND ENVIRONMENTAL STRATEGIES)
- MW–10 DEEP ZONE MONITORING WELL (FARALLON)
- MONITORING WELLS ABANDONED
- GP–11 BORING (GEOENGINEERS)
- SB–10 BORING (FARALLON)
- P12 RECONNAISSANCE GROUNDWATER SAMPLE LOCATION (SOUND ENVIRONMENTAL STRATEGIES)
- P4 BORING (SOUND ENVIRONMENTAL STRATEGIES)
- FLOOR DRAIN
- COMBINED STORM AND SANITARY SEWER MAIN
- SIDE SEWER LINE
- UTILITY MANHOLE
- CO CLEANOUT
- CATCH BASIN
- NATURAL GAS UTILITY
- WATER UTILITY
- OVERHEAD POWERLINE
- FORMER LOCATION OF DRY CLEANING EQUIPMENT
- STODDARD SOLVENT UNDERGROUND STORAGE TANKS (UST) (ABANDONED IN-PLACE)
- SUMP
- BR BATHROOM
- PCE TETRACHLOROETHENE
- mg/kg MILLIGRAMS PER KILOGRAM

NOTE

1. ALL LOCATIONS ARE APPROXIMATE.

Area	Tons of Soil	Affected Depth (ft bgs)	Current PCE Concentration (mg/kg)
1A	1,190	20	>60
1B	1,010	20	14-60
2	3,430	15	2-14
3	4,320	15	0.05-2
4	951	50	14-60
	951	50	2-14
	5,700	50	0.05-2
5	3,950	20	0.05-2
6	1,930	20	0.05-2

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APPROXIMATE SCALE IN FEET

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Issaquah, WA 98027

FIGURE 16

REMEDIATION AREAS 1 THROUGH 6
PLASTIC SALES AND SERVICE INC. SITE
6860 AND 6870 WOODLAWN AVENUE NE
SEATTLE, WASHINGTON

FARALLON PN: 343–002

Drawn By:DEW | Checked By: TC | Date:6/5/13 | Disk Reference: 343002A

TABLES

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

Table 1
Groundwater Elevation Data Summary
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Screened Interval (feet bgs)	Date Measured	Casing Elevation (feet msl[1])	Total Well Depth (feet)[2]	Depth to Groundwater (feet)[2]	Groundwater Elevation (feet msl[1])
Monitoring Wells Screened in Shallow Water-Bearing Zone						
MW-1	4 to 19	8/5/2004	178.24	18.42	7.91	170.33
		11/18/2004		18.42	7.00	171.24
		1/7/2005		—	5.91	172.33
		5/31/2006		—	6.36	171.88
		6/22/2006		—	8.22	170.02
		1/8/2007		18.15	3.93	174.31
		4/20/2007		18.15	5.38	172.86
		11/19/2008		18.48	6.78	171.46
		5/3/2010		18.37	6.33	171.91
		5/7/2010		—	6.52	171.72
MW-2	5 to 20	8/5/2004	176.22	19.48	6.39	169.83
		11/18/2004		19.50	6.41	169.81
		1/7/2005		—	5.88	170.34
		5/31/2006		—	5.75	170.47
		6/22/2006		—	7.01	169.21
		1/8/2007		—	4.56	171.66
		4/20/2007		—	4.90	171.32
		11/19/2008		19.31	6.86	169.36
		5/3/2010		19.45	6.50	169.72
		5/7/2010		—	6.48	169.74
MW-3	5 to 20	8/5/2004	175.87	19.55	6.56	169.31
		11/18/2004		19.56	6.64	169.23
		1/7/2005		—	5.86	170.01
		5/31/2006		—	2.79	173.08
		6/22/2006		—	3.69	172.18
		1/8/2007		19.54	2.18	173.69
		4/20/2007		19.54	1.96	173.91
		11/19/2008		19.6	2.65	173.22
		5/3/2010		19.45	2.54	173.33
		5/7/2010		—	2.59	173.28
MW-4	4 to 18	8/5/2004	176.15	18.08	7.66	168.49
		11/18/2004		18.08	7.35	168.80
		1/7/2005		—	6.82	169.33
		5/31/2006		—	7.88	168.27
		6/22/2006		—	8.19	167.96
		1/8/2007		17.95	5.80	170.35
		4/20/2007		17.95	6.49	169.66
		11/19/2008		17.61	8.45	167.70
		5/3/2010		17.54	8.02	168.13
		5/4/2010		—	8.09	168.06
		5/7/2010		—	7.98	168.17
MW-5	2.5 to 17.5	8/5/2004	177.37	17.45	8.71	168.66
		11/18/2004		17.45	7.86	169.51
		1/7/2005		—	7.15	170.22
		5/31/2006		—	7.50	169.87
		6/22/2006		—	9.12	168.25
		1/8/2007		17.44	2.90	174.47
		4/20/2007		17.44	6.63	170.74
		11/19/2008		17.47	8.30	169.07
		5/3/2010		17.45	7.54	169.83
		5/4/2010		—	7.87	169.50
		5/7/2010		—	8.01	169.36

Table 1
Groundwater Elevation Data Summary
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Screened Interval (feet bgs)	Date Measured	Casing Elevation (feet msl[1])	Total Well Depth (feet)[2]	Depth to Groundwater (feet)[2]	Groundwater Elevation (feet msl[1])
Monitoring Wells Screened in Shallow Water-Bearing Zone (continued)						
MW-6	15 to 20	11/18/2004	176.26	—	—	—
		1/7/2005		—	—	—
		5/31/2006		—	—	—
		6/22/2006		—	—	—
		1/8/2007		—	8.84	167.42
		4/20/2007		—	—	—
		5/3/2010		19.93	10.4	165.86
		5/7/2010		—	10.52	165.74
MW-15	5 to 20	5/31/2006	176.62	18.12	6.76	169.86
		6/22/2006		—	7.36	169.26
		1/8/2007		18.15	5.63	170.99
		4/20/2007		18.15	6.68	169.94
		11/19/2008		18.2	9.21	167.41
		5/3/2010		18.18	4.23	172.39
		5/7/2010		—	4.22	172.40
MW-16	5 to 20	5/31/2006	175.60	19.45	4.56	171.04
		6/22/2006		—	6.21	169.39
		1/8/2007		—	3.91	171.69
		4/20/2007		—	4.29	171.31
		11/19/2008		19.6	5.03	170.57
		5/3/2010		19.60	5.30	170.30
		5/7/2010		—	5.44	170.16
MW-17	5 to 20	5/31/2006	175.79	19.19	4.29	171.50
		6/22/2006		—	5.82	169.97
		1/8/2007		—	3.67	172.12
		4/20/2007		—	4.03	171.76
MW-19	10 to 20	11/20/2008	180.68	19.8	9.68	171.00
		5/3/2010		19.72	9.17	171.51
		5/4/2010		—	9.54	171.14
		5/7/2010		—	9.4	171.28
MW-21	14 to 24	11/19/2008	175.93	23.74	10.21	165.72
		5/3/2010		23.74	9.70	166.23
		5/7/2010		—	9.73	166.20
MW-23	10 to 20	11/19/2008	176.03	20.15	10.81	165.22
		5/3/2010		20.15	10.17	165.86
		5/7/2010		—	10.32	165.71
MW-24	8 to 18	11/19/2008	177.62	17.25	9.34	168.28
		5/3/2010		17.34	8.89	168.73
		5/4/2010		—	8.96	168.66
		5/7/2010		—	8.95	168.67
MW-25	8 to 18	5/3/2010	176.95	18.29	9.85	167.10
		5/4/2010		—	10.02	166.93
		5/7/2010		—	9.86	167.09
MW-26	8 to 18	5/3/2010	177.83	18.18	8.71	169.12
		5/4/2010		—	8.81	169.02
		5/7/2010		—	8.75	169.08
TMW-1	8 to 18	4/5/2010	176.98	18.75	5.12	171.86
		5/4/2010		18.80	5.27	171.71
		5/7/2010		—	5.31	171.67
TMW-2	8 to 18	4/5/2010	176.91	18.79	5.62	171.29
		5/4/2010		18.83	6.31	170.60
		5/7/2010		—	6.25	170.66
TMW-3	8 to 18	4/5/2010	177.14	18.22	6.96	170.18
		5/4/2010		18.25	7.53	169.61
		5/7/2010		—	7.52	169.62
MW-27	8.5 to 13.5	6/28/2011		13.5	—	

Table 1
Groundwater Elevation Data Summary
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Screened Interval (feet bgs)	Date Measured	Casing Elevation (feet msl[1])	Total Well Depth (feet)[2]	Depth to Groundwater (feet)[2]	Groundwater Elevation (feet msl[1])
Monitoring Wells Screened in Deep Water-Bearing Zone						
MW-7	21 to 31	12/6/2004	176.56	31.00	7.45	169.11
MW-7	21 to 31	1/7/2005	176.56	—	7.30	169.26
MW-7	21 to 31	5/31/2006	176.56	—	8.09	168.47
MW-7	21 to 31	6/22/2006	176.56	—	8.42	168.14
MW-7	21 to 31	1/8/2007	176.56	31.01	6.52	170.04
MW-7	21 to 31	4/20/2007	176.59	—	7.00	169.59
MW-7	21 to 31	11/19/2008	176.59	30.67	8.38	168.21
MW-7	21 to 31	5/3/2010	176.59	30.84	7.99	168.60
MW-7	21 to 31	5/7/2010	176.59	—	8.04	168.55
MW-8	30 to 40	12/6/2004	175.90	40.09	6.55	169.35
MW-8	30 to 40	1/7/2005	175.90	—	6.34	169.56
MW-8	30 to 40	5/31/2006	175.90	—	6.35	169.55
MW-8	30 to 40	6/22/2006	175.90	—	7.55	168.35
MW-8	30 to 40	1/8/2007	175.90	40.09	5.54	170.36
MW-8	30 to 40	1/8/2007	175.90	40.09	5.98	169.92
MW-8	30 to 40	11/19/2008	175.90	40.15	9.00	166.90
MW-8	30 to 40	5/3/2010	175.90	40.15	8.49	167.41
MW-8	30 to 40	5/7/2010	175.90	—	8.51	167.39
MW-9	30 to 40	12/6/2004	176.43	39.81	6.81	169.62
MW-9	30 to 40	1/7/2005	176.43	—	6.49	169.94
MW-9	30 to 40	5/31/2006	176.43	—	6.34	170.09
MW-9	30 to 40	6/22/2006	176.43	—	7.48	168.95
MW-9	30 to 40	1/8/2007	176.43	39.75	5.85	170.58
MW-9	30 to 40	4/20/2007	176.43	39.75	6.01	170.42
MW-9	30 to 40	11/19/2008	176.43	39.81	7.30	169.13
MW-9	30 to 40	5/3/2010	176.43	39.80	6.74	169.69
MW-9	30 to 40	5/7/2010	176.43	—	6.73	169.70
MW-10	30 to 40	12/6/2004	176.01	39.98	7.12	168.89
MW-10	30 to 40	1/7/2005	176.01	—	6.89	169.12
MW-10	30 to 40	5/31/2006	176.01	—	6.99	169.02
MW-10	30 to 40	6/22/2006	176.01	—	8.12	167.89
MW-10	30 to 40	1/8/2007	176.01	—	6.05	169.96
MW-10	30 to 40	4/20/2007	176.01	—	6.57	169.44
MW-10	30 to 40	11/19/2008	176.01	40.01	10.21	165.80
MW-10	30 to 40	5/3/2010	176.01	40.00	9.72	166.29
MW-10	30 to 40	5/7/2010	176.01	—	9.75	166.26
MW-11	57.5 to 67.5	5/31/2006	178.99	64.30	7.71	171.28
MW-11	57.5 to 67.5	6/22/2006	178.99	—	8.78	170.21
MW-11	57.5 to 67.5	1/8/2007	178.99	64.28	7.30	171.69
MW-11	57.5 to 67.5	4/20/2007	178.99	64.28	7.38	171.61
MW-11	57.5 to 67.5	11/19/2008	178.99	65.3	8.34	170.65
MW-11	57.5 to 67.5	5/3/2010	178.99	65.24	7.73	171.26
MW-11	57.5 to 67.5	5/7/2010	178.99	—	7.69	171.30
MW-12	57 to 67	5/31/2006	176.95	62.51	7.31	169.64
MW-12	57 to 67	6/22/2006	176.95	—	8.40	168.55
MW-12	57 to 67	1/8/2007	176.95	66.55	7.04	169.91
MW-12	57 to 67	4/20/2007	176.95	66.55	7.05	169.90
MW-12	57 to 67	11/19/2008	176.95	66.1	7.92	169.03
MW-12	57 to 67	5/3/2010	176.95	65.78	7.35	169.60
MW-12	57 to 67	5/7/2010	176.95	—	7.32	169.63
MW-13	55.5 to 65.5	5/31/2006	177.03	62.90	6.31	170.72
MW-13	55.5 to 65.5	6/22/2006	177.03	—	7.40	169.63
MW-13	55.5 to 65.5	1/8/2007	177.03	66.18	5.96	171.07
MW-13	55.5 to 65.5	4/20/2007	177.03	66.18	6.01	171.02
MW-13	55.5 to 65.5	11/19/2008	177.03	66.22	6.95	170.08
MW-13	55.5 to 65.5	5/3/2010	177.03	66.21	6.35	170.68
MW-13	55.5 to 65.5	5/7/2010	177.03	—	6.30	170.73

Table 1
Groundwater Elevation Data Summary
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Screened Interval (feet bgs)	Date Measured	Casing Elevation (feet msl[1])	Total Well Depth (feet)[2]	Depth to Groundwater (feet)[2]	Groundwater Elevation (feet msl[1])
Monitoring Wells Screened in Deep Water-Bearing Zone (continued)						
MW-14	63 to 73	5/31/2006	176.50	72.81	6.55	169.95
		6/22/2006		—	6.65	169.85
		1/8/2007		71.8	5.18	171.32
		4/20/2007	176.72	—	5.47	171.25
		11/19/2008		72.16	6.45	170.27
		5/3/2010		72.05	5.86	170.86
		5/7/2010		—	5.81	170.91
MW-18	68 to 78	5/31/2006	175.91	77.42	6.89	169.02
		6/22/2006		—	7.84	168.07
		1/8/2007		78.05	6.04	169.87
		4/20/2007		78.05	6.26	169.65
MW-20	40 to 50	11/19/2008	177.62	49.19	7.16	170.46
		5/3/2010		48.49	6.56	171.06
		5/7/2010		—	6.50	171.12
MW-22	39.5 to 49.5	11/19/2008	177.23	49.2	7.18	170.05
		5/3/2010		49.20	6.59	170.64
		5/7/2010		—	6.53	170.70

NOTES:
[1]Surveyed elevations in feet above mean sea level (msl).
[2]Depth below top of well casing.

— = not measured
bgs = below ground surface

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
GP-6	GP-6-6	GeoEngineers	11/22/2002	6	**0.266**	0.0272	0.00747	<0.005	<0.005
GP-7	GP-7-8	GeoEngineers	11/22/2002	8	<0.005	<0.005	<0.005	<0.005	<0.005
GP-9	GP-9-9	GeoEngineers	11/5/2004	9.0	<0.010	<0.010	<0.010	<0.010	<0.010
GP-10	GP-10-12	GeoEngineers	11/1/2004	12.0	<0.010	<0.010	0.014	<0.010	<0.010
GP-11	GP-11-6	GeoEngineers	11/1/2004	6.0	**1.50**	<0.010	<0.010	<0.010	<0.010
	GP-11-8	GeoEngineers	11/1/2004	8.0	**0.22**	<0.010	<0.010	<0.010	<0.010
GP-12	GP-12-12	GeoEngineers	11/5/2004	12.0	<0.010	<0.010	<0.010	<0.010	<0.010
GP-13	GP-13-4	GeoEngineers	11/5/2004	4.0	<0.010	<0.010	<0.010	<0.010	<0.010
	GP-13-14	GeoEngineers	11/5/2004	14.0	<0.010	<0.010	<0.010	<0.010	<0.010
SB-1	SB1-5-7	Farallon	8/4/2004	5 to 7	**230**	<1.1	<1.1	<1.1	<1.1
	SB1-13-16	Farallon	8/4/2004	13 to 16	**58**	<0.50	<0.50	<0.50	<0.50
SB-2	SB2-4-6	Farallon	8/4/2004	4 to 6	**190**	<0.26	<0.26	<0.26	<0.26
	SB2-14-16	Farallon	8/4/2004	14 to 16	**64**	**0.43**	<0.24	<0.24	<0.24
SB-3	SB3-6-8	Farallon	8/5/2004	6 to 8	**240**	<0.48	<0.48	<0.48	<0.48
	SB3-14-15.5	Farallon	8/5/2004	14 to 15.5	**570**	<0.48	<0.48	<0.48	<0.48
SB-4	SB4-6-8	Farallon	8/5/2004	6 to 8	**7.0**	**0.56**	0.12	<0.052	<0.052
	SB4-10-12	Farallon	8/5/2004	10 to 12	**4.2**	**0.23**	0.066	<0.046	<0.046
SB-5	SB5-6-8	Farallon	8/5/2004	6 to 8	**1.2**	<0.057	<0.057	<0.057	<0.057
	SB5-14-16	Farallon	8/5/2004	14 to 16	**0.076**	<0.0010	<0.0010	<0.0010	<0.0010
SB-7	SB7-2-4	Farallon	8/4/2004	2 to 4	**0.17**	<0.0015	<0.0015	<0.0015	<0.0015
	SB7-15-18	Farallon	8/4/2004	15 to 18	**0.38**	0.0012	<0.00096	<0.00096	<0.00096
SB-8	SB8-2-4	Farallon	8/4/2004	2 to 4	**0.46**	<0.0010	<0.0010	<0.0010	<0.0010
SB-9	SB9-4-6	Farallon	8/5/2004	4 to 6	**29**	<0.098	<0.098	<0.098	<0.098
	SB9-8-10	Farallon	8/5/2004	8 to 10	**1.3**	<0.047	<0.047	<0.047	<0.047
MTCA Cleanup Levels for Soil					**0.05**[3]	**0.03**[3]	**800**[4]	**1,600**[4]	**0.67**[4]

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
SB-10	SB10-4-6	Farallon	8/5/2004	4 to 6	**0.64**	**0.15**	0.069	<0.0012	<0.0012
	SB10-10-12	Farallon	8/5/2004	10 to 12	**0.23**	<0.0010	<0.0010	<0.0010	<0.0010
SB-11	SB11-66.5-67	Farallon	4/19/2006	66.5 to 67	<0.00084	<0.00084	<0.00084	<0.00084	<0.00084
SB-12	SB12-66-67	Farallon	4/17/2006	66 to 67	<0.00096	<0.00096	<0.00096	<0.00096	<0.00096
SB-13	SB13-70-71	Farallon	4/18/2006	70 to 71	<0.00087	<0.00087	<0.00087	<0.00087	<0.00087
SB-15	SB15-6-6.5	Farallon	4/20/2006	5 to 6.5	**0.92**	0.025	0.0016	<0.00079	<0.00079
	SB15-9-10	Farallon	4/20/2006	9 to 10	0.017	0.0094	0.054	0.0013	<0.00084
SB-16	SB16-6-7	Farallon	4/20/2006	6 to 7	**0.068**	<0.00093	<0.00093	<0.00093	<0.00093
	SB16-8-9	Farallon	5/3/2006	8 to 9	0.0065	<0.00078	<0.00078	<0.00078	<0.00078
SB-17	SB17-6.5-7	Farallon	5/3/2006	6.5 to 7	<0.00087	<0.00087	<0.00087	<0.00087	<0.00087
SB-18	SB18-7-8	Farallon	4/20/2006	7 to 8	0.023	<0.0011	<0.0011	<0.0011	<0.0011
SB-19	SB19-8-9	Farallon	4/20/2006	8 to 9	<0.00074	<0.00074	<0.00074	<0.00074	<0.00074
P01	P01-02	SES	5/22/2008	2	<0.05	<0.03	<0.05	<0.05	<0.05
	P01-06	SES	5/22/2008	6	**0.22**	<0.03	<0.05	<0.05	<0.05
	P01-15	SES	5/22/2008	15	<0.05	<0.03	<0.05	<0.05	<0.05
P02	P02-02	SES	5/22/2008	2	<0.05	<0.03	<0.05	<0.05	<0.05
	P02-05	SES	5/22/2008	5	**0.13**	<0.03	<0.05	<0.05	<0.05
	P02-07	SES	5/22/2008	7	**0.26**	<0.03	<0.05	<0.05	<0.05
	P02-11	SES	5/22/2008	11	<0.05	<0.03	<0.05	<0.05	<0.05
P03	P03-01	SES	5/22/2008	1	<0.05	<0.03	<0.05	<0.05	<0.05
	P03-06	SES	5/22/2008	6	**0.18**	<0.03	<0.05	<0.05	<0.05
	P03-08	SES	5/22/2008	8	**0.060**	<0.03	<0.05	<0.05	<0.05
	P03-14	SES	5/22/2008	14	<0.05	<0.03	<0.05	<0.05	<0.05
MTCA Cleanup Levels for Soil					**0.05[3]**	**0.03[3]**	**800[4]**	**1,600[4]**	**0.67[4]**

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
P04	P04-02	SES	5/22/2008	2	<0.05	<0.03	<0.05	<0.05	<0.05
	P04-04	SES	5/22/2008	4	<0.05	<0.03	<0.05	<0.05	<0.05
	P04-08	SES	5/22/2008	8	<0.05	<0.03	<0.05	<0.05	<0.05
	P04-12	SES	5/22/2008	12	**0.066**	<0.03	<0.05	<0.05	<0.05
P05	P05-02	SES	5/22/2008	2	**0.061**	<0.03	<0.05	<0.05	<0.05
	P05-04	SES	5/22/2008	4	**0.065**	<0.03	<0.05	<0.05	<0.05
	P05-07	SES	5/22/2008	7	**0.094**	<0.03	<0.05	<0.05	<0.05
	P05-10	SES	5/22/2008	10	**0.21**	<0.03	<0.05	<0.05	<0.05
P06	P06-04	SES	5/22/2008	4	**0.18**	<0.03	<0.05	<0.05	<0.05
	P06-08	SES	5/22/2008	8	<0.05	<0.03	<0.05	<0.05	<0.05
	P06-14	SES	5/22/2008	14	<0.05	<0.03	<0.05	<0.05	<0.05
P07	P07-05	SES	5/22/2008	5	<0.05	<0.03	<0.05	<0.05	<0.05
	P07-07	SES	5/22/2008	7	<0.05	<0.03	<0.05	<0.05	<0.05
	P07-10	SES	5/22/2008	10	<0.05	<0.03	<0.05	<0.05	<0.05
P09	P09-08	SES	5/22/2008	8	<0.05	<0.03	<0.05	<0.05	<0.05
	P09-13	SES	5/22/2008	13	<0.05	<0.03	<0.05	<0.05	<0.05
P10	P10-08	SES	5/22/2008	8	<0.05	<0.03	<0.05	<0.05	<0.05
	P10-10	SES	5/22/2008	10	<0.05	<0.03	<0.05	<0.05	<0.05
	P10-13	SES	5/22/2008	13	<0.05	<0.03	<0.05	<0.05	<0.05
P11	P11-07.5	SES	9/24/2009	7.5	**0.77**	**0.99**	0.34	<0.05	<0.05
	P11-09	SES	9/24/2009	9	<0.025	<0.03	<0.05	<0.05	<0.05
	P11-12	SES	9/24/2009	12	**0.48**	**0.072**	0.44	<0.05	<0.05
P12	P12-09	SES	9/24/2009	9	**0.25**	<0.03	<0.05	<0.05	<0.05
	P12-12	SES	9/24/2009	12	<0.025	<0.03	<0.05	<0.05	<0.05
	P12-14	SES	9/24/2009	14	<0.025	<0.03	<0.05	<0.05	<0.05
MTCA Cleanup Levels for Soil					**0.05**[3]	**0.03**[3]	**800**[4]	**1,600**[4]	**0.67**[4]

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
P13	P13-07.5	SES	9/25/2009	7.5	0.039	<0.03	<0.05	<0.05	<0.05
	P13-11	SES	9/25/2009	11	<0.025	<0.03	<0.05	<0.05	<0.05
	P13-16	SES	9/25/2009	16	0.028	<0.03	<0.05	<0.05	<0.05
P14	P14-05	SES	9/25/2009	5	<0.025	<0.03	<0.05	<0.05	<0.05
	P14-10	SES	9/25/2009	10	**0.35**	<0.03	<0.05	<0.05	<0.05
	P14-14	SES	9/25/2009	14	**0.087**	<0.03	<0.05	<0.05	<0.05
P15	P15-06	SES	9/25/2009	6	<0.025	<0.03	<0.05	<0.05	<0.05
	P15-09	SES	9/25/2009	9	<0.025	<0.03	<0.05	<0.05	<0.05
	P15-13	SES	9/25/2009	13	<0.025	<0.03	<0.05	<0.05	<0.05
P16	P16-08	SES	9/25/2009	8	<0.025	<0.03	<0.05	<0.05	<0.05
	P16-12.5	SES	9/25/2009	12.5	<0.025	<0.03	<0.05	<0.05	<0.05
	P16-18	SES	9/25/2009	18	<0.025	<0.03	<0.05	<0.05	<0.05
P17	P17-04	SES	9/25/2009	4	<0.025	<0.03	<0.05	<0.05	<0.05
	P17-09	SES	9/25/2009	9	0.048	<0.03	<0.05	<0.05	<0.05
	P17-13	SES	9/25/2009	13	**0.11**	<0.03	<0.05	<0.05	<0.05
SB-20	SB-20-2.5	Farallon	4/8/2010	2.5	<0.00091	<0.00091	<0.00091	<0.00091	<0.00091
	SB-20-7	Farallon	4/8/2010	7	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078
	SB-20-13.5	Farallon	4/8/2010	13.5	<0.00080	<0.00080	<0.00080	<0.00080	<0.00080
SB-21	SB-21-2.5	Farallon	4/8/2010	2.5	<0.00096	<0.00096	<0.00096	<0.00096	<0.00096
	SB-21-10	Farallon	4/8/2010	10	<0.00090	<0.00090	<0.00090	<0.00090	<0.00090
	SB-21-14.5	Farallon	4/8/2010	14.5	<0.00068	<0.00068	<0.00068	<0.00068	<0.00068
SB-22	SB-22-2.5	Farallon	4/8/2010	2.5	0.0028	<0.00083	<0.00083	<0.00083	<0.00083
	SB-22-11	Farallon	4/9/2010	11	**0.13**	0.0019	<0.00084	<0.00084	<0.00084
	SB-22-14	Farallon	4/9/2010	14	**0.19**	0.0029	<0.0012	<0.0012	<0.0012
MTCA Cleanup Levels for Soil					**0.05**[3]	**0.03**[3]	**800**[4]	**1,600**[4]	**0.67**[4]

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2]				
					PCE	**TCE**	**cis-1,2-Dichloroethene**	**trans-1,2-Dichloroethene**	**Vinyl Chloride**
SB-23	SB-23-2.5	Farallon	4/8/2010	2.5	**0.051**	<0.00091	<0.00091	<0.00091	<0.00091
	SB-23-10	Farallon	4/8/2010	10	0.0087	<0.00086	<0.00086	<0.00086	<0.00086
	SB-23-13.5	Farallon	4/8/2010	13.5	**0.052**	0.00087	<0.00071	<0.00071	<0.00071
SB-24	SB-24-2.5	Farallon	4/8/2010	2.5	0.0035	<0.00083	<0.00083	<0.00083	<0.00083
	SB-24-11	Farallon	4/9/2010	11	0.013	0.00079	<0.00059	<0.00059	<0.00059
	SB-24-14	Farallon	4/9/2010	14	0.013	0.00092	<0.00067	<0.00067	<0.00067
SB-25	SB-25-2.5	Farallon	4/8/2010	2.5	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
	SB-25-9	Farallon	4/8/2010	9	<0.00067	<0.00067	<0.00067	<0.00067	<0.00067
	SB-25-17	Farallon	4/8/2010	17	<0.0011	<0.0011	<0.0011	<0.0011	<0.0011
SB-26	SB26-1.3	Farallon	2/23/2011	1.3	**2.5**	0.0016	<0.00086	<0.00086	<0.00086
	SB26-8.0	Farallon	2/23/2011	8	**0.16**	0.0051	0.0073	<0.00082	<0.00082
SB-27	SB27-2.5	Farallon	2/23/2011	2.5	**48**	**0.032**	<0.0014	<0.0014	<0.0014
	SB27-7.5	Farallon	2/23/2011	7.5	**40**	**0.27**	0.031	0.0014	<0.0013
	SB27-12.0	Farallon	2/23/2011	12	**170**	**0.96**	0.020	<0.0011	0.0049
SB-29	SB29-4.0	Farallon	2/25/2011	4.0	**1.0**	<0.0011	<0.0011	<0.0011	<0.0011
	SB29-9.0	Farallon	2/25/2011	9.0	<0.0077	<0.00077	<0.00077	<0.00077	<0.00077
SB-30	SB30-3.0	Farallon	2/25/2011	3.0	**0.071**	<0.00082	<0.00082	<0.00082	<0.00082
	SB30-10.0	Farallon	2/25/2011	10.0	0.020	<0.00078	<0.00078	<0.00078	<0.00078
SB-31	SB31-2.0	Farallon	2/25/2011	2.0	**0.67**	0.0023	<0.0011	<0.0011	<0.0011
	SB31-8.5	Farallon	2/25/2011	8.5	0.013	<0.00085	<0.00085	<0.00085	<0.00085
SB-32	SB32-3.0	Farallon	2/25/2011	3.0	**1.9**	<0.0014	<0.0014	<0.0014	<0.0014
	SB32-7.5	Farallon	2/25/2011	7.5	**2.9**	0.0098	0.0017	<0.00079	<0.00079
SB-33	SB33-3.0	Farallon	2/25/2011	3.0	**0.46**	<0.0019	<0.0019	<0.0019	<0.0019
	SB33-8.5	Farallon	2/25/2011	8.5	<0.0075	<0.00075	0.00091	<0.00075	0.0050
SB-34	SB34-3.0	Farallon	2/25/2011	3.0	**0.12**	0.0010	<0.00085	<0.00085	<0.00085
	SB34-8.0	Farallon	2/25/2011	8.0	**7.3**	**0.11**	<0.054	<0.054	<0.054
SB-35	SB35-5.0	Farallon	2/25/2011	5.0	**0.12**	<0.00087	<0.00087	<0.00087	<0.00087
	SB35-10.5	Farallon	2/25/2011	10.5	<0.0077	<0.00077	<0.00077	<0.00077	<0.00077
MTCA Cleanup Levels for Soil					**0.05**[3]	**0.03**[3]	**800**[4]	**1,600**[4]	**0.67**[4]

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2] PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
SB-36	SB36-3.0	Farallon	2/25/2011	3.0	**0.075**	0.0056	<0.00092	<0.00092	<0.00092
	SB36-10.5	Farallon	2/25/2011	10.5	<0.0061	<0.00061	<0.00061	<0.00061	<0.00061
SB-37	SB37-5.5	Farallon	12/12/2012	5.5	**54**	NT	NT	NT	NT
	SB37-9.5	Farallon	12/12/2012	9.5	**79,000**	NT	NT	NT	NT
SB-38	SB38-5.5	Farallon	12/12/2012	5.5	**4.3**	NT	NT	NT	NT
	SB38-9.0	Farallon	12/12/2012	9.0	**17**	NT	NT	NT	NT
SB-39	SB39-5.5	Farallon	12/12/2012	5.5	**1.5**	NT	NT	NT	NT
	SB39-10.0	Farallon	12/12/2012	10.0	**11**	NT	NT	NT	NT
MW-1	MW-1-8.0	GeoEngineers	10/22/2003	8	<0.010	<0.010	<0.010	<0.010	<0.010
MW-2	MW-2-10.5	GeoEngineers	10/28/2003	10.5	<0.010	<0.010	<0.010	<0.010	<0.010
MW-3	MW-3-8.0	GeoEngineers	10/28/2003	8	<0.010	<0.010	<0.010	<0.010	<0.010
MW-4	MW-4-8.0	GeoEngineers	10/28/2003	8	<0.010	<0.010	<0.010	<0.010	<0.010
	MW-4-11.0	GeoEngineers	10/28/2003	11	<0.010	<0.010	<0.010	<0.010	<0.010
MW-5	MW-5-7.5	GeoEngineers	10/22/2003	7.5	<0.010	<0.010	0.022	<0.010	<0.010
MW-6	MW-6-15	GeoEngineers	11/5/2004	15.0	<0.010	<0.010	<0.010	<0.010	<0.010
MW-7	MW7-6.5-8.0	Farallon	11/18/2004	6.5 to 8.0	**6.30**	**0.96**	0.056	<0.055	<0.055
	MW7-14-15.5	Farallon	11/18/2004	14 to 15.5	**17.0**	**0.075**	<0.044	<0.044	<0.044
	MW7-21.5-23	Farallon	11/18/2004	21.5 to 23	0.042	<0.0010	<0.0010	<0.0010	<0.0010
	MW7-35-36	Farallon	11/18/2004	35 to 36	0.034	<0.0010	<0.0010	<0.0010	<0.0010
MW-8	MW8-5-6.5	Farallon	11/16/2004	5 to 6.5	**0.18**	0.0013	<0.0011	<0.0011	<0.0011
	MW8-45-46.5	Farallon	11/16/2004	45 to 46.5	0.0012	<0.0010	<0.0010	<0.0010	<0.0010
MW-9	MW9-45-46.5	Farallon	11/18/2004	45 to 46.5	**0.13**	<0.048	<0.048	<0.048	<0.048
MW-10	MW10-111204-5-6.5	Farallon	11/12/2004	5 to 6.5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	MW10-111204-22.5-24	Farallon	11/12/2004	22.5 to 24	<0.00083	<0.00083	<0.00083	<0.00083	<0.00083
	MW10-111204-45-46.5	Farallon	11/12/2004	45 to 46.5	<0.045	<0.045	<0.045	<0.045	<0.045
MTCA Cleanup Levels for Soil					**0.05**[3]	**0.03**[3]	**800**[4]	**1,600**[4]	**0.67**[4]

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2]				
					PCE	**TCE**	**cis-1,2-Dichloroethene**	**trans-1,2-Dichloroethene**	**Vinyl Chloride**
MW-11	MW11-67-67.5	Farallon	5/10/2006	67 to 67.5	<0.00079	<0.00079	<0.00079	<0.00079	<0.00079
MW-12	MW12-65.5-67	Farallon	5/8/2006	65.5 to 67	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078
MW-13	MW13-64-65.5	Farallon	5/9/2006	64-65.5	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078
MW-14	MW14-67.5-70	Farallon	5/22/2006	67.5 to 70	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
MW-15	MW15-5-6.5	Farallon	4/21/2006	5 to 6.5	<0.00093	<0.00093	<0.00093	<0.00093	<0.00093
	MW15-15-16.5	Farallon	4/21/2006	15 to 16.5	<0.00083	<0.00083	<0.00083	<0.00083	<0.00083
	MW15-25-25.5	Farallon	4/21/2006	25 to 25.5	**9.5**	**0.055**	0.00097	<0.00076	<0.00076
MW-16	MW16-7.5-9	Farallon	4/21/2006	7.5 to 9	<0.00075	<0.00075	<0.00075	<0.00075	<0.00075
MW-17	MW17-2.5-3.5	Farallon	4/21/2006	2.5 to 3.5	<0.00076	<0.00076	<0.00076	<0.00076	<0.00076
MW-18	MW18-27.5-28.5	Farallon	5/25/2006	27.5 to 28.5	<0.00073	<0.00073	<0.00073	<0.00073	<0.00073
	MW18-77-80	Farallon	5/25/2006	77 to 80	<0.00089	<0.00089	<0.00089	<0.00089	<0.00089
MW-20	MW-20-6-111008	Farallon	11/10/2008	6	**0.69**	0.044	0.0033	<0.00088	<0.00088
	MW-20-26-111008	Farallon	11/10/2008	26	0.0013	<0.00076	<0.00076	<0.00076	<0.00076
	MW-20-45-111008	Farallon	11/10/2008	45	<0.00087	<0.00087	<0.00087	<0.00087	<0.00087
MW-21	MW-21-6-111008	Farallon	11/10/2008	6.0	0.01	<0.00073	<0.00073	<0.00073	<0.00073
	MW-21-16-111008	Farallon	11/10/2008	16.0	<0.00095	<0.00095	<0.00095	<0.00095	<0.00095
MW-22	MW-22-6-111108	Farallon	11/11/2008	6	**0.12**	0.0028	<0.00099	<0.00099	<0.00099
	MW-22-10.5-111108	Farallon	11/11/2008	10.5	0.025	<0.00068	<0.00068	<0.00068	<0.00068
	MW-22-15-111108	Farallon	11/11/2008	15	0.013	<0.00074	<0.00074	<0.00074	<0.00074
	MW-22-25-111108	Farallon	11/11/2008	25	0.002	<0.00068	<0.00068	<0.00068	<0.00068
	MW-22-45-111108	Farallon	11/11/2008	45	<0.00095	<0.00095	<0.00095	<0.00095	<0.00095
MW-23	MW-23-5-111208	Farallon	11/12/2008	5.0	<0.00081	<0.00081	<0.00081	<0.00081	<0.00081
	MW-23-11-111208	Farallon	11/12/2008	11.0	<0.00089	<0.00089	<0.00089	<0.00089	<0.00089
	MW-23-16-111208	Farallon	11/12/2008	16.0	<0.00086	<0.00086	<0.00086	<0.00086	<0.00086
	MW-23-11-111210	Farallon	11/12/2008	20.5	<0.00088	<0.00088	<0.00088	<0.00088	<0.00088
MTCA Cleanup Levels for Soil					**0.05**[3]	**0.03**[3]	**800**[4]	**1,600**[4]	**0.67**[4]

Table 2
Soil Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Depth (feet)[1]	Analytical Results (milligrams per kilogram)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
MW-26	MW26-5.0	Farallon	4/26/2010	5.0	0.0047	<0.00089	<0.00089	<0.00089	<0.00089
	MW26-10.0	Farallon	4/26/2010	10.0	<0.00069	<0.00069	<0.00069	<0.00069	<0.00069
	MW26-20.0	Farallon	4/26/2010	20.0	<0.00081	<0.00081	<0.00081	<0.00081	<0.00081
MW-27	MW27-13.5	Farallon	6/28/2011	13.5	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012
TMW-1	TMW-1-2.5	Farallon	3/30/2010	2.5	0.0018	<0.00092	<0.00092	<0.00092	<0.00092
	TMW-1-02.5	SES	3/30/2010	2.5	<0.025	<0.03	<0.05	<0.05	<0.05
	TMW-1-6	Farallon	3/30/2010	6.0	0.0090	<0.00066	<0.00066	<0.00066	<0.00066
	TMW-1-06	SES	3/30/2010	6.0	<0.025	<0.03	<0.05	<0.05	<0.05
	TMW-1-11	Farallon	3/30/2010	11.0	0.0048	<0.00068	<0.00068	<0.00068	<0.00068
	TMW-1-20	Farallon	3/30/2010	20.0	<0.00099	<0.00099	<0.00099	<0.00099	<0.00099
TMW-2	TMW-2-3	Farallon	3/30/2010	3.0	0.0021	<0.00094	<0.00094	<0.00094	<0.00094
	TMW-2-03	SES	3/30/2010	3.0	<0.025	<0.03	<0.05	<0.05	<0.05
	TMW-2-05.5	SES	3/30/2010	5.5	0.047	<0.03	<0.05	<0.05	<0.05
	TMW-2-8	Farallon	3/30/2010	8.0	0.041	<0.00086	<0.00086	<0.00086	<0.00086
	TMW-2-15	Farallon	3/30/2010	15.0	0.017	<0.00089	<0.00089	<0.00089	<0.00089
	TMW-2-20	Farallon	3/30/2010	20.0	0.0027	<0.00084	<0.00084	<0.00084	<0.00084
TMW-3	TMW-3-3	Farallon	3/30/2010	3.0	<0.00082	<0.00082	<0.00082	<0.00082	<0.00082
	TMW-3-03	SES	3/30/2010	3.0	<0.025	<0.03	<0.05	<0.05	<0.05
	TMW-3-05.5	SES	3/30/2010	5.5	<0.025	<0.03	<0.05	<0.05	<0.05
	TMW-3-7.5	Farallon	3/30/2010	7.5	0.0016	<0.00072	<0.00072	<0.00072	<0.00072
	TMW-3-12.5	Farallon	3/30/2010	12.5	**0.47**	0.0035	0.0011	<0.00078	<0.00078
	TMW-3-20	Farallon	3/30/2010	20.0	0.014	<0.00077	<0.00077	<0.00077	<0.00077
MTCA Cleanup Levels for Soil					**0.05[3]**	**0.03[3]**	**800[4]**	**1,600[4]**	**0.67[4]**

NOTES:

Results in **bold** denote concentrations at or above applicable cleanup levels.
< denotes analyte not detected at or above the reporting limit listed.
[1]Depth in feet below ground surface.
[2]Analyzed by U.S. Environmental Protection Agency Method 8260B.
[3]Washington State Model Toxics Control Act Cleanup Regulation **Method A** Soil Cleanup Levels for Unrestricted Land Uses, Table 740-1 of Section 900 of Chapter 173-340 of the Washington Administrative Code, as revised November 2007.
[4]Washington State Cleanup Levels and Risk Calculations under the Washington State Model Toxics Control Act Cleanup Regulation, Standard **Method B** Formula Values for Soil (Unrestricted Land Use) - Direct Contact (Ingestion Only) and Leaching Pathways, https://fortress.wa.gov/ecy/clarc/Reporting/ChemicalQuery.aspx

Farallon = Farallon Consulting, L.L.C.
GeoEngineers = GeoEngineers, Inc.
MTCA = Washington State Model Toxics Control Act Cleanup Regulation
NT= not tested
PCE = tetrachloroethene
SES = Sound Environmental Strategies, Inc.
TCE = trichloroethene

Table 3
Reconnaissance Groundwater Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Sample Depth (feet)[1]	Analytical Results (micrograms per liter)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
GP-6	GP-6	GeoEngineers	11/22/2002	—	**163**	**55.8**	30.7	0.831	<0.200
GP-9	GP-9	GeoEngineers	11/1/2004	—	<2.0	<2.0	<2.0	<2.0	<2.0
GP-10	GP-10	GeoEngineers	11/1/2004	—	**10.0**	<2.0	<2.0	<2.0	<2.0
GP-11	GP-11	GeoEngineers	11/1/2004	—	**26.0**	<2.0	<2.0	<2.0	<2.0
SB-1	SB1-15-GW	Farallon	8/4/2004	15	**160,000**	<1,000	<1,000	<1,000	<1,000
SB-2	SB2-15-GW	Farallon	8/4/2004	15	**66,000**	**660**	<500	<500	<500
SB-3	SB3-15-GW	Farallon	8/5/2004	15	**19,000**	<500	<500	<500	<500
SB-4	SB4-11-GW	Farallon	8/5/2004	11	**7,000**	**32**	16	<10	<10
SB-6	SB6-10-GW	Farallon	8/4/2004	10	<0.20	<0.20	<0.20	<0.20	<0.20
SB-7	SB7-7-GW	Farallon	8/4/2004	7	0.23	<0.20	<0.20	<0.20	<0.20
	SB7-16-GW	Farallon	8/4/2004	16	<0.20	<0.20	<0.20	<0.20	<0.20
SB-9	SB9-11-GW	Farallon	8/5/2004	11	**500**	**25**	14	<4.0	<4.0
SB-10	SB10-12-GW	Farallon	8/5/2004	12	3.0	0.61	2.1	<0.20	<0.20
SB-11	RGW-SB11-27.5	Farallon	4/19/2006	27.5	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB11-47.5	Farallon	4/19/2006	47.5	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB11-55	Farallon	4/19/2006	55.0	2.2	<0.20	<0.20	<0.20	<0.20
	RGW-SB11-66.5	Farallon	4/19/2006	66.5	3.5	<0.20	<0.20	<0.20	<0.20
SB-12	RGW-SB12-25	Farallon	4/17/2006	25.0	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB12-37.5	Farallon	4/17/2006	37.5	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB12-57.5	Farallon	4/17/2006	57.5	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB12-67	Farallon	4/17/2006	67.0	<0.20	<0.20	<0.20	<0.20	<0.20
MTCA Cleanup Levels for Groundwater					**5**[3]	**5**[3]	**80**[4]	**160**[4]	**0.2**[3]

Table 3
Reconnaissance Groundwater Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Sample Depth (feet)[1]	Analytical Results (micrograms per liter)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
SB-13	RGW-SB13-25	Farallon	4/18/2006	25.0	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB13-35	Farallon	4/18/2006	35.0	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB13-57.5	Farallon	4/18/2006	57.5	<0.20	<0.20	<0.20	<0.20	<0.20
	RGW-SB13-67.5	Farallon	4/18/2006	67.5	<0.20	<0.20	<0.20	<0.20	<0.20
SB-15	RGW-15	Farallon	4/20/2006	8.5	**41**	**12**	17	0.57	<0.20
SB-18	RGW-18	Farallon	4/20/2006	8.5	**9.2**	0.29	<0.20	<0.20	<0.20
P11	P11-20090924	SES	9/24/2009	NA	**87**	**16**	36	<1	**1.3**
P12	P12-20090924	SES	9/24/2009	NA	**5.0**	<1	<1	<1	<0.2
P13	P13-20090925	SES	9/25/2009	NA	**20**	<1	<1	<1	<0.2
P14	P14-20090925	SES	9/25/2009	NA	**300**	<10	12	<10	<2
P15	P15-20090925	SES	9/25/2009	NA	**6.3**	<1	<1	<1	<0.2
P16	P16-20090925	SES	9/25/2009	NA	1.4	<1	<1	<1	<0.2
P17	P17-20090925	SES	9/25/2009	NA	**39**	<1	<1	<1	<0.2
SB-20	Recon-SB-20-040810	Farallon	4/8/2010	14.0	<0.20	<0.20	<0.20	<0.20	<0.20
SB-21	Recon-SB-21-040810	Farallon	4/8/2010	15.0	<0.20	<0.20	<0.20	<0.20	<0.20
	SB21-20100408-Recon	SES	4/8/2010	NA	<1	<1	<1	<1	<0.2
MTCA Cleanup Levels for Groundwater					**5**[3]	**5**[3]	**80**[4]	**160**[4]	**0.2**[3]

Table 3
Reconnaissance Groundwater Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Boring Location	Sample Identification	Sampled By	Sample Date	Sample Depth (feet)[1]	Analytical Results (micrograms per liter)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
SB-22	SB-22-040810-grab	Farallon	4/8/2010	1.0	<0.20	<0.20	<0.20	<0.20	<0.20
	SB22-20100408-Grab	SES	4/8/2010	NA	<1	<1	<1	<1	<0.2
	Recon-SB-22-040910	Farallon	4/9/2010	15.0	**190**	4.4	1.6	<0.20	<0.20
	SB22-20100409	SES	4/9/2010	NA	**220**	<10	<10	<10	<2
SB-23	Recon-SB-23-040810	Farallon	4/8/2010	15.0	**38**	1.1	0.79	<0.20	<0.20
	SB23-20100408-Recon	SES	4/8/2010	NA	**37**	1.0	<1	<1	<0.2
	SB23-20100408-Grab	SES	4/8/2010	NA	<1	<1	<1	<1	<0.2
SB-24	Recon-SB-24-0409/10	Farallon	4/9/2010	15.0	0.87	0.21	<0.20	<0.20	<0.20
SB-25	Recon-SB-25-040810	Farallon	4/8/2010	18.0	<0.20	<0.20	<0.20	<0.20	<0.20
SB-26	SB26-Recon	Farallon	2/23/2011	11.0	**240**	**5.7**	4.7	<1.0	<1.0
SB-27	SB27-Recon	Farallon	2/23/2011	13.5	**75000**	**590**	<500	<500	<500
SB-29	**SB29-Recon**	Farallon	2/25/2011	11.0	**120**	<1.0	<1.0	<1.0	<1.0
SB-30	**SB30-Recon**	Farallon	2/25/2011	11.0	**17**	<0.20	<0.20	<0.20	<0.20
SB-32	**SB32-Recon**	Farallon	2/25/2011	8.0	**68**	1.1	1.4	<0.40	<0.40
SB-35	SB35-Recon	Farallon	2/25/2011	11.0	**52**	<0.40	<0.40	<0.40	<0.40
MTCA Cleanup Levels for Groundwater					**5[3]**	**5[3]**	**80[4]**	**160[4]**	**0.2[3]**

NOTES:

Results in **bold** denote concentrations at or above applicable cleanup levels.

< denotes analyte not detected at or above the reporting limit listed.

[1]Depth in feet below ground surface.

[2]Analyzed by U.S. Environmental Protection Agency Method 8260B.

[3]Washington State Model Toxics Control Act Cleanup Regulation **Method A** Cleanup Levels for Groundwater, Table 720-1 of Section 900 of Chapter 173-340 of the Washington Administrative Code, as revised November 2007.

[4]Washington State Model Toxics Control Act Cleanup Regulation Cleanup Levels and Risk Calculations, Standard **Method B** Values for Groundwater, https://fortress.wa.gov/ecy/clarc/Reporting/ChemicalQuery.aspx

Farallon = Farallon Consulting, L.L.C.
GeoEngineers = GeoEngineers, Inc.
MTCA = Washington State Model Toxics Control Act Cleanup Regulation
PCE = tetrachloroethene
SES = Sound Environmental Strategies, Inc.
TCE = trichloroethene

Table 4
Monitoring Well Groundwater Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Sample Identification	Sampled By	Sample Date	Sample Point Depth (feet)[1]	Analytical Results (micrograms per liter)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
Monitoring Wells Screened in Shallow Zone									
MW-1	MW-1	GeoEngineers	10/30/2003	—	<2.0	<2.0	<2.0	<2.0	<2.0
	MW1-060206	Farallon	6/2/2006	16.42	1.1	<0.2	<0.2	<0.2	<0.2
	MW1-112008	Farallon	11/20/2008	16.48	1.5	<0.2	<0.2	<0.2	<0.2
	MW1-050410	Farallon	5/4/2010	11.50	1.8	<0.2	<0.2	<0.2	<0.2
MW-2	MW-2	GeoEngineers	10/30/2003	—	<2.0	<2.0	<2.0	<2.0	<2.0
	MW2-060106	Farallon	6/1/2006	17.50	<0.2	**5.5**	<0.2	<0.2	<0.2
	MW2-111908	Farallon	11/19/2008	17.31	**6.80**	4.6	<0.2	<0.2	<0.2
	MW2-050410	Farallon	5/4/2010	12.50	**9.50**	3.5	<0.2	<0.2	<0.2
MW-3	MW-3	GeoEngineers	10/30/2003	—	**170**	<2.0	<2.0	<2.0	<2.0
	MW3-060106	Farallon	6/1/2006	17.56	**150**	1.1	<1.0	<1.0	<1.0
	MW3-111908	Farallon	11/19/2008	17.60	**230**	1.6	2	<1.0	<1.0
	MW3-050410	Farallon	5/4/2010	12.50	**150**	<1.0	<1.0	<1.0	<1.0
MW-4	MW-4	GeoEngineers	10/30/2003	—	**2,100**	**220**	**92**	<2.0	**20**
	MW4-080504	Farallon	8/5/2004	16.00	**860**	**1200**	**250**	<10	**68**
	MW4-060206	Farallon	6/2/2006	16.08	**1,100**	**730**	**590**	<10	**170**
	MW4-042007	Farallon	4/20/2007	14.95	**3,100**	**720**	**940**	<20	**160**
	MW4-112008	Farallon	11/20/2008	15.61	**10,000**	**640**	**1,100**	<50	**130**
	MW4-050510	Farallon	5/5/2010	11.00	**10,000**	**1,000**	**1,600**	<50	**370**
MW-5	MW-5	GeoEngineers	10/30/2003	—	**270**	**46**	<2.0	<2.0	<2.0
	MW5-060106	Farallon	6/1/2006	15.45	**54**	**9.6**	3.3	<0.4	<0.4
	MW5-20080328	SES	3/28/2008	—	**19**	**110**	40	<1	2.8
	MW5-112008	Farallon	11/20/2008	15.47	**86**	**67**	37	1.4	**5.5**
	MW5-050410	Farallon	5/4/2010	10.00	**82**	**34**	27	0.44	**0.88**
MW-6	MW-6	GeoEngineers	11/8/2004	—	**29**	**18**	11	<2.0	**6**
	MW6-050410	Farallon	5/4/2010	14.50	**4,100**	**330**	**440**	<20	**110**
MTCA Cleanup Levels for Groundwater					**5**[3]	**5**[3]	**80**[4]	**160**[4]	**0.2**[3]

Table 4
Monitoring Well Groundwater Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Sample Identification	Sampled By	Sample Date	Sample Point Depth (feet)[1]	Analytical Results (micrograms per liter)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
MW-15	MW15-060106	Farallon	6/1/2006	16.12	0.22	<0.2	<0.2	<0.2	<0.2
	MW15-112008	Farallon	11/20/2008	13.20	0.26	<0.2	<0.2	<0.2	<0.2
	MW15-050410	Farallon	5/4/2010	12.50	<1.0	<0.2	<0.2	<0.2	<0.2
MW-16	MW16-060106	Farallon	6/1/2006	17.45	<0.2	<0.2	<0.2	<0.2	<0.2
	MW16-111908	Farallon	11/19/2008	17.60	<0.2	<0.2	<0.2	<0.2	<0.2
	MW16-050510	Farallon	5/5/2010	12.50	<1.0	<0.2	<0.2	<0.2	<0.2
MW-17	MW17-060106	Farallon	6/1/2006	17.19	<0.2	<0.2	<0.2	<0.2	<0.2
MW19	MW17-20080328	SES	3/28/2008	—	<1	<1	<1	<1	<0.2
	MW19-20090311	SES	3/11/2009	—	<1	<1	<1	<1	<0.2
	MW19-050310	Farallon	5/3/2010	15.00	<1	<0.2	<0.2	<0.2	<0.2
MW-21	MW21-112008	Farallon	11/20/2008	21.74	<0.2	<0.2	<0.2	<0.2	<0.2
	MW21-050410	Farallon	5/4/2010	19.00	<1.0	<0.2	<0.2	<0.2	<0.2
MW-23	MW23-112008	Farallon	11/20/2008	18.15	<0.2	<0.2	<0.2	<0.2	<0.2
	MW23-050410	Farallon	5/4/2010	15.00	<1.0	<0.2	<0.2	<0.2	<0.2
MW-24	MW18-20080328	SES	3/28/2008	—	**650**	<10	<10	<10	<2.0
	MW24-112008	Farallon	11/20/2008	15.25	**360**	3.4	<2.0	<2.0	<2.0
	MW24-20090304	Farallon	3/4/2009	—	**290**	<10	<10	<10	<2.0
	MW24-050510	Farallon	5/5/2010	13.00	**40**	0.42	<0.2	<0.2	<0.2
MW-25	MW25-050410	Farallon	5/4/2010	13.00	**14**	0.31	1.1	<0.2	<0.2
MW-26	MW26-050410	Farallon	5/4/2010	13.00	<1.0	<0.2	<0.2	<0.2	<0.2
MW-27	MW27-070111	Farallon	7/1/2011	11.00	<0.2	<0.2	<0.2	<0.2	<0.2
TMW-1	TMW-1-040510	Farallon	4/5/2010	13.75	**15**	0.29	<0.2	<0.2	<0.2
	TMW-1-20100405	SES	4/5/2010	NA	**16**	<1	<1	<1	<0.2
TMW-2	TMW-2-040510	Farallon	4/5/2010	13.79	**110**	1.5	<1.0	<1.0	<1.0
	TMW-2-20100405	SES	4/5/2010	NA	**150**	1.5	<1	<1	<0.2
TMW-3	TMW-3-040510	Farallon	4/5/2010	13.22	**310**	3.6	<2.0	<2.0	<2.0
	TMW-3-20100405	SES	4/5/2010	NA	**350**	3.7	<1	<1	<0.2
MTCA Cleanup Levels for Groundwater					**5**[3]	**5**[3]	**80**[4]	**160**[4]	**0.2**[3]

Table 4
Monitoring Well Groundwater Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Sample Identification	Sampled By	Sample Date	Sample Point Depth (feet)[1]	Analytical Results (micrograms per liter)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
Monitoring Wells Screened in Deep Zone									
MW-7	MW7-111904-01	Farallon	11/19/2004	26.00	**7,000**	**47**	<20	<20	<20
	MW7-060206	Farallon	6/2/2006	29.00	**530**	**16**	<4.0	<4.0	<4.0
	MW7-042007	Farallon	4/20/2007	28.00	2.5	<2.0	<2.0	<2.0	<2.0
	MW7-112008	Farallon	11/20/2008	28.67	**18.0**	0.69	<2.0	<2.0	<2.0
	MW7-050410	Farallon	5/4/2010	26.00	**12.0**	0.49	<0.2	<0.2	<0.2
MW-8	MW8-111904-01	Farallon	11/19/2004	35.00	0.36	<0.2	<0.2	<0.2	<0.2
	MW8-060106	Farallon	6/1/2006	38.09	<0.2	<0.2	<0.2	<0.2	<0.2
	MW8-111908	Farallon	11/19/2008	38.15	0.70	<0.2	<0.2	<0.2	<0.2
	MW8-050510	Farallon	5/4/2010	35.00	<1.0	<0.2	<0.2	<0.2	<0.2
MW-9	MW9-111904-01	Farallon	11/19/2004	35.00	**210**	<1.0	<1.0	<1.0	<1.0
	MW9-060106	Farallon	6/1/2006	37.81	**390**	<2.0	<2.0	<2.0	<2.0
	MW9-042007	Farallon	4/20/2007	36.75	**410**	<2.0	<2.0	<2.0	<2.0
	MW9-112008	Farallon	11/20/2008	37.81	**220**	<2.0	<2.0	<2.0	<2.0
	MW9-050410	Farallon	5/4/2010	35.00	**190**	<0.2	<0.2	<0.2	<0.2
MW-10	MW10-111904-01	Farallon	11/19/2004	34.98	2.50	<0.2	<0.2	<0.2	<0.2
	MW10-060106	Farallon	6/1/2006	37.98	<0.2	<0.2	<0.2	<0.2	<0.2
	MW10-042007	Farallon	4/20/2007	37.00	<0.2	<0.2	<0.2	<0.2	<0.2
	MW10-112008	Farallon	11/20/2008	38.01	<0.2	<0.2	<0.2	<0.2	<0.2
	MW10-050410	Farallon	5/4/2010	35.00	3.30	<0.2	<0.2	<0.2	<0.2
MW-11	MW11-060206	Farallon	6/2/2006	62.30	<0.2	<0.2	<0.2	<0.2	<0.2
	MW11-112008	Farallon	11/20/2008	63.30	<0.2	<0.2	<0.2	<0.2	<0.2
	MW11-050310	Farallon	5/3/2010	62.50	<1.0	<0.20	<0.2	<0.2	<0.2
MW-12	MW12-060206	Farallon	6/2/2006	60.51	0.76	<0.2	<0.2	<0.2	<0.2
	MW12-111908	Farallon	11/19/2008	64.10	<0.2	<0.2	<0.2	<0.2	<0.2
	MW12-050310	Farallon	5/3/2010	62.00	<1.0	<0.2	<0.2	<0.2	<0.2
MW-13	MW13-060206	Farallon	6/2/2006	60.90	<0.2	<0.2	<0.2	<0.2	<0.2
	MW13-042007	Farallon	4/20/2007	63.18	<0.2	<0.2	<0.2	<0.2	<0.2
	MW13-111908	Farallon	11/19/2008	64.22	<0.2	<0.2	<0.2	<0.2	<0.2
	MW13-050310	Farallon	5/3/2010	60.00	<1.0	<0.2	<0.2	<0.2	<0.2
MTCA Cleanup Levels for Groundwater					**5[3]**	**5[3]**	**80[4]**	**160[4]**	**0.2[3]**

Table 4
Monitoring Well Groundwater Analytical Results for Selected Halogenated Volatile Organic Compounds
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Monitoring Well Identification	Sample Identification	Sampled By	Sample Date	Sample Point Depth (feet)[1]	Analytical Results (micrograms per liter)[2]				
					PCE	TCE	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl Chloride
MW-14	MW14-060206	Farallon	6/2/2006	71.31	0.99	<0.2	<0.2	<0.2	<0.2
	MW14-032507	Farallon	3/25/2007	70.08	<0.2	<0.2	<0.2	<0.2	<0.2
	MW14-042007	Farallon	4/20/2007	68.80	<0.2	<0.2	<0.2	<0.2	<0.2
	MW14-112008	Farallon	11/20/2008	70.16	1.10	<0.2	<0.2	<0.2	<0.2
	MW14-050410	Farallon	5/4/2010	68.00	<1.0	<0.2	<0.2	<0.2	<0.2
MW-18	MW18-060106	Farallon	6/1/2006	75.92	<0.2	<0.2	<0.2	<0.2	<0.2
MW-20	MW20-112008	Farallon	11/20/2008	47.19	0.28	<0.2	<0.2	<0.2	<0.2
	MW20-050410	Farallon	5/4/2010	45.00	<1.0	<0.2	<0.2	<0.2	<0.2
MW-22	MW22-112008	Farallon	11/20/2008	47.19	<0.2	<0.2	<0.2	<0.2	<0.2
	MW22-050410	Farallon	5/4/2010	44.00	<1.0	<0.2	<0.2	<0.2	<0.2
MTCA Cleanup Levels for Groundwater					**5[3]**	**5[3]**	**80[4]**	**160[4]**	**0.2[3]**

NOTES:

Results in **bold** denote concentrations at or above applicable cleanup levels.
< denotes analyte not detected at or above the reporting limit listed.

[1]Depth in feet below ground surface.

[2]Analyzed by U.S. Environmental Protection Agency Method 8260B.

[3]Washington State Model Toxics Control Act Cleanup Regulation **Method A** Cleanup Levels for Groundwater, Table 720-1 of Section 900 of Chapter 173-340 of the Washington Administrative Code, as revised November 2007.

[4]Washington State Model Toxics Control Act Cleanup Regulation Cleanup Levels and Risk Calculations, Standard **Method B** Values for Groundwater, https://fortress.wa.gov/ecy/clarc/Reporting/ChemicalQuery.aspx

Farallon = Farallon Consulting, L.L.C.
GeoEngineers = GeoEngineers, Inc.
MTCA = Washington State Model Toxics Control Act Cleanup Regulation
PCE = tetrachloroethene
SES = Sound Environmental Strategies, Inc.
TCE = trichloroethene

Table 5
Summary of Groundwater Geochemistry Results
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

			Results (micrograms per liter)										Results		
Sample Location	Sample Identification	Date Collected	Dissolved Oxygen[1]	Nitrate[2]	Dissolved Manganese [3]	Total Iron[3]	Ferrous Iron[4]	Ferric Iron[5]	Sulfate[2]	Methane[6]	Ethane[6]	Ethene[6]	ORP[1] (millivolts)	Temperature[1] (Celsius)	pH[1]
Monitoring Well Screened in Shallow Zone															
MW-1	MW1-060206	6/2/2006	4.16	16	0.02	1.30	0.00	1.30	16	<0.01	<0.01	<0.01	198.6	14.37	6.71
Monitoring Wells Screened in Deep Zone															
MW-7	MW7-060206	6/2/2006	0.11	<0.15	0.10	4.30	0.00	4.30	65	0.33	<0.01	<0.01	20.6	15.3	7.62
MW-11	MW11-060206	6/2/2006	0.32	2.8	0.25	2.80	0.00	2.80	35	<0.01	<0.01	<0.01	149.2	13.65	7.15
MW-12	MW12-060206	6/2/2006	0.11	<0.15	0.11	4.20	0.00	4.20	39	<0.01	<0.01	<0.01	-91.2	15.34	7.14
MW-13	MW13-060206	6/2/2006	0.11	<0.15	0.24	2.20	0.00	2.20	35	<0.01	<0.01	<0.01	53.1	14.91	7.4
MW-14	MW14-060206	6/2/2006	0.10	<0.15	0.32	1.90	0.00	1.90	34	<0.01	<0.01	<0.01	-103.5	15.12	7.5

NOTES:

< denotes analyte not detected at or above reporting limit listed.

ORP = oxidation-reduction potential

[1]Analyzed by field instrument.

[2]Analyzed by U.S. Environmental Protection Agency (EPA) Method 300.0.

[3]Analyzed by EPA Method 6010.

[4]Analyzed by EPA Method SM 3500-Fe B or Field Kit Instrument.

[5]Ferric Iron = Total Iron minus Ferrous Iron. If concentrations of Ferrous Iron are non-detect, Ferric Iron is assumed to be equal to Total Iron.

[6]Analyzed by Headspace.

Table 6
January 2007 Shallow Zone Slug Test Results
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Well Identification	Well Type	Screen Interval (feet bgs)	Analytical Method	Aquifer Model	Test Type	Saturated Thickness (feet)	K (ft/day)	K (cm/sec)	Comments
MW-4	Test/Observation	4 -18	Bouwer-Rice (1976)	Unconfined	Falling Head	61.94	0.1609	5.68E-05	Used Visual Fit Curve.
			Bouwer-Rice (1976)	Unconfined	Rising Head	61.94	0.0144	5.09E-06	
MW-5	Test/Observation	2.5 -17.5	Bouwer-Rice (1976)	Unconfined	Falling Head	64.92	0.0420	1.48E-05	Used Visual Fit Curve.
			Bouwer-Rice (1976)	Unconfined	Rising Head	64.92	0.0146	5.15E-06	
MW-15	Test/Observation	5 - 20	Bouwer-Rice (1976)	Unconfined	Falling Head	62.64	0.0325	1.14E-05	Used Auto Fit Curve.
			Bouwer-Rice (1976)	Unconfined	Rising Head	62.64	0.0635	2.24E-05	

K (ft/day)	K (cm/sec)	
0.0546	1.93E-05	Mean K (all)
0.0378	1.33E-05	Geometric Mean K (all)

NOTES:
cm/sec = centimeters per second
feet bgs = feet below ground surface
ft/day = feet per day
K = hydraulic conductivity

Table 7
January 2007 Deep Zone Aquifer Pump Test Results
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Well Identification	Well Type	Screen Interval (feet bgs)	Analytical Method	Aquifer Model	T (ft^2/day)	Saturated Thickness (feet)	K (ft/day)	K (cm/sec)	Storativity (unitless)	Comments
MW-1	Observation	4 - 19	Cooper-Jacob (1946)	Unconfined	603	64	9.42	3.32E-03	0.13	Storativity indicates unconfined conditions
			Theis (1935)	Unconfined	697	64	10.89	3.84E-03	0.17	
			Hantush-Jacob (1955)	Leaky	1057	64	16.52	5.83E-03	0.12	
MW-7	Observation	21 - 31	Theis (1935)	Unconfined	506	67	7.55	2.66E-03	0.02	Storativity indicates unconfined to semi-confined conditions
			Hantush-Jacob (1955)	Leaky	467	67	6.97	2.46E-03	0.02	
MW-8	Observation	30 - 40	Theis (1935)	Unconfined	868	68	12.76	4.50E-03	0.007	Storativity indicates semi-confined to confined conditions
			Hantush-Jacob (1955)	Leaky	592	68	8.71	3.07E-03	0.007	
MW-9	Observation	30 - 40	Theis (1935)	Confined	1187	67	17.72	6.25E-03	0.0007	Storativity indicates semi-confined to confined conditions
			Hantush-Jacob (1955)	Leaky	453	67	6.76	2.39E-03	0.001	
MW-11	Pumping	57.5 - 67.5	Theis (1935)	Confined	498	68	7.32	2.58E-03	--	Cannot calculate storativity from pumping well
MW-12	Observation	57 - 67	Hantush-Jacob (1955)	Leaky	495	60	8.25	2.91E-03	0.0003	Storativity indicates confined conditions
MW-13	Observation	55.5 - 65.5	Hantush-Jacob (1955)	Leaky	418	60	6.97	2.46E-03	0.0002	Storativity indicates confined conditions
MW-14	Observation	63 - 73	Hantush-Jacob (1955)	Leaky	395	68	5.81	2.05E-03	0.0003	Storativity indicates confined conditions
MW-18	Observation	68 - 78	Hantush-Jacob (1955)	Leaky	404	72	5.61	1.98E-03	0.004	Storativity indicates semi-confined to confined conditions

9.38	3.31E-03	Mean K (all)
8.78	3.10E-03	Geometric Mean K (all)
11.92	4.21E-03	Geometric Mean Shallow Zone (MW-1)
8.08	2.85E-03	Geometric Mean Deep Zone

NOTES:

Wells MW-3, MW-4, MW-5, MW-15, and MW-17 could not be analyzed due to minimal or erratic response during pumping

cm/sec = centimeters per second

ft/bgs = feet below ground surface

ft/day = feet per day

ft^2/day = feet squared per day

K = hydraulic conductivity

T = transmissivity

Table 8
Potentially Applicable Local, State, and Federal Regulations
Plastics Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Regulation	Source	Description and Relevance
Potential Chemical-Specific ARARs[1]		
National Ambient Air Quality Standards	40 CFR 50	Specifies primary and secondary National Ambient Air Quality Standards, National Emission Standards for Hazardous Air Pollutants, and performance standards for new and existing stationary sources. National Ambient Air Quality Standards are applicable to those elements of the Remedial Action pertaining to the collection and management of soil vapor.
State Dangerous Waste Regulations	WAC 173-303	Establishes regulatory requirements for the generation, handling, storage, transport, treatment, and disposal of dangerous wastes in the State of Washington under the provisions of the Washington State Hazardous Waste Management Act. These regulations apply to waste deemed dangerous or extremely hazardous to public health or the environment. The regulations would apply to material generated during conduct of the Remedial Action that is found to be contaminated with dangerous waste, and requires treatment and disposal off the Site.
Puget Sound Clean Air Agency (PSCAA) Notice of Construction	Regulation I	Requires a Notice of Construction and Application for Approval before constructing or modifying an air contaminant source. This would apply to the Remedial Action due to potential emissions of soil vapor.
PSCAA Emission Standards for Toxic Air Pollutants	Regulation III	Implements at a regional level the National Emission Standards for Hazardous Air Pollutants (NESHAPS). It requires best available control technology for sources of toxic air contaminants; and requires that toxic air contaminants be quantified and compared against acceptable source impact levels for each contaminant.
Water Quality Standards for Groundwater of the State of Washington	WAC 173-200	Establishes regulatory requirements to implement Washington State's antidegradation policy ensuring the purity of Washington State's groundwaters. Numeric criteria established for primary and secondary contaminants, radionuclides, and carcinogens.

Table 8
Potentially Applicable Local, State, and Federal Regulations
Plastics Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Regulation	Source	Description and Relevance
Potential Location-Specific ARARs[1]		
Federal Archeological Resource Preservation	Chapter 27-53 RCW	This law addresses the discovery, identification, excavation, and study of archaeological resources; and the communication of information to state and federal agencies regarding the possible impact of constructions activities on Washington State archaeological resources. This law is potentially applicable during implementation of the excavation activities.
Protection of Upper Aquifer Zones	WAC 173-154	Establishes regulatory requirements for the protection of the occurrence, availability, and quality of groundwater within upper aquifers or upper aquifer zones where there are multiple aquifer systems.
State Permits for Archeological Excavation and Removal	WAC 25-48	Establishes application and review procedures for the issuance of archaeological excavation and removal permits, and for the issuance of civil penalties for violations. This law is potentially applicable in the event that archaeological resources are identified during implementation of the Remedial Action.
State Model Toxics Control Act Cleanup Regulation	WAC 173-340	Establishes administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances have come to be located.

Table 8
Potentially Applicable Local, State, and Federal Regulations
Plastics Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Regulation	Source	Description and Relevance
Potential Action-Specific ARARs[1]		
Monitoring, Maintenance, and Construction		
Accreditation of Environmental Laboratories	WAC 174-50	Establishes a Washington State program for accreditation of environmental laboratories which conduct tests and submit data to the Washington State Department of Ecology, the Department of Health, and other entities which require the use of accredited laboratories.
Federal Occupational Safety and Health Standards	29 CFR 1910.120	Requires that employers develop and implement a written safety and health program for their employees involved in hazardous waste operations. The program must be designed to identify, evaluate, and control safety and health hazards, and provide for emergency response for hazardous waste operations. This regulation is applicable to the implementation of the Remedial Action.
Safety Standards for Construction Work	WAC 296-155	Establishes rules specifying minimum safety requirements where construction, alteration, demolition, related inspection, and/or maintenance and repair work is performed.
State Occupational Health Standards	WAC 296-62	Establishes rules designed to protect the health of employees and help to create a healthy work place by establishing requirements to control health hazards. Requirements for chemical hazard communication programs, workplace lighting levels and exposure records are in the safety and health core rules of this chapter. This regulation is applicable to the implementation of the Remedial Action.
Well Construction Standards	WAC 173-160 Part Two	Part Two of this regulation defines minimum standards for the construction and decommissioning of the water resource protection wells that will be or have been installed as part of the groundwater monitoring program to be implemented as part of the Remedial Action. Resource protection wells may not be used to withdraw or inject water for domestic, industrial, municipal, commercial, or agricultural purposes. The standards defined in this regulation are applicable to the Remedial Action groundwater monitoring program.

Table 8
Potentially Applicable Local, State, and Federal Regulations
Plastics Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Regulation	Source	Description and Relevance
Potential Action-Specific ARARs (cont'd)		
Excavation and Filling		
State Particulate Matter Standards	WAC 173-470	Establishes maximum acceptable levels for particulate matter in ambient air based on the criteria defining particulate matter that have been developed by the U.S. Environmental Protection Agency. This regulation establishes requirements for monitoring, measuring, and reporting particulate matter data. It applies to dust-producing activities during implementation of the Remedial Action, particularly excavation and filling.
PSCAA Fugitive Dust Standards	Regulation I	Establishes emission standards for fugitive dust. Like the State Particulate Matter Standards (above), this regulation applies to dust-producing activities during implementation of the Remedial Action, particularly excavation and filling.
Treatment, Discharge, and Disposal		
National Pollutant Discharge Elimination System Permit	WAC 173-220	Establishes a state individual permit program, applicable to the discharge of pollutants and other wastes and materials to the surface waters of Washington State, operating under state law as a part of the Federal Water Pollution Control Act. Permits issued under this chapter are designed to satisfy the requirements for discharge permits under both the Federal Water Pollution Control Act and Washington State Water Pollution Control Act. This requirement is applicable to the control, collection, management, and discharge of stormwater runoff during and after construction of the Remedial Action.
State Waste Discharge General Permit Program	WAC 173-226	Establishes a state general permit program, applicable to the discharge of pollutants, wastes, and other materials to waters of the state, including discharges to municipal sewerage systems. Permits issued under this regulation are designed to satisfy the requirements for discharge permits under the Federal Water Pollution Control Act and the Washington State Water Pollution Control Act. This regulation is relevant and appropriate to the dewatering elements of the Remedial Action.
Industrial Waste Discharge to Metropolitan King County Sewer System	KCC 28.84.060	Establishes rules and regulations applicable to water pollution abatement activities, including the disposal of sewage into the metropolitan sewer system, whether delivered from within or from without King County. Authorizes King County to develop and implement such procedures and to take any other actions as may be necessary to ensure that local public sewers and private sewers discharging or proposing to discharge into the metropolitan sewer system are constructed and developed in accordance with applicable laws, regulations and plans. This regulation is relevant and appropriate to implementation of the dewatering elements of the Remedial Action.

Table 8
Potentially Applicable Local, State, and Federal Regulations
Plastics Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

Regulation	Source	Description and Relevance
Potential Action-Specific ARARs (cont'd)		
Treatment, Discharge, and Disposal (cont'd)		
City of Seattle Street Use	SMC Title 15, as applicable	Requires a written permit for any proposed activities that use City of Seattle street right-of-way, including construction activities and movement of equipment. A street use permit will be required for Remedial Action work elements occurring within the right-of-way.
City of Seattle Water Connection	SMC 21.04	Specifies an application and approval process for connecting to the City of Seattle water supply system. Water connection is potentially needed for dust control during grading or for other purposes during the Remedial Action.
City of Seattle Side Sewer Connection	SMC 21.16	Requires connection of all sources of polluted water with the nearest accessible sanitary sewer. Sewer connection will be needed for discharge of Remedial Action process water.
City of Seattle Electrical Service Connection	SMC 21.49	Specifies an application and approval process for obtaining electrical service from Seattle City Light Department. Electrical service will be needed to power Remedial Action machinery.
City of Seattle Building Codes	SMC Title 22, as applicable	Includes a number of requirements applicable to the Remedial Action, including electrical, mechanical, fire, and energy codes; and regulations for grading, stormwater, drainage, and erosion control (see more detail below).
City of Seattle Stormwater, Drainage, and Erosion Control	SMC 22.802	Specifies a drainage control review and approval process for projects that involve land-disturbing activities or new or replaced impervious surface. The Remedial Action will require a Drainage Control Plan and a Construction Stormwater Control Plan for these types of activities.
City of Seattle Grading	SMC 22.804	Specifies a process for application and approval of a grading permit for earth-moving activities. Grading must preserve natural drainage patterns, and not create unstable slopes or contribute to increased turbidity or other forms of pollution in a watercourse.
City of Seattle Noise Control	SMC 25.08	Specifies maximum permissible noise levels for construction activities, depending on the zoning designation.

NOTES:

[1]As noted in Section 3.1. Because it is understood that Washington MTCA is the overarching regulation governing all aspects of the Interim Action, it is not included in this table.

ARARs = applicable or relevant and appropriate requirements
CFR = Code of Federal Regulations
KCC = King County Code
MTCA = Washington State Model Toxics Control Act Cleanup Regulation
RCW = Revised Code of Washington
RI/FS = Remedial Investigation/Feasibility Study
SMC = Seattle Municipal Code
WAC = Washington Administrative Code

Table 9
Cleanup Technology Screening
Plastic Sales and Service, Inc. Site
Farallon PN: 343-002

				Primary Criteria Score[2]		Secondary Criterion Score[2]			
Media	**General Response Action**	**Technology**	**Process Option[1]**	**Implementability**	**Effectiveness**	**Relative Cost**	**Total Score[2]**	**Rank[3]**	**Retain[4]**
Non-Specific Zone									
Non-Specific	**No Action**	**None**	**None**	**3**	**0**	**3**	**6**	**2**	**Y**
	Institutional Controls	**Legal**	**Deed Restrictions (Environmental Covenant), Property Use Restrictions, Health Advisories**	**3**	**1**	**3**	**7**	**1**	**Y**
	Monitored Natural Attenuation	**Natural Degradation Processes, Monitoring, Modeling**	**Sample Collection and Analysis, Predictive Modeling**	**3**	**1**	**3**	**7**	**1**	**Y**
Shallow Zone									
Soil Vapor and Indoor Air	**Engineering Controls**	**Ventilate**	**Subgrade Venting and Depressurization**	**3**	**3**	**3**	**9**	**1**	**Y**
		Barrier	**Sub-Slab and Retaining Wall Membrane**	**3**	**3**	**3**	**9**	**1**	**Y**
	Mitigate Volatile Constituents in Groundwater and Soil	Various (see below)	Various (see below)	see above	see above	see above	see above	see above	see above
Soil	**Treat In-Situ**	Biological	Bioventing	2	2	2	6	3	N
			Enhanced Bioremediation	2	2	2	6	3	N
		Chemical	Chemical Oxidation	2	1	2	5	4	N
		Physical	Soil Flush	2	1	2	5	4	N
			Soil Vapor Extraction	2	1	2	5	4	N
			Thermal Remediation	**3**	**3**	**1**	**7**	**2**	**Y**
	Excavate and Treat or Contain On or Off the Site	Biological	Biopile	2	2	1	5	4	N
			Slurry Phase Biological Remediation	2	2	1	5	4	N
		Chemical	Dehalogenation	2	2	1	5	4	N
		Physical	Incineration	2	3	1	6	3	N
			Landfill	**2**	**3**	**2**	**7**	**2**	**Y**
			Thermal Desorption	2	3	1	6	3	N
	Containment	**Capping**	**Physical Barriers and Constructed Cover**	**3**	**2**	**3**	**8**	**1**	**Y**
Groundwater	**Treat In-Situ**	Biological	Enhanced Bioremediation	2	1	2	5	3	N
		Chemical	Chemical Oxidation Type 1--Ozone	2	1	2	5	3	N
			Chemical Oxidation Type 2--Permanganate	2	1	2	5	3	N
			Chemical Oxidation Type 3--Hydrogen Peroxide/ Fentons Reagent	2	1	2	5	3	N
			Passive or Reactive Treatment Wall	2	1	1	4	4	N
		Physical	Air Sparge	1	1	2	4	4	N
			Thermal Remediation	**2**	**3**	**1**	**6**	**2**	**Y**
	Containment	**Capping**	**Physical Barriers and Constructed Cover**	**3**	**1**	**3**	**7**	**1**	**Y**
		Vertical Barrier	Sheet Pile Wall	2	1	1	4	4	N
			Slurry Wall	1	1	1	3	5	N
	Collect and Treat Ex-Situ	Biological	Bioreactor	2	1	1	4	4	N
		Chemical	Advanced Oxidation Processes	2	1	1	4	4	N
			Granular Activated Carbon	2	1	1	4	4	N
		Physical	Air Stripping	2	1	1	4	4	N
			Dispose to Sanitary Sewer	2	1	2	5	3	N

Table 9
Cleanup Technology Screening
Plastic Sales and Service, Inc. Site
Farallon PN: 343-002

Media	General Response Action	Technology	Process Option[1]	Implementability	Effectiveness	Relative Cost	Total Score[2]	Rank[3]	Retain[4]
Deep Zone									
Soil	Treat In-Situ	**Biological**	Bioventing	2	2	2	6	3	N
			Enhanced Bioremediation	**3**	**3**	**2**	**8**	**1**	**Y**
		Chemical	**Chemical Oxidation**	**3**	**3**	**2**	**8**	**1**	**Y**
		Physical	Soil Flush	2	2	2	6	3	N
			Soil Vapor Extraction	1	1	2	4	5	N
			Thermal Remediation[5]	**2**	**3**	**2**	**7**	**2**	**Y**
	Excavate and Treat or Contain On or Off the Site	Biological	Biopile	1	2	1	4	5	N
			Slurry Phase Biological Remediation	1	2	1	4	5	N
		Chemical	Dehalogenation	1	2	1	4	5	N
		Physical	Incineration	1	3	1	5	4	N
			Landfill	**2**	**3**	**2**	**7**	**2**	**Y**
			Thermal Desorption	1	3	1	5	4	N
	Containment	**Capping**	**Physical Barriers and Constructed Cover**	**3**	**2**	**3**	**8**	**1**	**Y**
Groundwater	**Treat In-Situ**	**Biological**	**Enhanced Bioremediation**	**3**	**3**	**2**	**8**	**1**	**Y**
		Chemical	Chemical Oxidation Type 1--Ozone	1	1	2	4	4	N
			Chemical Oxidation Type 2--Permanganate	**3**	**3**	**2**	**8**	**1**	**Y**
			Chemical Oxidation Type 3--Hydrogen Peroxide/ Fentons Reagent	**3**	**3**	**2**	**8**	**1**	**Y**
			Passive or Reactive Treatment Wall	2	1	1	4	4	N
		Physical	Air Sparge	1	2	1	4	3	N
			Thermal Remediation[5]	**2**	**3**	**2**	**7**	**2**	**Y**
	Containment	**Capping**	**Physical Barriers and Constructed Cover**	**3**	**1**	**3**	**7**	**2**	**Y**
		Vertical Barrier	Sheet Pile Wall	2	1	1	4	4	N
			Slurry Wall	2	1	1	4	4	N
	Collect and Treat Ex-Situ	Biological	Bioreactor	2	1	1	4	4	N
		Chemical	Advanced Oxidation Processes	2	1	1	4	4	N
			Granular Activated Carbon	2	1	1	4	4	N
		Physical	Air Stripping	2	1	1	4	4	N

NOTES:
[1]Process options in bold and larger font are retained for consideration in Cleanup Alternatives 1 through 6.
[2]Scores: 0 least favorable, 3 most favorable
[3]Rank: Relative to an environmental medium (soil or groundwater) within a zone (shallow or deep)
[4]Retain: Y = Yes, retain for consideration in cleanup alternative(s). N = No, do not retain for consideration in cleanup alternative(s).
[5]While relative cost for thermal remediation in the Deep Zone if used alone would be considered high (score=1), the incremental cost if used with thermal remediation in the Shallow Zone would be moderate (score=2)

Table 10
Remedial Alternatives Cost Summary
Plastic Sales and Service, Inc.
Seattle, Washington
Farallon PN: 343-002

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Task	**Institutional and Engineering Controls, Monitored Natural Attenuation**	**In-Situ Thermal Treatment Shallow Zone, Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls**	**In-Situ Thermal Treatment Shallow Zone, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls**	**In-Situ Thermal Treatment Shallow Zone and Deep Zone, Excavation of Shallow Soil, Monitored Natural Attenuation, Institutional Controls**	**Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls**	**Excavation of Shallow Zone and Deep Zone Soil**
Capital Costs						
Project Management	$16,200	$155,000	$109,000	$180,000	$55,300	$182,000
Remedial Design	$26,000	$248,000	$174,000	$287,000	$88,500	$291,000
Construction Management	$19,500	$186,000	$131,000	$215,000	$133,000	$219,000
Site Preparation and Construction	$54,900	$938,000	$938,000	$1,140,000	$275,000	$169,000
Remediation	$75,000	$1,220,000	$518,000	$1,270,000	$1,480,000	$4,660,000
Performance Monitoring	Not Applicable	$86,200	$74,400	$135,000	$15,300	$27,400
Demobilization	Not Applicable	$101,000	$101,000	$125,000	Included Above	Included Above
Subtotal Construction	*$129,900*	*$2,345,200*	*$1,631,400*	*$2,670,000*	*$1,770,300*	*$4,856,400*
Contingency Percent	25%	25%	25%	25%	25%	50%
Contingency Price	$32,500	$586,000	$408,000	$668,000	$443,000	$2,430,000
Estimated Thermal Treatment Price Guarantee	Not Applicable	$174,000	$140,000	$252,000	Not Applicable	Not Applicable
Total Construction Cost	$162,400	$3,105,200	$2,179,400	$3,590,000	$2,213,300	$7,286,400
TOTAL CAPITAL COSTS	**$224,100**	**$3,694,200**	**$2,593,400**	**$4,272,000**	**$2,490,100**	**$7,978,400**
Ongoing Periodic and Future Costs						
Confirmational Groundwater Monitoring	$173,000	$82,000	$82,000	$82,000	$131,000	Not Applicable
Closure Report	Not Applicable	$23,000	$23,000	$23,000	$23,000	$34,800
TOTAL ONGOING PERIODIC AND FUTURE COSTS	**$173,000**	**$105,000**	**$105,000**	**$105,000**	**$154,000**	**$34,800**
REMEDIATION PROJECT TOTAL COST	**$397,100**	**$3,799,200**	**$2,698,400**	**$4,377,000**	**$2,644,100**	**$8,013,200**
Remediation Project Total Low Range (-10%)	**$357,000**	**$3,420,000**	**$2,430,000**	**$3,940,000**	**$2,380,000**	**$7,210,000**
Remediation Project Total High Range (+10%)	**$437,000**	**$4,180,000**	**$2,970,000**	**$4,810,000**	**$2,910,000**	**$8,810,000**
INCREMENTAL COSTS (i.e., costs in addition to Remediation Project Total Costs above):						
Incremental Cost if Remediation *Not* Conducted In Conjunction With Development of the Dry Cleaner Building Property	**Not Applicable**	**$1,100,000**	**$0**	**$1,100,000**	**$1,000,000**	**$1,000,000**
Incremental Cost For Active Shallow Zone Remediation Elements Extended into Rights-of-way	**Not Applicable**	**$2,600,000**	**$2,600,000**	**$3,500,000**	**$2,000,000**	**Not Applicable**

Table 11
Cleanup Alternative Evaluation
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

	Cleanup Alternative 1 **Institutional and Engineering Controls, Monitored Natural Attenuation, Deferred Remediation**		**Cleanup Alternative 2** **In-Situ Thermal Treatment Shallow Zone, Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls**		**Cleanup Alternative 3** **In-Situ Thermal Treatment Shallow Zone, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls**	
Overall MTCA Composite Benefit Score[1]	**4.9**		**7.8**		**7.8**	
MTCA THRESHOLD REQUIREMENTS						
Protection of Human Health and the Environment	**Yes** - Alternative will protect human health and the environment.		**Yes** - Alternative will protect human health and the environment.		**Yes** - Alternative will protect human health and the environment.	
Compliance with Cleanup Standards	Contamination would remain until attenuated naturally.		**Yes** - Active remedial measures would be used to comply with cleanup standards.		**Yes** - Active remedial measures would be used to comply with cleanup standards.	
Compliance with Applicable State and Federal Laws	Contamination will remain above chemical-specific applicable laws until attenuated naturally. Alternative will be implemented in compliance with applicable state, federal, and local laws.		**Yes** - Alternative complies with applicable laws. Alternative will be implemented in compliance with applicable state, federal, and local laws.		**Yes** - Alternative complies with applicable laws. Alternative will be implemented in compliance with applicable state, federal, and local laws.	
Provision for Compliance Monitoring	**Yes** - Provisions for long-term groundwater monitoring included in the alternative.		**Yes** - Alternative includes provisions for compliance monitoring.		**Yes** - Alternative includes provisions for compliance monitoring.	
OTHER MTCA REQUIREMENTS						
Restoration Time Frame	Restoration time frame is undefined and dependent upon future property development activities and natural attenuation processes. Used alone, the restoration time frame for this alternative per MTCA is less favorable than with alternatives employing active remediation approaches. Compliance monitoring will be conducted through Year 35.		Restoration time frame for the Shallow Zone of the Dry Cleaner Building Property and for the Deep Zone is less than 2 years for implementation of active remedial measures. Restoration time frame for the Shallow Zone in the rights-of-way will be considerably longer, estimated to be in the 25 to 35 year time frame. Cleanup alternative includes compliance monitoring through Year 35.		Restoration time frame for the Shallow Zone of the Dry Cleaner Building Property and for the Deep Zone is less than 2 years for implementation of active remedial measures. Restoration time frame for the Shallow Zone in the rights-of-way will be considerably longer, estimated to be in the 25 to 35 year time frame. Cleanup alternative includes compliance monitoring through Year 35.	
Permanent to the Maximum Extent Practicable (see detail below)	**Yes**, but considered to be the least permanent of all cleanup alternatives.		**Yes.** Detail below.		**Yes.** Detail below.	
Evaluation Criteria for Permanence to the Maximum Extent Practicable[2]						
Protectiveness (30% Weighted Factor)	Alternative will offer protection from remaining residual contamination and no short-term risks will occur from implementation. Cleanup standards would only be achieved over a long period of time through natural attenuation processes. **Score=**	**4**	Alternative will attain cleanup standards through active remediation and overall protection of human health and the environment and improvement of overall environmental quality is considered to be good. There is uncertainty with regards to time required to achieve cleanup standards with thermal treatment in the Shallow Zone. While Deep Zone contamination in the right-of-way will be actively remediated, Shallow Zone contamination in the right-of-way will be reduced only through long-term attenuation processes. Short-term risks associated with implementation will occur. **Score=**	**8.5**	Alternative will attain cleanup standards through active remediation and overall protection of human health and the environment and improvement of overall environmental quality is considered to be good. There is uncertainty with regards to time required to achieve cleanup standards in the Shallow Zone with thermal treatment but a high degree of certainty that remediation levels will be achieved. While Deep Zone contamination in the right-of-way will be actively remediated, Shallow Zone contamination in the rights-of-way will be reduced only through long-term attenuation processes. Short-term risks associated with implementation will occur although excavation is not included in this alternative. Score=	**8**
Permanence (20% Weighted Factor)	Contamination will diminish with natural attenuation processes. Biodegradation of contamination permanently reduces toxicity, mobility, and volume where the process is completed. Other active remedial measures would not occur until the Dry Cleaner Building Property is developed. **Score=**	**4**	Thermal treatment in the Shallow Zone will permanently reduce toxicity, mobility, volume of contamination at the Site. Thermal treatment effectively transfers the mass of contamination from the subsurface to granular activated carbon which is then transported off-Site for treatment, recycling, or disposal. Excavation of Shallow Zone soil with residual contamination transfers contaminant mass from the Site to a controlled landfill. Chemical oxidation and bioremediation in the Deep Zone are considered to be permanent remedies if applied after completion of Shallow Zone treatment and would destroy contamination on-Site. Natural attenuation down-gradient and outside the treatment zone is also considered permanent where it occurs. **Score=**	**8**	Thermal treatment in the Shallow Zone will permanently reduce toxicity, mobility, volume of contamination at the Site. Thermal treatment effectively transfers the mass of contamination from the subsurface to granular activated carbon which is then transported off-Site for treatment, recycling, or disposal. Excavation of Shallow Zone soil with residual contamination transfers contaminant mass from the Site to a controlled landfill. Chemical oxidation and bioremediation in the Deep Zone are considered to be permanent remedies if applied after completion of Shallow Zone treatment and would destroy contamination on-Site. Natural attenuation down-gradient and outside the treatment zone is also considered permanent where it occurs. **Score=**	**8**
Long-Term Effectiveness (20% Weighted Factor)	Use of institutional and engineering controls will limit exposures to contamination and would be applied to the Dry Cleaner Building Property and to adjacent rights-of-way. MTCA considers use of institutional controls to have a low degree of long-term effectiveness. Natural attenuation processes will reduce levels of contamination over a long period of time. Score=	**2**	There is a high degree of certainty that thermal treatment will be successful removing PCE to below the 2 mg/kg soil remediation level in the Shallow Zone. There is uncertainty with regards to thermal treatment achieving the PCE MTCA Method A soil cleanup level, and it may take up to 4 months additional treatment time. Based on testing to date, use of chemical oxidation will effectively destruct contamination in the Deep Zone, and bioremediation also will be effective. Effectiveness of injections will depend on how well the injected material can be distributed in the subsurface. MTCA considers treatment resulting in destruction of contamination to have a high degree of long-term effectiveness and off-Site disposal to have a moderate degree of long-term effectiveness. Natural attenuation in the Shallow Zone in the rights-of-way will occur in the medium to long-term. Score=	**8**	There is a high degree of certainty that thermal treatment will be successful reducing PCE to below the 2 mg/kg soil remediation level in the Shallow Zone. Based on testing to date, use of chemical oxidation will effectively destruct PCE concentrations in the Deep Zone and bioremediation will also be effective. Effectiveness of injections will depend on how well the injected material can be distributed in the subsurface. MTCA considers treatment resulting in destruction of contamination to have a high degree of long-term effectiveness. Natural attenuation in the Shallow Zone in the rights-of-way will occur in the moderate to longer term. Score=	**8**
Short-Term Risk Management (10% Weighted Factor)	Institutional and engineering controls will mitigate contamination exposure during future construction activities and from potential vapor intrusion into a structure at the Dry Cleaner Building Property. Short-term risk management is minimal. **Score=**	**9**	Use of high voltage electricity, chemical oxidants, and excavation will require a moderate degree of short-term risk management. Institutional and engineering controls will mitigate contamination exposure during future construction activities and from potential vapor intrusion into a structure at the Dry Cleaner Building Property. Short-term risk management is moderate. **Score=**	**6.5**	Use of high voltage electricity and chemical oxidants will require a moderate degree of short-term risk management. This alternative does not present short-term risks from excavation. Institutional and engineering controls will mitigate contamination exposure during future construction activities and from potential vapor intrusion into a structure at the Dry Cleaner Building Property. Short-term risk management is minimal. **Score=**	**7**
Implementability (10% Weighted Factor)	The proposed institutional and engineering controls are considered to be highly implementable on the Dry Cleaner Building property. However, implementation of institutional controls in the rights-of-way will be administratively challenging. Score=	**8.5**	Use of thermal and chemical oxidation or bioremediation are technically and administratively implementable. The implementability of this alternative is considered to be relatively moderate. Thermal remediation is relatively complex and there are permitting/authorization requirements for construction, street-use, electrical work, and subsurface injections. Excavation in close proximity to rights-of-way and underground utilities with high groundwater conditions, requires special measures. Score=	**7**	Use of thermal and chemical oxidation or bioremediation and excavation are technically and administratively implementable. Thermal treatment technologies are relatively complex and there are permitting/authorization requirements for construction, street-use, electrical work, subsurface injections. The implementability of this alternative is considered to be good. **Score=**	**8**
Public Concerns (10% Weighted Factor)	Alternative leaves contamination in the subsurface. With use of this alternative, public concerns are expected to be moderate. **Score=**	**7**	While reduction of contamination will be favorably perceived, public concerns regarding implementation of thermal treatment and excavation and trucking of contaminated soil off-Site are expected to be moderate but can be addressed. **Score=**	**7**	While reduction of contamination will be favorably perceived, public concerns regarding implementation of thermal treatment are expected to be minimal and can be addressed. **Score=**	**7**
Estimated Cost[3]	**$397,100**		**$3,799,200**		**$2,698,400**	

NOTES:

[1] Basis for overall Washington State Model Toxics Control Act Cleanup Regulation (MTCA) Composite Benefit Score provided in text above and quantitatively with a "score" from 0 (least favorable) to 10 (most favorable) for each of the six evaluation criteria for permanence to the Maximum Extend Practicable above. MTCA Composite Benefit Scores are calculated by summing the mathematical product of the score times the weighting factor for each of the six criteria.

[2] Basis for the weighting of the six criteria to evaluate permanence to the maximum extent practicable from Washington State Department of Ecology.

Table 11
Cleanup Alternative Evaluation
Plastic Sales and Service, Inc. Site
Seattle, Washington
Farallon PN: 343-002

	Cleanup Alternative 4 **In-Situ Thermal Treatment Shallow Zone and Deep Zone, Excavation of Shallow Zone Soil, Monitored Natural Attenuation, Institutional Controls**		**Cleanup Alternative 5** **Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls**		**Cleanup Alternative 6** **Excavation of Shallow Zone and Deep Zone Soil**	
Overall MTCA Composite Benefit Score[1]	**6.9**		**7.7**		**5.0**	
MTCA THRESHOLD REQUIREMENTS						
Protection of Human Health and the Environment	**Yes** - Alternative will protect human health and the environment.		**Yes** - Alternative will protect human health and the environment.		**Yes** - Alternative will protect human health and the environment.	
Compliance with Cleanup Standards	**Yes** - Active remedial measures would be used to comply with cleanup standards.		**Yes** - Active remedial measures would be used to comply with cleanup standards.		**Yes** - Active remedial measures would be used to comply with cleanup standards.	
Compliance with Applicable State and Federal Laws	**Yes** - Alternative complies with applicable laws. Alternative will be implemented in compliance with applicable state, federal, and local laws.		**Yes** - Alternative complies with applicable laws. Alternative will be implemented in compliance with applicable state, federal, and local laws.		**Yes** - Alternative complies with applicable laws. Alternative will be implemented in compliance with applicable state, federal, and local laws.	
Provision for Compliance Monitoring	**Yes** - Alternative includes provisions for compliance monitoring.		**Yes** - Alternative includes provisions for compliance monitoring.		**Yes** - Alternative includes provisions for compliance monitoring (progress monitoring during excavation; no long-	
OTHER MTCA REQUIREMENTS						
Restoration Time Frame	Restoration time frame for the Shallow Zone of the Dry Cleaner Building Property and for the Deep Zone is less than 2 years for implementation of active remedial measures. Restoration time frame for the Shallow Zone in the rights-of-way will be considerably longer, estimated to be in the 25 to 35 year time frame. Cleanup alternative includes compliance monitoring through Year 35.		Restoration time frame for the Shallow Zone of the Dry Cleaner Building Property and for the Deep Zone is less than 2 years for implementation of active remedial measures. Restoration time frame for the Shallow Zone in the rights-of-way will be considerably longer, estimated to be in the 25 to 35 year time frame. Cleanup alternative includes compliance monitoring through Year 35.		Restoration time frame is less than one year for implementation. No ongoing monitoring would be implemented.	
Permanent to the Maximum Extent Practicable (see detail below)	**Yes.** Detail below.		**Yes.** Detail below.		**No-** impracticable under MTCA.	
Evaluation Criteria for Permanence to the Maxir						
Protectiveness (30% Weighted Factor)	Alternative will attain cleanup standards through active remediation and overall protection of human health and the environment and improvement of overall environmental quality is considered to be good. There is uncertainty with regards to time required to achieve cleanup standards with thermal treatment but a high degree of certainty that remediation levels will be achieved. Contamination in the Shallow Zone and the Deep Zone in the rights-of-way will be reduced only through long-term attenuation processes. Short-term risks associated with implementation will occur. Score=	**7**	Alternative will attain cleanup standards through active remediation and overall protection of human health and the environment and improvement of overall environmental quality is considered to be good. There is some uncertainty with regards to time required to achieve cleanup standards in the Deep Zone. Short-term risks associated with implementation will occur and are considered greater with excavation and off-Site disposal of contaminated soil. **Score=**	**7.5**	Alternative will attain cleanup standards at the Dry Cleaner Building Property and achieve cleanup levels down-gradient in the rights-of-way through active remediation and overall protection of human health and the environment, and improvement of overall environmental quality is considered to be good. Short-term risks associated with implementation will occur and are considered great with excavation and utility shoring in the rights-of-way and off-Site disposal of contaminated soil. Score=	**6.5**
Permanence (20% Weighted Factor)	Thermal treatment in the Shallow Zone will permanently reduce toxicity, mobility, volume of contamination at the Site but the thermal treatment effectively transfers the mass of contamination removed from the subsurface to granular activated carbon which is then transported off-Site for treatment, recycling, or disposal. Excavation of Shallow Zone soil with residual contamination transfers contaminant mass from the Site to a controlled landfill. Natural attenuation down-gradient and outside the treatment zone is also considered permanent where it occurs. **Score=**	**7**	Excavation and off-Site disposal of Shallow Zone soil will reduce the mobility of residual contamination when placed in permitted Subtitle D or Subtitle C landfills. Chemical oxidation and bioremediation in the Deep Zone are considered to be permanent remedies if applied after completion of Shallow Zone treatment. Natural attenuation down-gradient and outside the treatment zone is also considered permanent where it occurs. **Score=**	**7.5**	Excavation and off-Site disposal of Shallow Zone and Deep Zone soil, from both on-Site and in adjacent rights-of-way, will reduce the mobility of residual contamination when placed in permitted Subtitle D or Subtitle C landfills. Score=	**6.5**
Long-Term Effectiveness (20% Weighted Factor)	There is a high degree of certainty that thermal treatment will be successful removing PCE to below the 2 mt/kg soil remediation level in the Shallow and Deep Zones. There is uncertainty with regards to thermal treatment achieving the PCE MTCA Method A cleanup level, and it may take up to 4 months additional treatment time. MTCA considers treatment resulting in destruction of contamination to have a high degree of long-term effectiveness and off-Site disposal to have a moderate degree of long-term effectiveness. Natural attenuation in the Shallow and Deep Zones in the rights-of-way will occur but only over the long-term. Score=	**7**	There is a high degree of certainty that excavation of Shallow Zone soil and disposal in a permitted Subtitle C or D landfill will effectively reduce residual contamination in the Shallow Zone to below cleanup levels. Off-Site treatment of material prior to disposal at a Subtitle C landfill will also be effective. Based on testing to date, use of chemical oxidation will effectively reduce contaminant concentrations in the Deep Zone and bioremediation would also be effective. Effectiveness of injections will depend on how well the injected material can be distributed in the subsurface. MTCA considers treatment resulting in destruction of contamination to have a high degree of long-term effectiveness and off-Site disposal to have a moderate degree of long-term effectiveness. Natural attenuation will occur in the Shallow Zone in the rights-of-way in the medium to long-term. Score=	**8**	There is a high degree of certainty that excavation of Shallow Zone and Deep Zone soil and disposal at a permitted Subtitle C or D landfill will effectively reduce residual PCE contamination below the MTCA Method A cleanup level where excavation can occur. Off-site treatment of material not suitable for disposal at a Subtitle C will also be effective. MTCA considers off-Site disposal to have a moderate degree of long-term effectiveness. **Score=**	**6.5**
Short-Term Risk Management (10% Weighted Factor)	Use of high voltage electricity, and excavation will require a moderate degree of short-term risk management. Institutional and engineering controls will mitigate contamination exposure during future construction activities and from potential vapor intrusion into a structure at the Dry Cleaner Building Property. Short-term risk management is moderate. **Score=**	**7**	Use of chemical oxidants and excavation of contaminated soil will require a significant degree of short-term risk management. Institutional and engineering controls will mitigate contamination exposure during future construction activities and from potential vapor intrusion into a structure at the Dry Cleaner Building Property. **Score=**	**7**	Use of excavation of contaminated soil will require a significant degree of short-term risk management especially with Deep Zone excavation in the rights-of-way. Score=	**1**
Implementability (10% Weighted Factor)	Use of thermal treatment is technically and administratively implementable. Because the technology is relatively complex especially when applied to the Deep Zone and there are permitting/authorization requirements for construction, street-use, electrical work, the implementability of this alternative is considered to be relatively moderate. **Score=**	**5.5**	Use of excavation and chemical oxidation or bioremediation are technically and administratively implementable. The implementability of this alternative is considered to be relatively moderate. There are permitting/authorization requirements for construction, street-use, excavation, subsurface injections. **Score=**	**8**	Use of excavation is technically and administratively implementable, but consent for closure of Woodlawn Avenue Northeast for up to 2 months is improbable. Deep excavation and excavation in the right-of-way of a traffic arterial with underground utilities will be both technically and administratively challenging. The implementability of this alternative is considered to be low. **Score=**	**1**
Public Concerns (10% Weighted Factor)	While reduction of contamination will be favorably perceived, public concerns regarding implementation of thermal treatment and excavation and trucking of contaminated soil off-Site are expected to be moderate but can be addressed. **Score=**	**7**	While removal and destruction of contamination will be favorably perceived, public concerns regarding implementation of excavation and truck transport are expected to be moderate but can be addressed. **Score=**	**8**	While removal of contamination will be favorably perceived, public concerns regarding implementation of excavation and truck transport and temporary closure of a traffic arterial are expected to be significant. **Score=**	**2**
Estimated Cost[3]	**$4,377,000**		**$2,644,100**		**$8,013,200**	

NOTES:

[1] Basis for overall Washington State Model Toxics Control Act Cleanup Regulation (MTCA) Composite Benefit Score provided in text above and quantitatively with a "score" from 0 (least favorable) to 10 (most favorable) for each of the six evaluation criteria for permanence to the Maximum Extend Practicable above. MTCA Composite Benefit Scores are calculated by summing the mathematical product of the score times the weighting factor for each of the six criteria.

[2] Basis for the weighting of the six criteria to evaluate permanence to the maximum extent practicable from Washington State Department of Ecology.

Table 12
Summary of Cleanup Alternative Evaluation
Plastics Sales and Service, Inc.
Seattle, Washington
Farallon PN: 343-002

			Other MTCA Requirements								
				Permanence to the Maximum Extent Practicable[1]							
	Alternative	Satisfy MTCA Threshold Requirements	Restoration Time Frame	Protectiveness	Permanence	Long-term Effectiveness	Short-Term Effectiveness	Implementability	Public Concerns	MTCA Composite Benefit Score	Estimated Cost[2]
1	Institutional and Engineering Controls, Monitored Natural Attenuation	Contamination will remain until attenuated naturally	Undefined and dependent upon future property development activities and natural attenuation processes	4	4	2	9	8.5	7	4.9	$397,100
2	In-Situ Thermal Treatment Shallow Zone, Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls	Yes	Less than 2 years and natural attenuation for up to 25 to 35 years	8.5	8	8	7	7	7	7.8	$3,799,200
3	In-Situ Thermal Treatment Shallow Zone, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls	Yes	Less than 2 years and natural attenuation for up to 25 to 35 years	8	8	8	7	8	7	7.8	$2,698,400
4	In-Situ Thermal Treatment Shallow Zone and Deep Zone, Excavation of Shallow Zone Soil, Monitored Natural Attenuation, Institutional Controls	Yes	Less than 2 years and natural attenuation for up to 25 to 35 years	7	7	7	7	5.5	7	6.9	$4,377,000
5	Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls	Yes	Less than 2 years and natural attenuation for up to 25 to 35 years	7.5	7.5	8	7	8	8	7.7	$2,644,100
6	Excavation of Shallow Zone and Deep Zone Soil	Yes	Less than 1 year	6.5	6.5	6.5	1	1	2	5.0	$8,013,200

NOTES:

[1] Basis for scoring and definition of MTCA Composite Benefit Score provided in Table 11 and in the text. Scoring provides a quantitative evaluation of criteria for "permanence to the maximum extent practicable." A score of 0 is least favorable and a score of 10 is most favorable.

[2] Estimated cost for cleanup concurrent with development of Dry Cleaner Building Property. See Table 10 for incremental cost if cleanup independent of development of Dry Cleaner Building Property.

MTCA = Washington State Model Toxics Control Act Cleanup Regulation

Table 13
Summary of Disproportionate Cost Analysis
Plastics Sales and Service, Inc.
Seattle, Washington
Farallon PN: 343-002

			Estimated Cost			
	Alternative	**MTCA Composite Benefit Score[1]**	**Remediation in Conjunction with Development**	**Incremental Cost For Remediation Independent of Development**		**Incremental Cost With Remediation Extended into Right-of-Ways (includes road closure)**
1	Institutional and Engineering Controls, Monitored Natural Attenuation	4.9	$397,100	Alternative 1 would be selected if no development is to occur	Not Applicable	Not Applicable
2	In-Situ Thermal Treatment Shallow Zone, Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls	7.8	$3,799,200	This is the incremental cost estimate for excavation of the entire Dry Cleaner Building Property to 15 feet bgs including shoring, excavation, transportation, dewatering, off-Site disposal, and backfilling.	$1,100,000	$2,600,000
3	In-Situ Thermal Treatment Shallow Zone, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls	7.8	$2,698,400	Soil excavation is not required for remediation. Environmental covenant will include provisions for the management of media containing residual concentrations of PCE if potential future development requires excavation and/or dewatering.	$0	$2,600,000
4	In-Situ Thermal Treatment Shallow Zone and Deep Zone, Excavation of Shallow Zone Soil, Monitored Natural Attenuation, Institutional Controls	6.9	$4,377,000	This is the incremental cost estimate for excavation of the entire Dry Cleaner Building Property to 15 feet bgs including shoring, excavation, transportation, dewatering, off-Site disposal, and backfilling.	$1,100,000	$3,500,000
5	Excavation of Shallow Zone Soil, Deep Zone Oxidation or Bioremediation, Monitored Natural Attenuation, Institutional Controls	7.7	$2,644,100	This is the incremental cost estimate for excavation of the entire Dry Cleaner Building Property to 15 or 20 feet bgs including site preparation, shoring, excavation, transportation, dewatering, off-Site disposal, and backfilling.	$1,000,000	$2,000,000
6	Excavation of Shallow Zone and Deep Zone Soil	5.0	$8,013,200	This is the incremental cost estimate for excavation of the entire Dry Cleaner Building Property to the depth of PCE contamination including site preparation, shoring, excavation, transportation, dewatering, off-Site disposal, and backfilling.	$1,000,000	Not Applicable

NOTES:

Shading indicates the preferred alternative (Cleanup Alternative 3)

MTCA = Washington State Model Toxics Control Act Cleanup Regulation

[1]The MTCA Composite Benefit Score is a numeric score ranging from 0 to 10 representing the degree to which an alternative satisfies the MTCA criterion for "permanence to the maximum extent practicable" determined by evaluating 6 subcriteria: protectiveness, permanence, long-term effectiveness, short-term risk management, implementability, and public concerns. The MTCA Composite Benefit Score is calculated for each alternative by summing the mathematical product of the subcriterion score times a weighting factor, as indicated in the text. A score of 6 represents moderate environmental benefit on a scale of 0 to 10 (highest environmental benefit).

Table 14
Summary of Technical Elements of the Preferred Cleanup Alternative
Plastics Sales and Service, Inc.
Seattle, Washington
Farallon PN: 343-002

		Preliminary Cleanup Level Selection									
Media-Pathway	**Chemicals of Concern (COCs)**	**Primary COC**	**Concentration and Basis**	**Point of Compliance**	**PCE Remediation Level**	**Remediation/ Mitigation**	**Institutional Controls**	**Engineering Controls**	**Compliance Monitoring**	**Restoration Time Frame**	**Contingency Action**
Indoor air: inhalation *Cross-media: soil vapor to indoor air (not a confirmed pathway)*	PCE, TCE, Cis-1,2-DCE, Trans-1,2-DCE, Vinyl Chloride	PCE	**9.6 ug/m3 (Indoor Air MTCA Method B)**	Standard: Site-wide ambient air for indoor air inhalation	None	Thermal treatment (Areas 1 and 2) Physical barriers (Dry Cleaner Building floor slab, paved roadway)	Environmental Covenant: Maintenance of engineering controls	Maintenance of physical barriers (Areas 1 through 6) New development would include sub-slab depressurization system and/or vapor barrier	None	None	Continued operation and maintenance of sub-slab depressurization system and/or vapor barrier, as needed
Soil: direct contact (dermal contact, ingestion) *Cross-media: soil to groundwater*	PCE, TCE, Cis-1,2-DCE, Trans-1,2-DCE, Vinyl Chloride	PCE	**0.05 mg/kg (Soil MTCA Method A cleanup level protective of groundwater) Residual soil concentrations will be protective of groundwater based on empirical demonstration by groundwater compliance monitoring**	Standard: Direct Contact Exposure 0 to 15 feet bgs	Shallow and Deep Zones: 2 mg/kg	Shallow Zone thermal treatment (Areas 1 and 2) / physical barriers; Deep Zone chemical oxidation/ bioremediation (Areas 1, 2, and 4)	Environmental Covenant: Maintenance of engineering controls; development of media management plan to be used for future construction work on the property and in the adjacent right-of-ways	Maintenance of Physical Barriers: Dry Cleaner Building floor slab remains in-place until property development (Areas 1 through 3); and paved roadways in rights-of-way Areas 4 through 6)	Confirmation soil sampling thermal treatment area (Areas 1 and 2)	Thermal Treatment Area: Less than 8 months to achieve remediation level Natural attenuation of residual concentrations 25 to 30 years or removal during potential future development	Shallow Zone--Dry Cleaner Building Property: Extended operation of thermal treatment system, install additional electrodes; Shallow Zone--Down-Gradient of Thermal Treatment Area: To be determined based on groundwater monitoring results following pilot test including application of chemical oxidant and per details to be provided in the Engineering Design Report
Groundwater: direct contact (dermal contact, ingestion) *Cross-media: groundwater to indoor air (not a confirmed pathway)*	PCE, TCE, Cis-1,2-DCE, Trans-1,2-DCE, Vinyl Chloride	PCE	**5 ug/l (Groundwater MTCA Method A based on applicable State and Federal law)**	Conditional: Down-Gradient Dry Cleaner Building Property Boundary	Shallow Zone: 100 ug/l (thermal treatment area); and Deep Zone: 20 ug/l (Site-wide)	Shallow Zone: thermal treatment (Areas 1 and 2); and Deep Zone: Chemical oxidation/ bioremediation (Areas 1, 2, and 4)	Environmental Covenant: Maintenance of engineering controls; prohibit domestic use of groundwater; provide for compliance groundwater sampling	Provide for appropriate monitoring and treatment of groundwater during potential future dewatering associated with construction	Groundwater confirmation sampling to confirm remediation levels in thermal treatment area (Areas 1 and 2) and chemical oxidant/biotreatment area (Areas 1, 2, and 4) Shallow and Deep Zone: Long-term monitoring at point of compliance monitoring wells on the property boundary and on the north side of Woodlawn Avenue right-of-way (north of Areas 4 through 6)	Shallow Zone: Less than 8 months to achieve remediation level in thermal treatment area (Areas 1 and 2) Deep Zone: Chemical oxidation/ bioremediation less than 2 years to attain remediation level (Areas 1, 2, and 4); and Natural attenuation of residual contamination-- a. rights-of-way Shallow and Deep Zones: attain cleanup level in 25 to 35 years (Areas 4 through 6); and b. Dry Cleaner Building Property Shallow Zone: attain cleanup level at conditional point of compliance in 10 years from completion of thermal treatment (Areas 1 through 3).	Shallow Zone--Dry Cleaner Building Property: Extended operation of thermal treatment system, install additional electrodes; Shallow Zone--Down-Gradient of Thermal Treatment Area: To be determined based on groundwater monitoring results following application of chemical oxidant and per details to be provided in the engineering design report Deep Zone: Additional chemical oxidation/ bioremediation injection events, install additional injection points

NOTES:
Bold denotes selected cleanup levels for an environmental medium

bgs = below ground surface
DCE = dichloroethene
mg/kg = milligrams per kilogram
MTCA = Washington State Model Toxics Control Act Cleanup Regulation
PCE = tetrachloroethene
TCE = trichloroethene
ug/l = micrograms per liter
ug/m3 = micrograms per cubic meter

APPENDIX A
BORING/WELL CONSTRUCTION LOGS FOR FARALLON SUBSURFACE INVESTIGATIONS

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX B
LABORATORY ANALYTICAL REPORTS FOR COMPLETION OF THE REMEDIAL INVESTIGATION

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX C
WASTE DISPOSAL DOCUMENTATION

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX D
SHALLOW ZONE SLUG TEST DATA

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX E
DEEP ZONE AQUIFER PUMP TEST DATA

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX F
BIOCHLOR TWO-DIMENSIONAL MODELING DATA

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX G
CHEMICAL OXIDANT PILOT TEST DATA

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX H
REMEDIAL ALTERNATIVE CONCEPTUAL DESIGN DETAILS

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002

APPENDIX I
TERRESTRIAL ECOLOGICAL EVALUATION

DRAFT FINAL REMEDIAL INVESTIGATION
AND FEASIBILITY STUDY
6860 and 6870 Woodlawn Avenue Northeast
Seattle, Washington
Agreed Order No. DE 7084

Farallon PN: 343-002