FINAL CLEANUP ACTION PLAN

FOX AVENUE SITE
SEATTLE, WASHINGTON

Issued by:

Washington State Department of Ecology
Toxics Cleanup Program
Northwest Regional Office
Bellevue, Washington

June 2012

Fox Avenue Site
Seattle, Washington

Cleanup Action Plan

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List of Abbreviations and Acronyms

Abbreviation/ Acronym	Definition
1st SH	First Silt Horizon
ARAR	Applicable or Relevant and Appropriate Requirement
AST	Aboveground storage tank
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and xylene
CAA	Cleanup Action Area
CAP	Cleanup Action Plan
Cascade Columbia	Cascade Columbia Distribution
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Chemical of concern

Abbreviation/ Acronym	Definition
CPOC	Conditional point of compliance
CVOC	Chlorinated volatile organic compound
DCE	Dichloroethene
DNAPL	Dense non-aqueous phase liquid
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
Eh	Reduction-oxidation (redox) potential
EOS	Edible oil substrate
ERD	Enhanced reductive dechlorination
ERH	Electrical Resistance Heating
Fox LLC	Fox Avenue Building, LLC
FS	Feasibility Study
GWCC	Great Western International Chemical Company
LDW	Lower Duwamish Waterway
LGZ	Lower Groundwater Zone
LNAPL	Light non-aqueous phase liquid
LTM	Long-term monitoring
MNA	Monitored natural attenuation
MTCA	Model Toxics Control Act
NAPL	Non-aqueous phase liquid
NAVD88	North American Vertical Datum
PCE	Tetrachloroethene
Penta	Pentachlorophenol
PID	Photoionization detector
POC	Point of compliance
PRB	Permeable Reactive Barrier
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RI/PRA	Remedial Investigation/Preliminary Risk Assessment
RL	Remediation level
Seattle Chain	Seattle Chain and Manufacturing Company
SH	Silt Horizon
Site	Fox Avenue Site
SVE	Soil vapor extraction
TCE	Trichloroethene
TPH	Total petroleum hydrocarbon
UCL	Upper confidence limit
UGZ	Upper Groundwater Zone
URS	URS Corporation
UST	Underground storage tank
VC	Vinyl chloride
VOC	Volatile organic compound

Abbreviation/ Acronym	**Definition**
WAC	Washington Administrative Code
WBZ	Water Bearing Zone
ZVI	Zero-valent iron

DECLARATIVE STATEMENT

Consistent with the Model Toxics Control Act, Chapter 70.105D RCW, as implemented by the Model Toxics Control Act Cleanup Regulation, Chapter 173-340 WAC, it is determined that the selected cleanup actions are protective of human health and the environment, attain federal and state requirements that are applicable or relevant and appropriate, comply with cleanup standards, provide for compliance monitoring, use permanent solutions to the maximum extent practicable, provide for a reasonable restoration time-frame, and consider public concerns raised during public comment.

6/19/2012

Sunny Becker
Site Manager
Toxics Cleanup Program
Northwest Regional Office

Date

6-19-12

Robert W. Warren, P.Hg., MBA
Regional Section Manager
Toxics Cleanup Program
Northwest Regional Office

Date

1.0 Introduction

This Cleanup Action Plan (CAP) describes the cleanup action selected by the Washington State Department of Ecology (Ecology) for the Fox Avenue Site (the Site). The Site is the former location of Great Western International Chemical Company (GWCC) and is currently in operation as the Cascade Columbia Facility located at 6900 Fox Avenue S. in Seattle, Washington (Figure 1.1). The selected cleanup action described in this document fulfills the requirements of the Model Toxics Control Act (MTCA), Chapter 70.105D of the Revised Code of Washington (RCW), administered by Ecology under the MTCA Cleanup Regulation Chapter 173-340 of the Washington Administrative Code (WAC).

This CAP was developed using information presented in the Remedial Investigation/Feasibility Study (RI/FS) for the Site, which was prepared by Floyd|Snider, Inc. in 2011 on behalf of Fox Avenue, LLC, and reviewed and approved by Ecology. Fox Avenue, LLC and Ecology entered into an Agreed Order (No. DE 6486) on May 6, 2009.The Agreed Order required Fox Avenue, LLC to initiate an interim action for groundwater, update the existing RI/FS for the Site, and submit a draft CAP to Ecology.

The objective of this document is to satisfy the MTCA requirements for cleanup action plans set forth in WAC 173--340--380(1). Consistent with the requirement of that chapter, this CAP provides the following information:

- Site description, background, and characterization
- Cleanup standards and remediation levels for each hazardous substance in each media of concern
- Description of the selected remedial action, including justification for the selection
- Brief summary of the remedial action alternatives considered in the RI/FS
- Implementation schedule and restoration time frame
- Institutional controls
- Applicable state and federal laws

This final CAP incorporates public comment received on the draft CAP.

2.0 Site Description, Background, and Characterization

The Site currently includes the Cascade Columbia Facility located at 6900 Fox Avenue S. and certain downgradient properties under which a groundwater contaminant plume travels and eventually discharges to the Lower Duwamish Waterway (LDW). The Site is located in the Duwamish industrial corridor of Seattle as shown on Figure 1.1.

The Cascade Columbia Facility occupies approximately 2.5 acres of flat land located approximately 400 feet from the S. Myrtle Street Embayment of the LDW. The property is bordered to the north by South Willow Street, to the south by the Whitehead property, to the east by East Marginal Way S, and to the west by Fox Avenue S. Active rail lines also cross the site area. The area is zoned for heavy industry and a large number of commercial and industrial operations are located nearby, including: Seattle Iron and Metals Corporation, a metals recycler; Seattle Boiler Works, a fabricator of steel pressure vessels; Schultz Fuel Distributing, a distributor of petroleum products; and Dawn Foods Distribution, a warehouse distributor of food products. Figure 2.1 shows the Site and surrounding properties.

2.1 CURRENT FACILITY USE

Cascade Columbia warehouses, packages, and distributes mainly liquid and solid bulk chemicals for the aerospace, electronics, food manufacturing, personal care, water treatment, and metal plating industries. Product is received either by rail tanker via a rail spur on the south side of the facility or truck via a main loading dock on the northeast side of the warehouse and a smaller loading dock along Fox Avenue. Product is offloaded and stored in bermed aboveground storage tanks (ASTs) or in a variety of sacks, bags, drums, and containers. Currently there are no active underground storage tanks (USTs) at the facility and Cascade Columbia does not distribute or repackage chlorinated solvents. Approximately 20 personnel work full time at the Cascade Columbia Facility. Figure 2.2 shows the current primary operational areas of the Cascade Columbia Facility.

2.2 HISTORICAL OWNERSHIP AND HISTORY

The Fox Avenue Building, LLC (Fox LLC) property was first developed in the early 20th century by the Seattle Chain and Manufacturing Company (Seattle Chain). Seattle Chain and successor companies operated coke- and oil-fired furnaces and built warehouses on the property. For the next 20 years, ownership of the property changed hands several times until 1956 when Marian Properties, LLC Enterprises bought the property and leased a portion of it to GWCC, which started its operations in the former Seattle Chain warehouse building that is still in use today by Cascade Columbia as a warehouse and loading dock. Other lessees of the Site during the 1950s and 1960s included Campbell Chain Company, which leased the warehouse in the northern part of the property, and Tyee Lumber Company, which leased parts of the warehouse building for storage and product assembly until 1969 when the Tyee Lumber Company shut down. From the 1960s through the 1980s, GWCC replaced and upgraded much of the earlier structures and built the current warehouse and exterior operational areas.

GWCC operated a chemical and petroleum repackaging and distribution facility on the property. GWCC received bulk chemical products and repackaged, transferred, and distributed both liquid and dry chemical products, including solvents (e.g., mineral spirits, toluene, tetrachloroethene

[PCE[1]], etc.). Until the late 1980s, GWCC supplied chemicals and supplies to the laundry and dry cleaning industry. This aspect of GWCC business, as well as most of its petroleum product handling, was phased out by 1990. GWCC pumped bulk product received via tanker truck or rail through buried pipes at the rail siding area along the southern edge of the warehouse or by hoses that ran along the ground surface. Additionally, GWCC began handling pentachlorophenol (Penta) on the property sometime in 1966. Penta was stored in one of the 12,000-gallon tank compartments and, for a period of one to two years only, Penta was blended with Stoddard solvents or mineral spirits in a small AST north and west of the drum shed. From 1969 until the late 1970s or early 1980s, GWCC purchased mixed Penta in drums from outside vendors.

The GWCC facility had a number of ASTs and USTs that stored chemical and petroleum products, including solvents, acids, Penta, and lube oils. A series of six USTs were originally installed in 1956 under the current Flammables Shed and a set of 10 double-compartment USTs were later installed in 1976 under the current Production Area. Both sets of tanks were decommissioned in 1989 by GWCC. The ten newer USTs were physically removed along with a limited amount of associated contaminated soil; however, the six older USTs were abandoned in place by cleaning the contents and then filling the USTs with pea gravel. These tanks were not able to be safely removed due to their location under warehouse structural elements. Portable, vertical ASTs called “tote bins,” used for product storage, were stored on pallets in the vicinity of the older UST tank farm.

A 1,000-gallon UST located near the Loading Dock Area historically was used for storage of gasoline. It was decommissioned in place in 1989. Two 1,000-gallon, aboveground “wing tanks” were also used historically on the loading dock. One of the wing tanks contained PCE and the other tank stored methanol.

Soil contamination was first discovered in 1990 at the Site in the main tank farm area following removal of the main tank farm USTs. Subsequent to that discovery, GWCC entered into an Agreed Order with Ecology in September 1991. The Agreed Order required that GWCC perform a Remedial Investigation (RI) to address the nature and extent of contamination discovered during the UST removal, an environmental and health risk assessment and a Feasibility Study (FS) to study and evaluate remedial options at the Site. Results of the RI were presented in a Remedial Investigation/Preliminary Risk Assessment (RI/PRA), which was submitted to Ecology in December 1993 by Hart Crowser, Inc.

Since that time, the Site has been the subject of numerous additional investigative activities and interim remedial actions. The RI/FS prepared by Floyd|Snider in 2011 presented a detailed summary of all prior investigations at the Site.

2.3 REGIONAL AND SITE GEOLOGY

In general, the Lower Duwamish Valley deposits consist of 50 to 100 feet of older alluvium, representing sand and silt estuarine deposits. Locally, these older sediments contain discontinuous gravel lenses, shells, and some wood. The younger alluvial deposits atop the older alluvium have a relatively uniform thickness and depth, with a base that almost everywhere is within 5 to 10 feet of the modern sea level. These deposits, which consist of silt,

[1] The abbreviation “PCE” is derived from perchloroethene, a synonym to the International Union of Pure and Applied Chemistry name of tetrachloroethene. Other synonyms for tetrachloroethene include Perc, tetrachloroethylene, and perchloroethylene.

sand, and sandy silt with abundant wood and organics, represent channel and floodplain deposits laid down by the modern Duwamish River. Overlying the younger alluvium are varying amounts of fill that range in thickness from 3 to 10 feet. The fill material is composed of a mixture of sand, gravel, silt, and miscellaneous construction debris.

At the Site, near-surface soil predominately consists of fill material. Fill ranges in depth from 5 to 10 feet below ground surface (bgs). Typically, the fill is thickest near the center of the Site and thinner near the edges. Some of the thickest fill deposits occur beneath the raised outdoor storage and Production Area. Fill material is predominately composed of poorly graded silty fine sand to gravelly sand, or sandy silt to gravelly sandy silt. Locally, fill includes some organic matter, wood, and debris, including pieces of masonry, cinders, and slag.

The first native soils encountered beneath the fill are interpreted to represent recent (i.e., pre-development) alluvial deposits of the Lower Duwamish Valley. These deposits range in composition from fine to medium sand to slightly silty to very silty fine to medium sand. Locally, within these deposits, fine sandy silt lenses are intercepted. Where fill is lacking, these deposits range in depth from near-surface to approximately 10 to 15 feet bgs. These deposits have been interpreted to represent channel and floodplain deposits laid down by the modern Duwamish River (Booth and Herman 1998). These younger alluvial deposits host the first occurrence of groundwater at the Site, as described in further detail in the following section.

One primary low permeability horizon of significance to site conditions has been identified. This unit is termed the First Silt Horizon (1^{st} SH) and occurs at the base of the recent alluvial deposits. The 1^{st} SH is too discontinuous to act as an aquitard, but it can influence chemical migration. When it is present and relatively clean, it acts to limit diffusion and dispersion of groundwater contaminants with depth; however, when it is contaminated, it acts as a substantial reservoir of contamination. The 1^{st} SH is located beneath most of the Cascade Columbia Facility, except for a small area northwest of the former main UST farm. The 1^{st} SH is absent south of the Cascade Columbia Facility along Fox Avenue, but tends to exist, with discontinuities, further downgradient. By Seattle Boiler Works, the 1^{st} SH is no longer contaminated, and, where present, acts to limit chemical dispersal with depth.

2.4 REGIONAL AND SITE GROUNDWATER

Groundwater occurs throughout the Lower Duwamish Valley in both the older and younger alluvial deposits. Shallow groundwater can also occur locally within fill material. In general, the valley alluvium is believed to comprise a single, large aquifer system (Booth and Herman 1998). Where this aquifer is thickest, upper and lower groundwater zones are often differentiated on a site-specific basis, based on the occurrence of locally-continuous silt layers, upward gradients at depth, and/or saline groundwater pockets (Booth and Herman 1998).

Locally, the valley aquifer is differentiated based on continuous silt aquitards that separate the major water bearing zones (WBZs) and the occurrence of upward gradients and/or the occurrence of saline groundwater pockets. Of most importance to site conditions is the Upper Groundwater Zone (UGZ). The UGZ is hosted by both younger and older alluvial deposits and typically occurs down to depths of 60 to 80 feet bgs. The net groundwater flow within the UGZ is generally toward the LDW; however, locally, daily tidal effects have been shown to cause apparent groundwater flow reversal near the waterway. Of lesser importance to site conditions is the Lower Groundwater Zone (LGZ), which is hosted in deeper estuarine/deltaic deposits. The LGZ is typically differentiated from the UGZ by a higher percentage of fines, an abundance of shell fragments, and brackish groundwater conditions caused by contact with seawater. In the central part of the Duwamish Valley, where the Site is located, the LGZ is estimated to occur at depths greater than 80 feet bgs (Booth and Herman 1998).

Two groundwater bearing zones (i.e., 1st WBZ and 2nd WBZ) have been distinguished within the UGZ at the Site. This distinction is based on water chemistry, tidal effects, and the presence or absence of a low permeability deposit (the 1st SH) separating the zones. The 1st WBZ is the uppermost groundwater bearing unit. This zone is primarily composed of native alluvial deposits of fine to medium sand to slightly silty to very silty fine to medium sand. The 1st WBZ is unconfined, with depth to the water table ranging from approximately 7 to 13 feet bgs. Where present, the 1st SH serves as the base for the 1st WBZ throughout most of the Site. Where absent, the 1st WBZ grades into the underlying 2nd WBZ with no identifiable marker. The 1st WBZ is 3 to 8 feet thick in sections where the 1st SH is present. The 2nd WBZ is contained within a semi-confined (i.e., locally unconfined) estuarine/deltaic aquifer that consists of fine to medium silty sands with interbeds, stringers, and lenses of dense to very dense silty fine sand to soft to medium stiff sandy silt. In general, estuarine/deltaic deposits become fine-grained with depth, but often show repeated sequences of silt to silty sand to sand. The 2nd WBZ ranges in depth from approximately 15 to at least 80 feet bgs.

The general direction of groundwater flow at the Site is to the southwest, towards the LDW, regardless of the tidal cycle. At low tide, west of Fox Avenue, groundwater flows toward the S. Myrtle Street Embayment; however, at high tide, groundwater flows northeast towards the Site. This reversal in groundwater flow direction during the tidal cycle is typical of aquifers in contact with marine water bodies.

2.5 CHEMICALS OF CONCERN AND CLEANUP AREAS

The primary chemicals of concern (COCs) identified at the Site are PCE in soil, groundwater, and air; trichloroethene (TCE) in groundwater and air; benzene in soil and ground water; and 1,1-dichloroethene (1,1- DCE), Penta, total petroleum hydrocarbons (TPH; Mineral spirits to heavy oil range), and vinyl chloride (VC) in groundwater only.

The majority of contamination at the Site originates from well-defined source areas. Volatile and other mobile chemicals have migrated in groundwater and reached the S. Myrtle Street Embayment, but non-mobile contaminants, such as Penta, remain localized in their source areas.

The Site has been divided into the following cleanup areas as shown in Figure 2.3.

- **Main Source Area:** The Main Source Area represents those areas of the Site where past releases have occurred and the underlying soil is now the source of the plume found in downgradient groundwater. Contaminants in soil and groundwater include PCE, TCE, the dichloroethene (DCE) isomers, VC, aromatic volatile organic compounds (VOCs; benzene, toluene, ethylbenzene, and xylene [BTEX] for example), TPH (as mineral spirits) and Penta. The Main Source Area extends from under the Flammables Shed and Production Area to the southern part of the Site beneath the railroad tracks on Frontenac Street. Current and historical soil contamination in this area gives rise to groundwater plumes in the 1st WBZ and deeper 2nd WBZ that extends across the corner of the Whitehead Property that lies between the Fox Avenue right-of-way.

The Loading Dock Source Area is a subarea of the Main Source Area. Contamination in this area is limited to the vadose zone and 1st WBZ, and does not extend to the 2nd WBZ.

- **Northwest Corner Source Area:** The Northwest Corner Source Area is a smaller separate plume that is not commingled with the Main Source Area, and is located in the northwest corner of the Site in the parking lot. A distinct soil source has never been identified for the Northwest Corner Plume and its origin is thought to be related to several minor spills that occurred from tanker cars stored along the S. Willow Street rail line. The Northwest Corner Plume is composed primarily of PCE and TCE and is confined to 1st WBZ groundwater. Soil impacts greater than the selected cleanup levels have not been identified in this area.

- **Downgradient Groundwater Plume:** The Downgradient Groundwater Plume extends from the source areas southwest toward the S. Myrtle Street Embayment until it is discharged to the S. Myrtle Street Embayment via several prominent seeps along a tidal bank as well as direct discharge through the sediments of the embayment. There is no associated soil contamination in the Downgradient Groundwater Plume. The plume is comprised primarily of PCE and TCE in the 1st WBZ groundwater, and DCE and VC in the 2nd WBZ groundwater. There are also occurrences of 1,1-DCE, benzene, Penta, and TPH in this plume. The Penta is primarily found in 1st WBZ groundwater upgradient from Fox Avenue. Since 2009, this plume has been the subject of an interim action using enhanced reductive dechlorination (ERD) to stimulate the natural biological destruction of the chlorinated solvents. The ERD interim action is still ongoing and data to date indicate significant acceleration in the conversion of parent PCE to the daughter products TCE, DCE, and VC, as well as the increased production of the end product of dechlorination, ethene gas.

A conceptual site model for the release, which depicts contaminant migration at the Site, is shown on Figure 2.4.

2.6 CONTAMINANT DISTRIBUTION BY MEDIA

Soil on the Site has been impacted by the following COCs:

- **PCE and TCE.** PCE is the most abundant and prevalent Site contaminant in soil. It sometimes occurs as droplets of dense non-aqueous phase liquid (DNAPL). TCE is also present in site soil but at much lower relative concentrations and is limited in occurrence to those areas of significant PCE accumulations. The distribution of PCE and TCE (PCE+TCE) in soil with depth is shown on Figure 2.5.

- **TPH and BTEX.** Site soil in the Main Source Area may also contain limited areas of TPH and BTEX. The TPH is mainly comprised of mineral spirits and the BTEX represents a soluble fraction of the mineral spirits. In places, the mineral spirits contains commingled PCE.

- **Penta.** Penta contamination remains in shallow site soil in a limited area under the railroad spur.

Groundwater on the Site has been impacted by the following COCs:

- **PCE, TCE, DCE, and VC.** Groundwater in the 1st and 2nd WBZ from the Main Source Area is contaminated with Chlorinated volatile organic compounds (CVOCs). Seeps in the S. Myrtle Street Embayment where this contamination discharges contain PCE and its degradation products, especially VC. The distribution of PCE+TCE, cis-1,2-DCE, and VC in groundwater (1st WBZ and 2nd WBZ) is shown on Figure 2.6.
- **TPH and BTEX.** The TPH footprint is similar to the solvent footprint with the highest concentrations located near the railroad spur in the Production Area and in the Loading Dock Area. TPH concentrations are either non-detectable or in compliance with groundwater cleanup levels by Fox Avenue. Groundwater in the 1st and 2nd WBZ from the Main Source Area is contaminated with benzene, which appears to have commingled and migrated with the CVOC plume discharging along with the CVOCs in the 2nd WBZ seeps.
- **Penta.** Penta occurs primarily in groundwater within the 1st WBZ. Concentrations are either non-detectable or in compliance with groundwater cleanup levels by Fox Avenue.

Indoor Air on the Site has been impacted by the following COCs:

- **PCE and TCE.** Concentrations of PCE and TCE levels in indoor air are greater than the MTCA Method C cleanup levels in the downstairs office and restroom at Cascade Columbia. Indoor air samples collected by URS at the Seattle Boiler Works facility in December 2010 indicate that PCE and TCE are present in indoor and outside ambient air (background) at concentrations greater than the MTCA Method B cleanup levels but lower than MTCA Method C cleanup levels. A summary of soil gas and indoor air sampling results at Seattle Boiler Works and at Cascade Columbia is included in Table 2.1.

Sediments and surface water in the S. Myrtle Street Embayment are not contaminated by COCs associated with the Site and are not considered contaminated media.

The stormwater from the operational areas of the Site is combined with process water, treated, and sent to the sanitary sewer under permit. Stormwater is not considered a contaminated media at this Site.

3.0 Cleanup Standards

Cleanup standards have been established for this Site. Establishment of cleanup standards requires specification of the cleanup levels (chemical concentrations that are protective of human health and the environment) for each COC in each impacted media and the location on the Site where the cleanup levels must be attained, the point of compliance (POC).

3.1 SOIL CLEANUP LEVELS

The following pathways were considered for the establishment of soil cleanup levels at the Site:

- Protection of human health via direct exposure using MTCA Method C for industrial workers.
- Protection of ecological receptors. Since the Cascade Columbia Facility is paved with active industrial operations, and will remain paved for the foreseeable future, an ecological evaluation is not required under MTCA. Institutional controls will ensure the industrial future use of the Cascade Columbia property.
- Protection of groundwater resources from chemicals leaching from soil.
- Protection of indoor air from vapor intrusion from contaminated soil and/or groundwater.

In developing cleanup levels, the following site-specific information is relevant:

- The Fox LLC property and the adjacent properties that make up the Site are currently zoned industrial. This area has been an industrial area since the 1920s. Furthermore, the City of Seattle has identified this area for future industrial land use and redevelopment. For these reasons, industrial land use exposure assumptions have been applied to the Site.
- Soil contamination at the Site is limited to the Cascade Columbia facility because exceedances of applicable cleanup levels have not been detected in off-property areas.
- The Fox LLC property is presently covered with buildings or pavement. Although the direct exposure pathway will be considered in setting cleanup levels, it should be understood that direct exposure to contaminated soil is currently a “blocked” pathway in that there is no ongoing exposure.

The upper 15 feet of the Site is the standard POC for soil under MTCA, assuming direct contact. Only PCE has a maximum soil concentration that exceeds the Method C value and only occurs within the Fox LLC property boundary. The Method C PCE cleanup level for soil based on direct contact is, however, not sufficiently protective of groundwater or indoor air so it was not selected as the cleanup level. The soil cleanup level protective of both groundwater and indoor air will not be a numerical value but an empirical demonstration that confirms that soil concentrations remaining after active remediation will be protective of groundwater and indoor air, as allowed under MTCA (WAC 173-340-747(3)(f)). Final cleanup levels for soil are provided in Section 3.4.

3.2 GROUNDWATER CLEANUP LEVELS

The following pathways were considered for the establishment of groundwater cleanup levels at the Site:

- Protection of surface water resources, based on the discharge of groundwater into the Duwamish River at the S. Myrtle Street Embayment. The surface water resources will be protected for both human health (via the consumption of VOC-contaminated aquatic organisms) and ecological receptors.
- Protection of indoor air at the Cascade Columbia Facility and downgradient properties from vapor intrusion from contaminated groundwater in the 1st WBZ.
- Protection of sediment in the LDW was *not* considered a pathway because VOCs are not regulated under the Sediment Management Standards due to the chemical properties that prevent them from partitioning to sediments.

In developing groundwater cleanup levels for the Site, the following site-specific information is relevant:

- Groundwater at the Site is within a tidally-influenced section of the Lower Duwamish Valley. The section of the aquifer in which the Site is located is non-potable, and its maximum beneficial use is protection of adjacent surface water resources in the LDW.
- The water in the LDW is saline and qualifies as a marine water body.

Consistent with the regulation, MTCA equations for the calculation of cleanup levels based on fish consumption were only used when there were no promulgated standards for that pathway. The applicable cleanup levels for groundwater discharging to marine waters are listed in Tables 3.1 and 3.2. Where multiple criteria were available for a chemical, the lowest value was selected, consistent with MTCA (WAC 173-340-730(3)(b)(i)). Only a few compounds were detected in the seeps at concentrations greater than the cleanup levels. These compounds include PCE, TCE, 1,1-DCE, and VC. Final cleanup levels for COCs in groundwater, as well as groundwater seeps, are provided in Section 3.4. A groundwater cleanup level protective of indoor air was not calculated; instead, an empirical demonstration will be used to confirm that groundwater concentrations during and after active remediation are protective of indoor air as described in Section 6.6.

3.3 INDOOR AIR CLEANUP LEVELS

In developing cleanup levels for indoor air, the following site-specific information is relevant:

- The Fox Avenue Building and the adjacent properties that make up the Site are zoned industrial. This area has been an industrial area since the 1920s. Furthermore, the City of Seattle has identified this area for future industrial land use and redevelopment. For these reasons, industrial land use (MTCA Method C) exposure assumptions have been applied to the Fox Avenue facility.
- The Seattle Boiler Works property is also currently zoned industrial; however, the property owner will not currently accept a covenant that restricts future property use to industrial; therefore, Ecology determined that MTCA Method B cleanup levels be applied to the Seattle Boiler Works property.

Standard MTCA Method B and C cleanup levels to protect indoor air quality exist for the individual COCs as derived using the equations in WAC 173-340-750. Final cleanup levels for COCs in indoor air are provided in Section 3.4.

3.4 FINAL CLEANUP LEVELS

The final site-wide cleanup levels are:

Chemical of Concern	Soil Cleanup Level—Protection of Groundwater/ Indoor Air	Groundwater Cleanup Level—Protection of Surface Water (μg/L)	MTCA Method B[1] Indoor Air Cleanup Level ($\mu g/m^3$)	MTCA Method C[2] Indoor Air Cleanup Level ($\mu g/m^3$)
Benzene	Empirical[3]	51	NA	NA
1,1-DCE	Empirical[3]	3.2	NA	NA
Penta	Empirical[3]	3.0	NA	NA
PCE	Empirical[3]	3.3	0.42	4.2
TCE	Empirical[3]	30	0.10	1.0
TPH (Mineral Spirits to Heavy Oil Range)	Empirical[3]	500	NA	NA
Vinyl Chloride	Empirical[3]	2.4	NA	NA

Notes:
1 MTCA Method B Air CULs are applied to the Seattle Boiler Works property
2 MTCA Method C Air CULs are applied to the Cascade Columbia building.
3 CUL has no numeric value. Instead, soil, indoor air, and groundwater will be empirically demonstrated to be in compliance when indoor air and groundwater (at the conditional point of compliance) meet their respective cleanup levels within the estimated restoration time frame.

Abbreviations:
CUL Cleanup level
DCE Dichloroethene
μg/L Micrograms per liter
$\mu g/m^3$ Micrograms per cubic meter
MTCA Model Toxics Control Act
NA: Not applicable, the chemical is not a contaminant of concern for air
PCE Tetrachloroethene
Penta Pentachlorophenol
TCE Trichloroethene
TPH Total petroleum hydrocarbon

3.5 POINTS OF COMPLIANCE

POCs (locations were the cleanup levels shall be achieved) are established for each impacted media at the Site. These impacted media include groundwater, air, and soil. The POCs for each medium are discussed separately below.

3.5.1 Soil Points of Compliance

The points of compliance for soil are based on three pathways of exposure:

1. **Soil direct contact.** The MTCA standard POC for soil for direct contact is from the ground surface to a depth of 15 feet bgs. Compliance will be determined by direct sampling of soil following source area remediation.
2. **Soil leaching contaminants to groundwater**. This is a cross-media pathway that concerns all site soil that is a potential source of chemicals to groundwater. Compliance will be demonstrated empirically by directly comparing groundwater concentrations at the Fox Avenue conditional point of compliance (CPOC) following source area remediation to the groundwater remediation and cleanup levels. If groundwater at the CPOC meets the groundwater cleanup levels, this pathway will be empirically demonstrated to be in compliance.
3. **Soil in the vadose zone causing vapor intrusion**. For protection of this cross-media pathway, the POC is from the surface to the uppermost groundwater table (approximately 10 feet bgs at the Site). Compliance will be demonstrated empirically by direct sampling of indoor air following source area remediation. If indoor air is in compliance with the indoor air cleanup levels, then this pathway will be empirically demonstrated to be in compliance.

3.5.2 Groundwater Conditional Point of Compliance

The standard POC for groundwater under MTCA is "throughout the site from the uppermost level of the saturated zone extending vertically to the lowest depth which could potentially be affected by the site" (WAC 173-340-720(8)(b)); however, per MTCA (WAC 173-340-720(8)(c)), where it can be demonstrated that it is not practicable to meet the cleanup levels throughout the Site in a reasonable restoration time frame, a CPOC may be approved by Ecology. Currently, there is not a practicable technology that exists to clean up the source areas at DNAPL sites in a reasonable restoration time frame to meet current regulatory levels. This is especially true at this Site due to the continued presence of DNAPL and the large mass of solvent released at this Site. Therefore, a CPOC is warranted. At the Cascade Columbia facility, source areas such as at the loading dock and rail spur lie at the property boundary making the property boundary along Fox Avenue a justifiable CPOC.

Therefore, the CPOC for groundwater is Fox Avenue, along the downgradient property boundary of both the Fox LLC property and the Whitehead Property under which the groundwater plume travels (refer to Figure 2.3). These two properties encompass the full width of the plume. The owner of the Whitehead property has provided written agreement to the use of a conditional POC.

The current owner of the downgradient Seattle Boiler Works property has indicated that he will not concur with a CPOC that extends across Fox Avenue and onto his property (i.e., at the S. Myrtle Street Embayment). In the future, should he or a subsequent owner consent to the use of an off-property CPOC for groundwater, Ecology will consider moving the CPOC off-property from Fox Avenue to the S. Myrtle Street Embayment per MTCA (WAC 173-340-720(8)(d)(ii)).The POC for the groundwater seeps discharging to surface water will be the seeps along the S. Myrtle Street Embayment. The seeps will be sampled and the concentrations directly compared to the groundwater cleanup standards that are protective of surface water.

3.5.3 Indoor Air Point of Compliance

The POC for ambient and indoor air is site-wide; however, vapor intrusion from subsurface contaminants occurs only in enclosed spaces and structures such as the Cascade Columbia office, or buildings overlying the downgradient plume. The active remedial actions proposed for the source areas are intended to reduce soil concentrations by approximately 98 percent on average. The resultant residual soil and groundwater concentrations following active remediation are anticipated to be protective of indoor air site-wide. Compliance will be documented by measuring indoor air in the Cascade Columbia office, the downgradient Seattle Boiler Works buildings, and other potentially impacted structures before, during, and after active remediation of soil and groundwater. Details of the plan and schedule for compliance sampling of indoor air are described in Section 6.6. Additional details will be set forth in the EDR.

3.6 REMEDIATION LEVELS

In accordance with WAC 173-340-200, a remediation level “means a concentration of a hazardous substance in soil, air, water, or sediment above which a particular cleanup action component will be required as part of a cleanup action at a site.” Remediation levels are, by definition, concentrations that exceed cleanup standards and are used when a combination of cleanup action components are necessary to achieve cleanup levels at the POC. Cleanup actions that use remediation levels to meet the cleanup standards at a CPOC are also considered to comply with the cleanup standards.

Remediation levels are applicable to this Site because implementation of multiple aggressive treatment technologies will likely be necessary to achieve cleanup levels for groundwater at the CPOC, located along Fox Avenue and throughout the Downgradient Groundwater Plume. As explained in the RI, COC concentrations in soil and groundwater are elevated and occur deep within the aquifer. Attaining the groundwater cleanup levels would require at least four orders of magnitude reduction (99.99 percent) in the current concentrations in groundwater; a challenge that is beyond the ability of any single existing technology to achieve in a reasonable restoration time frame. Compounding the situation is the location of the source areas with respect to the CPOC for groundwater. The Main Source and Loading Dock Areas lie very close to or abut Fox Avenue, leaving no room for attenuation between the soil source and the CPOC.

Given the above situation, a combination of cleanup technologies must be used at this Site in order to reduce concentrations of COCs to the lowest concentrations technologically achievable and practicable. Remediation levels, therefore, were established that allow one cleanup technology to transition to another, as described in more detail in Section 4.0.

The selected remediation levels for soil and groundwater are summarized in the table below.

Groundwater Remediation Level	Basis	Soil Remediation Level	Basis
250 µg/L Total CVOCs (as measured in the designated monitoring well network)	1. Expected residual average concentration in source area groundwater following source area remedy implementation. 2. Use of thermal treatment and ERD to achieve 250 µg/L total CVOCs, which is predicted to result in achieving cleanup levels at the seeps in reasonable restoration time frame. 3. Concentration will not present a vapor intrusion risk in downgradient properties. 4. Cleanup levels will be attained at the CPOC over an extended restoration time frame via natural attenuation.	10 mg/kg (average soil concentration following source area treatment)	1. Technologically achievable; represents 98 percent reduction from source area average concentration. 2. Achieves MTCA Method C direct contact levels. 3. Expected to eliminate source of current vapor intrusion into Cascade Columbia office. 4. Expected to result in 98 percent reduction in source area groundwater concentrations in 1st and 2nd WBZs.

Abbreviations:

CPOC	Conditional point of compliance
CVOC	Chlorinated volatile organic compound
ERD	Enhanced reductive dechlorination
µg/L	Micrograms per liter
mg/kg	Milligrams per kilogram
MTCA	Model Toxics Control Act
WBZ	Water Bearing Zone

4.0 Description of Cleanup Action

A preliminary screening of remedial technologies was conducted as part of the RI/FS for each of the cleanup action areas (CAAs) to reduce the number of alternatives included in the detailed evaluation. The screening, which is summarized in Table 4.1, presented information regarding technology benefits and constraints. As a result, certain technologies were rejected from further evaluation. The technologies retained for detailed evaluation included monitored natural attenuation, permeable reactive barriers, capping, thermal treatment, soil vapor extraction, enhanced reductive dechlorination, and air sparging. Table 4.2 lists the technologies considered for each cleanup action area. The detailed evaluation of these technologies is contained in the RI/FS.

The selected cleanup action is comprised of the highest ranking and most permanent of the remedial alternatives evaluated for each cleanup action area. It is a comprehensive final remedy for the Site that is compliant with all of the applicable remedy selection requirements under MTCA. The cleanup action is described below and summarized in the table that follows. Figure 4.1 displays the locations and major elements of the selected remedy.

4.1 MAIN SOURCE AREA CLEANUP ACTION AREA

- **Soil:** To treat CVOCs in soil in the Main Source Area CAA, thermal treatment by Electrical Resistance Heating (ERH) will occur until the mean soil concentration in the treatment area meets the 10 mg/kg total PCE+TCE remediation level (refer to Section 6.1.3). This will be followed by post-thermal application of ERD as a polish to further destroy contaminant mass in the source areas. The predicted time frame for soil to achieve compliance with remediation level is expected to be 1 year.
- **Groundwater:** Subsequent to source area removal using ERH, CVOCs in groundwater in the Main Source Area CAA will be treated by post-thermal applications of ERD as a polish to further destroy contaminant mass in the source areas. ERD will occur until groundwater concentrations at the CPOC meet the remediation level of 250 µg/L total CVOCs. The predicted time frame for groundwater to achieve compliance with remediation level is expected to be 5 years following thermal remediation.

4.2 DOWNGRADIENT GROUNDWATER PLUME CLEANUP ACTION AREA

- **Groundwater:** The selected technology for groundwater treatment is ERD, which will occur until the groundwater remediation level of 250 µg/L total CVOCs is achieved throughout the downgradient plume and the groundwater seeps at the S. Myrtle Street Embayment are in compliance with the cleanup levels. It is anticipated that ERD will continue throughout the majority of the Downgradient Groundwater Plume for approximately 10 years, and then will be phased out as areas come into compliance with the remediation level over the following 5 years. Following attainment of the remediation levels, monitored natural attenuation (MNA) of groundwater will occur until the cleanup levels are achieved throughout the Downgradient Groundwater Plume CAA, which may take an additional 50 years due to low regulatory levels and the high starting concentrations.

- **Soil:** There are no technologies proposed for soil treatment in the Downgradient Groundwater Plume CAA, as there are no soil cleanup level exceedances in the downgradient area of the Site.

4.3 NORTHWEST CORNER PLUME CLEANUP ACTION AREA

- **Groundwater:** The selected technology for groundwater treatment is ERD, which has shown to be effective at the Site based on results of the ERD Interim Action. ERD will be used to treat groundwater where concentrations of total CVOCs are greater than the remediation level of 250 µg/L, which is limited to the 1^{st} WBZ. The predicted time frame for groundwater to achieve compliance with the 250 µg/L total CVOC remediation level at the CPOC is expected to be approximately 5 years.
- **Soil:** The selected technology for vadose zone soil treatment is soil vapor extraction (SVE), which is expected to operate for approximately 1 year or until asymptotic levels of extracted PCE are achieved. SVE is expected to remove several hundred pounds of PCE from the subsurface, thereby reducing the contamination mass in soils leaching to groundwater, and reducing the restoration time frame for groundwater compliance.

Summary of Selected Remedy Elements

Cleanup Action Area	Applied To	Technology	Implemented until Compliance with RL or CUL Achieved	Approximate Time Frame Required
Main Source Area	Vadose, 1^{st} WBZ, 1^{st} SH, 2^{nd} WBZ (to 65 feet bgs)	Electrical Resistance Heating (Primary)	RL: 10 mg/kg total PCE + TCE in soil	1 year of active heating
	1^{st} and 2^{nd} WBZ soil > 10 mg/kg or groundwater > 1,000 µg/L	ERD (Polish)	RL: 250 µg/L total CVOCs in groundwater (measured at CPOC)	5 years (post-thermal)
Downgradient Groundwater Plume	1^{st} and 2^{nd} WBZ groundwater (to 70 feet bgs) with total CVOCs > 100 µg/L at Fox Avenue	ERD	RL: 250 µg/L total CVOCs in groundwater (as measured in the designated monitoring well network)	10–15 years (post-thermal)
		MNA	CUL: Refer to table in Section 3.4 (cleanup levels measured in all downgradient wells)	50 years (post-ERD)

Cleanup Action Area	**Applied To**	**Technology**	**Implemented until Compliance with RL or CUL Achieved**	**Approximate Time Frame Required**
Northwest Corner Plume	1st WBZ groundwater with total CVOC concentrations > 250 µg/L	ERD/SVE	RL: 250 µg/L total CVOCs in groundwater (measured at CPOC)	5 years (post-SVE)
	1st WBZ groundwater with total CVOC concentrations < 250 µg/L	MNA	CUL: Refer to table in Section 3.4 (measured at CPOC)	50 years (post-ERD)

Abbreviations:

<	Less than	MNA	Monitored natural attenuation
>	Greater than	PCE	Tetrachloroethene
bgs	Below ground surface	RL	Remediation level
CVOC	Chlorinated volatile organic carbon	SH	Silt Horizon
CPOC	Conditional point of compliance	SVE	Soil vapor extraction
CUL	Cleanup level	TCE	Trichloroethene
ERD	Enhanced reductive dechlorination	WBZ	Water Bearing Zone

4.4 JUSTIFICATION FOR CLEANUP ACTION SELECTION

The selection of the cleanup action is justified as it meets the following minimum requirements for selection of a cleanup action under MTCA WAC 173-340-360(2)(a):

(i) **Protect Human Health and the Environment.** The selected remedy will protect human health and the environment in both the short- and long-term. The remedy will permanently reduce the identified risks presently posed to human health (worker exposure to soil and indoor air) and the environment (discharge of the seeps to surface water) through a combination of source area treatment via thermal treatment followed by ERD polish, downgradient ERD treatment of groundwater, and natural attenuation of groundwater.

(ii) **Comply with Cleanup Standards.** The selected remedy is expected to comply with the cleanup and remediation levels for groundwater, soil, and indoor air. While standard POCs are appropriate for soil and indoor air, a CPOC at Fox Avenue is appropriate for groundwater.

(iii) **Comply with Applicable State and Federal Laws.** The selected remedy is expected to comply with all state and federal laws and regulations.

(iv) **Provide Compliance Monitoring.** The selected remedy will include rigorous compliance monitoring for soil, indoor air, groundwater, and seeps to assess the effectiveness and permanence of each remedy element in each CAA. The monitoring is expected to be more intensive for the initial years of remedy implementation, with less frequent monitoring in the future.

The selected remedy also meets the other requirements for selection under MTCA WAC 173-340-360(2)(b), which includes the following:

(i) **Using Permanent Solutions to the Maximum Extent Practicable.** The selected remedy utilizes permanent solutions to the degree practical. Thermal treatment will remove a large portion of the existing contaminant mass from subsurface soil and will destroy it in a thermal oxidizer. SVE will extract PCE mass in the Northwest Corner Plume CAA and will capture it in activated carbon that will be regenerated or by using the thermal oxidizer. ERD destroys contaminant mass in groundwater in-situ by biological transformation of COCs into harmless by-products.

(ii) **Providing for Reasonable Restoration Time Frame.** The thermal element of the selected remedy will require approximately 1 year to construct and complete the heating phase. Remediation levels in soil are expected to be attained following thermal shutdown. This will achieve restoration of soil for protection of workers (via direct contact to soil and also indoor air exposure from soil). The time frame for post-thermal treatment via ERD to achieve groundwater remediation levels at the CPOC is anticipated to be approximately 5 years, and compliance with cleanup levels at the point of discharge to surface water at the S. Myrtle Street Embayment is expected within approximately 10 to 15 years through a combination of ERD and MNA, assuming no access limitations. Once accomplished, this will eliminate all existing ecological risk from the migration of site contaminants. Attainment of the cleanup levels in the entire groundwater plume will take considerably longer, likely 50 years; however, assuming that indoor air levels are in compliance, no risk to human health and the environmental has been identified by the Downgradient Groundwater Plume (except at the seeps) because this section of the aquifer is considered non-potable.

(iii) **Considering Public Concerns.** This document was presented to the public and stakeholders through a public comment process. Ecology prepared a responsiveness summary that documents how each of the public comments were considered and addressed. This final CAP incorporated modifications based on public comment.

Finally, because this remedy relies on a CPOC due to the impracticality of attaining cleanup levels throughout the source area, this cleanup action is not considered permanent under WAC 173-340-360(2). The selected alternative complies with the following requirements for non-permanent groundwater cleanup actions under MTCA WAC 173-340-360(2)(c)(ii):

A. **Treatment or Removal of the Source Including Light Non-aqueous Phase Liquid (LNAPL) and DNAPL.** This will be done to the extent practical by using thermal treatment in the source areas, followed by ERD to address any residually-contaminated areas.

B. **Groundwater Containment, Including Barriers, to Avoid Spreading of the Groundwater Plume.** This will be done by the use of ERD that will, in effect, create a “biological barrier” that will prevent spreading of the plume and treat CVOCs within the plume.

5.0 Selected Cleanup Action Implementation

The general details of the selected remedy are presented below. Additional details will be provided in the Engineering Design Report (EDR), which will be prepared prior to cleanup action implementation.

5.1 MAIN SOURCE AREA CLEANUP ACTION AREA

This remedy consists of two components, thermal treatment and post-thermal ERD. The major elements of each are described below.

5.1.1 Thermal Treatment Area

The soil and groundwater in the Main Source Area CAA will be treated using thermal heating via ERH, which is ideally suited to site conditions. The area to be thermally treated is defined by the 1 mg/kg total PCE + TCE contour in soil that occurs within the Fox Avenue Building footprint, as shown on Figure 2.5. It is the large mass of solvent within this contour that is contributing to the longevity and magnitude of the plumes found primarily in 1st WBZ groundwater downgradient from the Loading Dock Area, Rail Spur Area, Flammables Shed, and in 2nd WBZ groundwater downgradient from primarily the Flammables Shed.

5.1.2 Penta and Mineral Spirits

The mass of mineral spirits at the Site, which includes a large BTEX fraction, also resides within this zone. Given that the most toxic light-end component of the mineral spirits present is benzene, which volatilizes at 80 degrees C, it is expected that the benzene fraction will also be treated by the thermal process that will reach temperatures close to the boiling point of water; however, the heavier end of mineral spirits, such as xylene and heavy organics such as Penta, which are found primarily in 1st WBZ groundwater, volatilize at temperatures greater than the boiling point of water and so will not be as effectively treated by the thermal process as the lighter, more volatile chlorinated solvents. Penta will not be effectively remediated by the thermal or ERD treatment processes; however, the current data do not indicate significant migration of TPH or Penta. TPH and Penta will be monitored in groundwater following remedial actions to confirm that concentrations of these COCs are stable in groundwater, or are reducing over time.

Concentrations of PCE and TCE in soil that are less than 1 mg/kg occur across a much larger portion of the Site but represent a very minor amount of solvent mass, rendering thermal treatment impractical. Additionally, these concentrations are found primarily in 1st WBZ soil downgradient from the Main Source Area CAA and are suspected to be the result of solvent migration from upgradient source areas and subsequent adsorption of the PCE and TCE in soil organic matter. These areas of low PCE and TCE concentrations in soil will be addressed by the remedy for the Downgradient Groundwater Plume CAA.

5.1.3 Thermal Treatment Zones

The area with combined concentrations of PCE and TCE in soil greater than 1 mg/kg will be thermally treated within the footprint shown on Figure 5.1. This footprint has been divided into five zones, each with a unique treatment depth that captures the depth range of soil contamination greater than 1 mg/kg PCE and TCE as follows:

1. Loading Dock Area: 2,300 square feet, treat to 15 feet bgs
2. West Rail Area: 4,500 square feet, treat to 17 feet bgs
3. East Rail Area/East Flammables Shed Area: 4,600 square feet, treat to 22 feet bgs
4. Former Pump House and West Flammables Shed Area: 7,500 square feet, treat 1 to 65 feet bgs
5. Alkaline Shed and Production Area: 4,460 square feet, treat 15 to 65 feet bgs

Together, these areas represent a soil volume of approximately 33,000 cubic yards that will be treated; however, a significant fraction of this soil volume is actually free of contamination or exhibits very low concentrations. This is primarily a consequence of having two depth zones to treat, one shallow and widespread, and one much deeper and confined, with a relatively non-impacted zone in between. These two areas are separated by approximately 20 to 30 feet of relatively clean soil. This cleaner intermediate zone must be heated to boiling in order for the solvent mass liberated from the deep zone to rise and be captured by the vapor recovery wells located in the vadose zone. If heating is not equal throughout the treatment zone, liberated solvent mass may recondense prior to recovery, causing significant risk of solvent mass loss to downgradient groundwater. The benefit of this approach is to provide a high level of assurance that solvent mass (whether in soil or groundwater) within each zone will be treated. Because all soil within the treatment zone will be treated, it will result in significant reductions in those areas of soil with chemical concentrations now close to or less than the remediation level (i.e., the 1 to 10 mg/kg contour) resulting in significantly less residual source mass following thermal treatment.

5.1.4 System Layout and Vapor Treatment

The expected layout of the thermal system is shown on Figure 5.2, and includes the electrode locations and temperature monitoring points that are used to verify that the subsurface soil has achieved its boiling point. Figure 5.2 also shows the halo of soil lying outside of the immediate treatment zone that will also be heated to the boiling point and subject to cleanup. This additional 5- to 7-foot buffer provides added confidence that the limits of source area contamination are within the treatment area.

The electrodes (steel pipe surrounded by graphite) will be designed to function as steam/condensate extraction wells and will include the ability to remove free product mineral spirits should any be captured by the system. Electrodes are, in effect, remediation wells with the added capacity to direct electrical current to the proper depth for subsurface heating. Electrodes can serve as vapor and steam recovery points or can operate as multiphase extraction wells for the recovery of vapor, steam, water, and NAPL from the subsurface. The steam and vapors will be removed via a large blower using standard polyvinyl chloride (PVC) piping that will be manifolded at the ground surface and will run to the treatment compound. The extracted steam and vapor stream will pass through a condenser. The steam will condense back to water that will be relatively clean and either be treated with liquid phase carbon and disposed via sanitary sewer or dripped back into the vadose zone to prevent the soil from drying out, which would stop the flow of electrical current and hence the subsurface heating.

The vapor stream flowing out of the condenser will be chemical-rich and will be directed to a thermal oxidizer with an acid gas scrubber for destruction of the chlorinated and aromatic compounds extracted. The aboveground equipment will be located in a treatment compound located on the east side of the warehouse, as shown in Figure 5.2.

5.1.5 Electrical Service

A new electrical service supplying 13.8 kilovolts of power will be required to operate the remediation system. This large amount of power will require a temporary high voltage electrical service be brought into the Site by Seattle City Light. Specialized power control units will transform that voltage and feed it into the ground via copper cabling that services each electrode.

5.1.6 Post-thermal ERD

Following shutdown of the thermal treatment system, the steam within the treatment area will re-condense to groundwater, but will still be quite warm for several months. During this cool-down period, an assessment will be made of post-thermal groundwater quality within the treatment area. This will be done using a Geoprobe to collect samples at multiple depth intervals from 10 to 12 locations. Also, during the cool-down phase, the microbial community will be reestablished, and the subsurface environment will be amenable to accelerated biodegradation. The injection of ERD substrate into the thermal zone (using the existing steel electrodes that will be slotted to allow injection of substrate) will assist in promoting the correct conditions for anaerobic biodegradation of the residual chlorinated solvent that remains in the treatment area. As explained above, it is expected that the zone of residually-contaminated soils will be much smaller than the current footprint.

Following receipt of post-thermal groundwater data, a targeted ERD treatment plan will be designed based on the site-specific conditions at that time. If any areas are found to be residual “hot spots,” they will likely be targeted for injection of edible oil substrate (EOS). EOS has a very limited zone of influence since it does not readily dissolve into groundwater, so it is long lasting and ideal for source area treatments in areas with residual source that is expected to “bleed” solvent for an extended time period. In addition to the EOS, depending on site conditions, a more soluble substrate may be used—possibly combined with nano-scale zero-valent iron (ZVI), or other substrates that would increase the rate or effectiveness of the ERD injections. This post-thermal ERD will initially be applied to the majority of the residual treatment area, but subsequent treatments will be focused on any remaining smaller sub-areas that are found to be continuing sources of downgradient groundwater exceedances.

5.2 DOWNGRADIENT GROUNDWATER PLUME CLEANUP ACTION AREA

The remedy for the Downgradient Groundwater Plume CAA consists of two components—ERD as it currently is being implemented per the ongoing interim action, followed by MNA. The ERD component of the Downgradient Groundwater Plume remedy is intended to clean up the plume to the remediation level of 250 µg/L total CVOCs and the seeps to the cleanup levels in a relatively short time frame (anticipated in approximately 10 to 15 years). The MNA component will be used to reach the cleanup levels in groundwater upgradient from the seeps up to the CPOC in a longer time frame (approximately 50 years).

5.2.1 Enhanced Reductive Dechlorination

The full implementation of ERD will commence in parallel with the construction of the thermal remediation system. The goal of full implementation is to have a complete ERD network installed and functioning by the time the thermal treatment zone is undergoing heating. This will add protectiveness to the remedy because the full ERD network can act in its full capacity to destroy any unanticipated loss of solvent from the Main Source Area CAA during thermal remediation. A portion of the ERD network directly downgradient from the thermal heating zones will also benefit from the increased microbial activity that will occur because groundwater leaving the thermal treatment zone will be heated to levels greater than ambient temperature for up to an estimated 200 feet downgradient.

The full implementation of the ERD remedy will require installing an estimated 10 additional “Row 1” ERD wells along Fox Avenue to complement the existing 7 wells. The addition of these new wells will result in an ERD network along Fox Avenue that will treat the full width and depth of the current plume that lies within the 100 µg/L total CVOC contour. Locations for these additional “Row 1” wells are shown on Figure 4.1. Up to seven “Row 2” ERD wells may also be installed further downgradient, on Seattle Boiler Works and Dawn Foods Distribution Warehouse properties to extend the existing Row 2 well network across the full width of the plume prior to its discharge to the S. Myrtle Street Embayment. These two rows of ERD injection wells will aggressively remediate the downgradient plume, which will be without a significant source following thermal remediation. Access for installation and injection of the ERD wells located on private property is discussed below. Once the groundwater remediation level is achieved in wells downgradient from Fox Avenue, ERD injections will decrease in frequency, or cease. Further details will be provided in the EDR. Contingent actions that address the inability of ERD to achieve the remediation levels in groundwater and the cleanup levels in the seeps or indoor air within the specified time frames are discussed in Section 6.0.

5.2.2 Monitored Natural Attenuation

The ERD injections are expected to decrease in frequency and stop after 10 to 15 years. Following ERD injections, the aquifer is expected to remain adequately reducing for a significant time frame into the future. This condition will promote the continued natural attenuation of the residual concentrations of chlorinated solvents in the downgradient plume. Measurements will be collected regularly to determine if natural attenuation is occurring; however, given the very low cleanup levels, and the tendency for PCE and TCE in groundwater to adsorb to soil organic matter and then slowly release back to groundwater, it is expected that the full restoration of the downgradient plume to the cleanup levels for all COCs will be a long process, estimated to be 50 years or longer. Regardless, all risk to human health and the environment will have been addressed following achievement of cleanup levels at the seeps and elimination of the downgradient vapor intrusion pathway

5.2.3 Long-term Monitoring

Long-term monitoring (LTM) activities will commence following the termination of ERD injections, which are expected to last for 10 to 15 years following thermal remediation. LTM will be conducted under a plan that will be submitted to Ecology for review and approval following cessation of ERD injections. This plan will identify the wells and seeps that will form the designated monitoring network. The wells will be located along Fox Avenue, as well as downgradient of Fox Avenue. This network is expected to consist of 8 to 10 wells and 2 to

3 seeps. The frequency of sampling is expected to be semi-annual for an initial 5-year period, then decline to annual until cleanup levels are achieved. When cleanup levels are met site wide in the designated well network, quarterly monitoring will commence for a 1-year period. Compliance with the cleanup levels will be evaluated using the quarterly data and the procedures specified in WAC 173-340-720 (9). If compliance is demonstrated, then monitoring shall cease site-wide.

5.3 NORTHWEST CORNER PLUME CLEANUP ACTION AREA

The remedy for the Northwest Corner Plume CAA consists of two components: SVE and ERD. Each is described separately below.

5.3.1 Soil Vapor Extraction

The SVE remedy element will remove PCE from the vadose zone that otherwise would act as a long-term source of groundwater contamination. The SVE system is expected to consist of four vertical SVE wells placed in the parking lot located in the Northwest Corner Plume CAA and along S. Willow Street. The wells will be tied together via subsurface piping, which will extend above the surface at a central manifold location where they will be connected to a blower. The exhaust will be vented through granular activated carbon vessels or through the thermal system oxidizer prior to discharge to the atmosphere under a Puget Sound Clean Air Agency permit. It is expected that the footprint of the aboveground components of the SVE system will be limited and will be able to fit within a portable trailer or small shed located adjacent to the Cascade Columbia warehouse. An electrical power line will be extended from the warehouse to service the blower and control panel. The proposed layout of the SVE system is shown on Figure 4.1.

The SVE system will be run until asymptotic concentrations are achieved. Because previous investigations have determined that there is not substantial source mass in this area, achieving asymptotic concentrations is expected to occur within 1 year of operation. The effectiveness of the SVE system will primarily be determined by the total mass of PCE removed, and its impact upon groundwater concentrations in this area.

5.3.2 Enhanced Reductive Dechlorination

Groundwater impacts are limited to the 1st WBZ in the Northwest Corner Plume CAA. ERD injections upgradient from Fox Avenue will occur in a series of three shallow wells recently installed in the parking lot area. These three wells plus the Row 1 ERD wells along Fox Avenue further downgradient are expected to adequately treat the plume within the 100 µg/L total CVOC contour. A conceptual layout is presented in Figure 4.1. The substrate injections will be more frequent at first due to the need to convert the currently aerobic or slightly anaerobic groundwater to strongly anaerobic conditions, a process that will require approximately 1 to 2 years of injections on a regular basis (two to three times per year). The addition of nano-scale ZVI particles to the fermentable substrate may be considered to accelerate the promotion of strongly-reducing conditions. It is expected that once sufficient biogeochemical conditions are achieved in the treatment area, the frequency of injections will diminish to one to two times per year.

ERD will continue until the remediation level for groundwater of 250 µg/L total CVOCs is reached at the CPOC at Fox Avenue. The percent reduction in current concentrations necessary to achieve the remediation level is approximately 75 percent, which is well within the range of the ERD technology. Therefore, the expected period of performance for ERD injections is 5 years. Current groundwater and ERD monitoring practices will continue as part of the ERD Interim Action and results will be provided regularly to Ecology.

Following 5 years of active treatment, if ERD has not achieved compliance with the 250 µg/L total CVOCs remediation level (as measured within the treatment area), then contingent actions will be evaluated as discussed in Section 6.0.

5.4 PERMISSION, ACCESS, AND INSTITUTIONAL CONTROLS

The use of a CPOC for properties near, but not abutting, surface water requires the written consent of affected property owners. The CPOC along Fox Avenue requires written permission from the owners of the Whitehead Property (executed copy included in Appendix A). Access was also obtained for groundwater sampling at the Whitehead Property, and will be required for other downgradient properties with monitoring and/or ERD injection wells (e.g., Seattle Iron and Metals). Access will also be required from Seattle Boiler Works and possibly other downgradient properties to allow for injection of ERD substrate into existing and new ERD wells, as well as access to sample indoor air and groundwater and install additional ERD wells necessary to optimize the Downgradient Groundwater Plume remediation following completion of source area thermal treatment. Should access to downgradient properties be withheld, the remedy for the Downgradient Groundwater Plume CAA cannot be fully implemented, making it impractical to meet the remediation and cleanup levels within the expected restoration time frame.

Following achievement of remediation levels for groundwater, implementation of institutional controls will be required on those portions of affected properties where chemical concentrations in groundwater or indoor air exceed applicable cleanup levels and are expected to remain greater than cleanup levels for an extended time frame. Institutional controls (in the form of an environmental covenant) will likely include the following:

- Restriction in withdrawal of groundwater from the affected property for drinking purposes
- Consent to long-term access for environmental monitoring and maintenance

Additionally, Fox LLC and Whitehead properties will be required to be maintained for industrial use only, (as they are located upgradient of the groundwater CPOC at Fox Avenue) in a manner consistent with applicable zoning requirements. The owner for the Seattle Boiler Works property has indicated that a restrictive covenant on the Seattle Boiler Works property will not be allowed restricting future uses to industrial, resulting in MTCA Method B cleanup levels being applied for indoor air at the Seattle Boiler Works property. Figure 5.3 shows the tax lots where institutional controls will be implemented.

5.5 APPLICABLE STATE AND FEDERAL LAWS

5.5.1 Chemical-specific Applicable or Relevant and Appropriate Requirements

The selected alternative is predicted to attain concentration-based cleanup levels developed under MTCA for the COCs in applicable media at the Site. In addition, compliance with the Water Quality Standards for Washington Surface Waters (WAC 173-201A) and the National Toxics Rule, which were described in further detail in the RI/FS (Floyd|Snider 2011), will also be necessary.

5.5.2 Action-specific Applicable or Relevant and Appropriate Requirements

Action-specific applicable or relevant and appropriate requirements (ARARs) are requirements that define acceptable management practices and are usually specific to certain kinds of activities that occur or are specific to the technologies that are used during the implementation of cleanup actions. These selected alternatives will comply with the rules or regulations, which were described in further detail in the RI/FS (Floyd|Snider 2011), identified below.

- Washington Dangerous Waste Regulations (WAC 173-303)
- Water Quality Standards for Surface Waters of the State of Washington (RCW 90.48 and 90.54; WAC 173-201A)
- Federal, state, and local Air Quality Protection Programs
- Federal and State of Washington Worker Safety Regulations (Hazardous Waste Operations and Emergency Response (HAZWOPER), WAC 296-62; Health and Safety 29 CAR 1901.120)
- Occupational Safety and Health Act
- Washington Industrial Safety and Health Act, WAC 296-62, WAC 296-155, RCW 49.1
- Underground Injection Well Registration
- Sanitary Sewer Discharge

5.6 PROPOSED CLEANUP ACTION PLAN SCHEDULE

In general, the following reporting and remedial action implementation activities will occur in accordance with the following schedule. This schedule is subject to change based on Ecology's review schedule, permits, contractor availability, on- and off-site access, and weather.

A 30-day public comment period for the draft CAP was conducted in March of 2012. Ecology addressed public comments in a Responsiveness Summary and this final CAP has been modified to address public comments received on the draft CAP.

An EDR will be prepared and submitted within 30 days of Ecology's issuance of the Final CAP. Construction plans and specifications for the thermal, SVE, and expanded ERD remedy components will be included with the EDR as well as a construction schedule. A detailed plan for post-thermal ERD polish in the main source area will not be submitted until thermal remediation is completed, as the plan will be focused to treat specific areas with residual contamination.

An Operation and Maintenance Plan will be included in the EDR, as well as a compliance monitoring sampling and analysis plan for the active remedy elements.

After the active remedy elements have been completed and the Site transitions to Monitored Natural Attenuation, a LTM Plan will be submitted to Ecology for review and approval.

Field work for the construction of the thermal system, ERD well network, and the SVE system (including well installations and surface completions) will commence following the approval of the EDR. It is anticipated that construction activities will be completed within two to three months and that the thermal and SVE system activation will occur immediately following construction completion, final engineering inspections, and permitting.

An As-Built Construction Report, which will include drawings and a report documenting construction and start-up and testing activities, will be submitted to Ecology within 90 days of completion of thermal, SVE, and ERD system installation activities. Monthly progress reports will be submitted to Ecology during the thermal remediation phase of the remedy. A final completion report including all confirmatory soil sampling results and final operational data will be submitted to Ecology 90 days following termination of the thermal remedy.

6.0 Remedial Action Monitoring and Contingency Actions

Performance and compliance monitoring for soil, groundwater, and indoor air will be conducted within each of the CAAs as described in general terms below. Contingency actions are also identified should the remediation and cleanup levels not be met in the predicted restoration time frames using the selected remedies. Additional details will be provided in a Compliance Monitoring Plan, which will be submitted as part of the EDR.

6.1 MAIN SOURCE AREA THERMAL REMEDIATION

The performance monitoring associated with the thermal remedy will include the collection of system operational data and soil compliance data.

6.1.1 Operational Data

One of the most important system operational data to collect is the soil temperature, which will be constantly monitored at over 100 individual temperature sensors (thermistors) installed in borings throughout the full width and depth of the subsurface treatment zone. Thermistors will also be placed in downgradient monitoring wells and/or ERD injection wells to monitor the off-site flow of heat from the treatment zone. The temperature data will document the rise of the subsurface temperature during the heating phase and identify areas of uneven heating, in which case additional current or other modifications will be directed to those areas. The temperature data will also confirm that the entire thermal treatment area has reached its design temperature (100 degrees C) and stays at this temperature for the predicted period of time necessary to treat the Main Source Area to achieve the soil remediation level.

Additional performance measures include the amount of electricity used (tracked daily) and VOC concentrations at the influent and effluent of the vapor stream being fed to the thermal oxidizer. It is expected that influent concentrations will rise slowly as the subsurface is heated, then rise to a maximum value as the subsurface is at the boiling point, and then drop off quickly as the contaminant source mass is depleted.

6.1.2 Soil Compliance Testing

Soil samples will be collected to assess remedy compliance with the remediation level of 10 mg/kg PCE + TCE. These soil samples will be collected at two stages. The Site, like many sites, is composed of a large volume of soil with relatively low chemical concentrations and a much smaller volume of “hot spot” soil with high chemical concentrations. The hot spot areas contain the bulk of the contaminant mass. Given that the energy needed to vaporize the contaminant mass in areas with low chemical concentrations is less than the energy needed in the higher concentration areas, the lower concentrated areas are expected to come into compliance well before the hot spot areas. Additional heating of these low concentration areas once they are in compliance does not provide any additional benefit, so evaluation of these areas will be conducted mid-way through the heating process to determine the need for continued heating. These intermediate compliance samples will be collected following temporary shutdown of the thermal system, so that steam is not being generated in the subsurface. Areas that are found to be in compliance after this intermediate testing will no longer be heated. The remaining energy will be directed to the higher concentration areas and any sampled areas found to be greater than the remediation level.

A second round of compliance samples will be collected in the remaining heating areas after 100 percent of the predicted total energy demand of 9.7 megawatts has been utilized and the chemical concentrations in the effluent vapor have decreased significantly.

Contingency Actions: If concentrations in soil remain greater than the 10 mg/kg remediation level (PCE + TCE) then an engineering assessment of various options to attain the compliance level will be undertaken. These options may include additional heating, chemical oxidation, installation of additional electrodes, or potential limited excavation. Compliance sampling of these areas will occur following any contingency actions until compliance has been demonstrated within the thermal footprint.

6.1.3 Compliance Testing Scheme

The compliance testing scheme is rigorous and expected to include the following elements:

1. Soil samples will be obtained in each of the five treatment areas by Geoprobe to collect continuous cores. Sample cores will be chilled, spilt open, screened with a photoionization detector (PID), and sampled for analysis from the interval with the highest observed PID reading.
2. Boring locations will be uniformly located within each of the five areas excluding areas within the 1 to 10 mg/kg PCE +TCE contour since these areas are already in compliance with the remediation level.
3. The approximate number of soil borings per zone, sample interval, and number of samples collected for analysis is defined in the table below. For the deep treatment areas, the intermediate zone of soil between elevations 0 to -20 feet will not be sampled because this elevation interval is currently in compliance site-wide.[2]
6. Each zone will be evaluated for compliance with the remediation level separately.

The 95 percent upper confidence level (UCL) of the mean concentration shall be compared to the remediation level to judge compliance.[3]

Treatment Area	Square Footage	Treatment Interval (feet bgs)	Number of Borings	Samples Per Boring	Total
Loading Dock	2,300	0 to 15 feet	5	1 per vadose zone 1 per 1st WBZ 1 per 1ST SH, if present	15
West Rail Siding	4,500	0 to 17 feet	8	1 per vadose zone/1st WBZ 1 per 1ST SH/ 2nd WBZ	16

2 In the event of an elevated PID reading in soil collected from this zone, a sample will be collected and added to the compliance dataset.

3 The determination of the 95 percent UCL shall be in accordance with current Ecology guidance.

Treatment Area	Square Footage	Treatment Interval (feet bgs)	Number of Borings	Samples Per Boring	Total
East Rail/ East Flammables	4,600	0 to 22 feet	8	1 per vadose zone/1st WBZ 1 per 1ST SH/ 2nd WBZ	16
Former Pump House/Flammables Shed	7,500	0 to 65 feet	10	1 per vadose zone/1st WBZ 1 per 1ST SH/ top 2nd WBZ 5 (every 5 feet starting at 45 feet bgs)	70
Production Area/Alkaline Shed	4,400	15 to 65 feet	7	5 (every 5 feet, starting at 45 feet bgs)	35
		TOTAL	**38**		**152**

Note:
The numbers in the above table are approximate. Actual numbers to be determined based on field conditions.

Abbreviations:
bgs Below ground surface
SH Silt Horizon
WBZ Water Bearing Zone

6.2 MAIN SOURCE AREA ENHANCED REDUCTIVE DECHLORINATION

Groundwater quality within the thermal treatment zone will be assessed following thermal shutdown. Based on groundwater data at that time, a plan for ERD substrate injections will be developed. Following the initial substrate injections, performance monitoring will occur to assess the effectiveness of post thermal ERD. The performance monitoring will be similar to that described for the Northwest Corner Plume CAA and ongoing Interim Action. This includes regular measurements (typically semi-annually) of water quality parameters (e.g., dissolved oxygen, reduction-oxidization potential (Eh), pH, and conductivity) from selected injection and monitoring wells and collection of water samples for total organic carbon (to judge substrate levels), VOCs (to judge concentration trends), and the dissolved gases ethane and ethene (the by-products of VC degradation).

The goal of the post-thermal ERD will be to achieve remediation levels for site groundwater in wells along Fox Avenue within 5 years following thermal treatment. If achieved in less than 5 years, then the frequency of injections may be reduced or discontinued. If monitoring indicates rebound of groundwater concentrations, then additional ERD injections will occur for no more than 2 additional years.

Contingency Actions: If following additional ERD injections, monitoring indicates that ground water concentrations continue to exceed the groundwater remediation level of 250 µg/L total CVOCs at the CPOC, contingency actions will be evaluated for implementation. This evaluation is expected to first include an investigation to identify the source of the exceedance. Depending on the magnitude, concentration, and extent of any identified soil source mass, contingency actions such as excavation, Permeable Reactive Barrier (PRB) wall installation, or continued ERD will be considered. For example, if shallow soils are identified, excavation may be considered. If chemical source soils are found to be more extensive, a PRB may be installed downgradient from the area causing the exceedance subject to the location of existing utilities. Should the exceedances be confined to the 2nd WBZ soils, then additional ERD injection wells and/or injection of nano-scale ZVI and/or bacterial inoculation (by adding cultured dechlorinating bacteria) into existing wells may be considered depending on the site-specific conditions.

6.3 DOWNGRADIENT GROUNDWATER PLUME ENHANCED REDUCTIVE DECHLORINATION

The implementation of ERD in the Downgradient Groundwater Plume CAA will include performance monitoring consisting of regular measurements (typically semi-annually) of water quality parameters (e.g., dissolved oxygen, Eh, pH, conductivity) from selected injection and monitoring wells and collection of water samples for total organic carbon (to judge substrate levels), volatile organic compounds (to judge concentration trends), and the dissolved gases ethane and ethene (the by-products of VC degradation).

ERD will be terminated when the groundwater concentrations in the designated monitoring well network are less than or equal to the 250 µg/L total CVOC remediation level. It is expected that ERD injections will be phased out from individual wells and sub-areas over time as sub-areas of the Site come into compliance with the 250 µg/L remediation level for total CVOCs. In the event the seeps in the S. Myrtle Street Embayment are not in compliance with the surface water cleanup levels when the 250 µg/L total CVOC remediation level is achieved, the continued use of ERD to reduce concentrations from the seeps or other contingency actions will be evaluated as follows.

Contingency Actions: Contingency actions will be evaluated if groundwater concentrations in the monitoring well network remain greater than the 250 µg/L remediation level and the continued use of ERD is found to be ineffective. Factors to be considered include the location, magnitude, and scale of the exceedance. Possible contingency actions include the installation of additional ERD wells, use of different ERD substrates, injection of cultured dechlorinating bacteria, and/or injection of nano-scale ZVI.

Contingency actions to be considered if the seeps do not comply with surface water cleanup levels depending upon the magnitude and nature of the exceedance. The first step in evaluating potential contingency actions will be an assessment of the actual (not predicted) concentrations of COCs in shellfish near the seeps, the primary environmental exposure pathway. If actual concentrations are detected in shellfish posing a risk to human health and the environment, then a plan will be developed to identify a range of options for addressing the exposure. This plan may include the use of new science to reexamine current exposure assumptions and cleanup levels, the use of Shellfish Consumption Advisories expected to be in place in the LDW, further investigation to identify and address in-situ the source of the seep exceedance, and/or interception and treatment of the groundwater immediately prior to discharge to the seeps.

It is also possible that in the future the seeps will no longer be present as a result of future restoration projects in the S. Myrtle Street Embayment. Restoration actions may involve cutting back the current steep slope and removal of the concrete debris in the 1st WBZ that is thought to be causing the channelization and seepage of groundwater flow. Should the seeps be permanently lost as part of a habitat restoration, or other redevelopment activity, compliance at the seeps will be measured at the closest upgradient groundwater monitoring well. If this occurs, per WAC 173-340-720(8)(e)(ii), an estimate of the natural attenuation occurring between the monitoring well and the point or points of discharge should be considered when evaluating whether compliance in surface water has been achieved.

6.4 DOWNGRADIENT GROUNDWATER PLUME CLEANUP ACTION AREA MONITORED NATURAL ATTENUATION

Following attainment of the groundwater remediation level in the Downgradient Groundwater Plume wells and attainment of the cleanup levels at the seeps, the Site will transition to monitored natural attenuation. The former ERD injection wells will become monitoring wells. ERD wells will be useful for monitoring as they are screened in deeper portions of the 2^{nd} WBZ, unlike existing monitoring wells.

Performance monitoring will consist of measurements (typically semi-annually) of water quality parameters (e.g., dissolved oxygen, Eh, pH, conductivity) from selected injection and monitoring wells, VOCs (to judge concentration trends), and the dissolved gases ethane and ethene (the by-products of VC degradation).

Measurements of total organic carbon (to assess substrate levels), however, will no longer be necessary. Given the long time frame necessary for monitored natural attenuation to obtain cleanup levels site-wide in groundwater, monitoring will occur on an annual or biannual basis using a select subset of wells in the Downgradient Groundwater Plume CAA. Once all of these wells are in compliance with the cleanup levels, the restoration of the Site will be considered complete.

Contingency Actions: Contingency actions for this portion of the remedy include restarting the ERD process for any areas of the Downgradient Groundwater Plume that show rebound following termination of ERD or remain out of compliance.

6.5 NORTHWEST CORNER PLUME CLEANUP AREA SOIL VAPOR EXTRACTION AND ENHANCED REDUCTIVE DECHLORINATION

6.5.1 Soil Vapor Extraction

Performance monitoring of the SVE system will consist of monthly readings of influent and effluent vapor concentrations to demonstrate removal of solvent mass and compliance with the air discharge permit. Quarterly progress reports will be submitted to Ecology that track the mass of CVOCs extracted from the vadose zone. The SVE system is expected to operate until asymptotic discharge concentrations are reached and sustained for a 2-month period. The system will then be shut down for 1 month and then restarted to monitor rebound. If rebound does not occur, the system will be decommissioned. If rebound does occur, SVE system operation will continue, likely in cycles of on then off, with monitoring for rebound during the off cycles. The results of the SVE pilot test conducted in 2010 indicate that asymptotic conditions may be achieved within 1 year of operation as there is thought to be a limited amount of solvent mass in this area.

6.5.2 Enhanced Reductive Dechlorination

Performance monitoring of ERD will be initiated following the beginning of substrate injections. The monitoring will be similar to what is currently being done for the ERD interim action. This includes regular measurements (typically semi-annually) of water quality parameters (e.g., dissolved oxygen, Eh, pH, conductivity) from injection wells and selected monitoring wells. Samples will also be collected for analysis of total organic carbon (to evaluate substrate levels), VOCs (to evaluate concentration trends), and the dissolved gases ethane and ethene (the by-products of VC degradation).

The frequency of ERD injections will be based upon the rate at which substrate is fermented by the microbes. It is expected that injections will be more frequent in the first year and less frequent in the subsequent years as the aquifer becomes more anaerobic. The VOC concentration trends of the existing monitoring wells located in the parking lot area of the Northwest Corner Plume CAA and downgradient along Fox Avenue will be used to judge the effectiveness of this remedy element. Substrate injections will continue for an expected 5 years or until concentration of total CVOCs along the Fox Avenue wells in this area are in compliance with the groundwater remediation level of 250 µg/L (total CVOCs). Following that, the groundwater in this area will continue to be monitored semiannually until concentrations have stabilized at concentrations less than the remediation level, then the monitoring frequency shall decrease to annual or less frequent, depending on site conditions and Ecology approval.

Contingency Actions: Several contingency actions will be considered for implementation should the 250 µg/L (total CVOCs) remediation level not be reached within the expected 5 years. These include the following:

- Continue ERD injections. This contingency is appropriate if concentrations are on a downward trend and close to the remediation levels.
- Continue SVE system operation. This contingency is appropriate if the operation of the SVE system can be correlated with a decrease in groundwater concentrations, and mass removal is still occurring via SVE.
- Install a PRB wall along Fox Avenue downgradient from those areas of the plume not in compliance with the remediation level. The PRB wall would be similar to that evaluated in the analysis of remedial alternatives for this area. The PRB wall would be designed to treat the chemicals in the 1st WBZ groundwater (as contamination is not present in the 2nd WBZ) without the need for other cleanup actions.

6.6 INDOOR AIR

Monitoring of indoor air quality is a critical component of the remedial action to ensure protectiveness during active remediation, and to identify the need for contingency actions. Indoor air will be monitored at two properties, as described below.

6.6.1 Cascade Columbia Office

Current data indicate indoor air concentrations in the Cascade Columbia office exceed the MTCA Method C cleanup level for PCE and TCE. An interim mitigation measure, which included upgrading the ventilation fan in the men's bathroom with a more powerful motor that is wired to run continuously during the work day, was completed in May 2011. Sampling will be used to evaluate the effectiveness of this interim measure. Additional mitigation measures will be evaluated if the implementation of the exhaust fan does not appear effective; however, the active soil and groundwater remediation will significantly reduce source area concentrations, which will mitigate soil gas and indoor air concentrations.

Compliance with the indoor air cleanup levels will be determined by direct measurement of indoor air inside the Cascade Columbia office during and following completion of thermal and Northwest Corner SVE remediation. In addition to direct sampling of indoor air, measurements of other parameters will be collected including monthly measurements of sub-slab vacuum and VOC concentrations. These data will be used to judge effectiveness of the SVE/thermal vapor collection system. The specific sampling scheme and schedule will be outlined in the EDR. Sampling methodologies are expected to be consistent with the methods implemented in 2009 to assess current conditions. Contaminant concentrations in indoor air will be corrected to account for ambient (background) concentrations of PCE and TCE in accordance with Section 3.2.3 of Ecology's *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Actions*, Draft October 2009 (Ecology 2009) and then directly compared to the MTCA Method C indoor air cleanup levels.

Contingency Action Trigger: Contingency actions to mitigate vapor intrusion for protection of workers at Cascade Columbia will be evaluated if indoor air concentrations exceed MTCA Method C cleanup levels.

6.6.2 Seattle Boiler Works

Current indoor air concentrations at the Seattle Boiler Works facility (Pipe Building) indicate that PCE and TCE exceed the MTCA Method B cleanup levels. In addition, PCE and TCE were also present in an ambient outside air (background) sample at concentrations greater than MTCA Method B cleanup levels. Prior to the beginning of thermal remediation, a comprehensive assessment of indoor air will be performed. This assessment will be used to identify which buildings on Seattle Boiler Works property are currently impacted at levels greater than cleanup levels and by what magnitude. During thermal remediation, measurements of sub-slab VOC concentrations will be collected monthly to monitor concentration trends and judge effectiveness of the remedial action. Groundwater temperature will also be continually monitored. Depending on sub-slab concentration and groundwater temperature trends, re-sampling of indoor air may be necessary followed by contingency actions as described below.. At a minimum, indoor air will be tested at the mid-point of thermal heating and also during the cool down phase. The specific sampling scheme and schedule will be outlined in the EDR. Contaminant concentrations measured in indoor air will be corrected to account for ambient (background) concentrations of PCE and TCE in accordance with Section 3.2.3 of Ecology's draft soil vapor intrusion guidance (Ecology 2009). Access to the Seattle Boiler Works property is required for sample collection.

Contingency Action Trigger: Contingency actions to protect workers will be evaluated if air samples in any occupied Seattle Boiler Works buildings exceed the trigger level. Ecology has determined that modified MTCA Method B indoor air cleanup levels will be applied as the trigger level for contingency actions at Seattle Boiler Works. Modified MTCA Method B levels are allowable under WAC 173-340-705 (2) and in this situation are modified to take into account the current industrial use of the property. While meeting standard MTCA Method B air cleanup levels is necessary to free the property of any future development restrictions, modified MTCA Method B concentrations are protective concentrations for the current industrial site use. Modified MTCA Method B indoor air VOC concentrations, fully protective of the current receptors inside a non-residential building can be calculated by changing the inputs to Equations 750-1 and/or 750-2, as applicable, to better reflect exposures to an adult worker. The resultant protective air levels will be utilized to decide if contingency measures are needed.

The acceptable adjustments to Equation 750-2 are to reduce the worker exposure from the standard 30 years to 15 years (given that the restoration time frame to achieve standard MTCA Method B cleanup levels in indoor at Seattle Boiler Works is 15 years) and to reduce the exposure frequency to reflect worker exposure (i.e., 8 hours per day, for 5 days per week, for 49 weeks per year). This results in the following contingency action trigger levels:

PCE: 3.7 $\mu g/m^3$

TCE: 0.88 $\mu g/m^3$

If, however, the site is converted to residential use, the contingency trigger will be revised downward to the standard MTCA Method B cleanup levels.

6.6.3 Contingency Action Description

At both facilities, the nature of the contingency action will depend on the magnitude of the exceedance, and may include physical modification to ventilation systems, sealing of floors and foundation cracks, or installation of a passive or active building or sub-slab ventilation system. Additionally, localized treatment of soil or groundwater to reduce the source of the vapor intrusion may also be considered. A work plan to implement contingency measures will be prepared and submitted to Ecology within 30 days following verification of any exceedance of the applicable contingency action trigger levels in indoor air as described above.

At the end of active remediation (estimated 10–15 years following thermal treatment), if the standard MTCA Method B indoor air cleanup level is exceeded at Seattle Boiler Works due to the release from the Site, similar contingency actions will be implemented.

6.7 SUMMARY OF REMEDIAL ACTIONS, COMPLIANCE TESTING, AND CONTINGENCIES

The above paragraphs describe details of the compliance testing and contingency actions for each of the CAAs. Table 6.1 presents the information presented in this section in a tabular format that is organized by impacted media (e.g., soil, indoor air, groundwater) and exposure pathways, and also includes summary information on the COCs, the cleanup levels, points of compliance, and restoration time frame.

7.0 References

Booth, D. and L. Herman. 1998. *Duwamish Basin Groundwater Pathways Conceptual Model Report.* Duwamish Industrial Area Hydrogeologic Pathways Project. City of Seattle Office of Economic Development and King County Office of Budget and Strategic Planning. April.

Floyd|Snider. 2011. *Draft Fox Avenue Site Remedial Investigation/Feasibility Study.* Prepared for Fox Avenue Building LLC. 25 February.

Washington State Department of Ecology (Ecology). 2007. *Model Toxics Control Act Statute and Regulation.* Chapter 173-340 WAC. Publication No. 94-06. November.

———. 2009. *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action*. Publication No. 09-09-047. October.

Fox Avenue Site
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Cleanup Action Plan

Tables

Table 2.1
Soil Gas and Indoor Air Sample Results
Seattle Boiler Works and Cascade Columbia

Sample ID	Sample Date	Tetrachloroethene (μg/m^3)	Trichloroethene (μg/m^3)	Sample Location
Indoor Air —Cascade Columbia				
IA-1	3/26/2009	**75**	**1.1**	Inside office, near sink
IA-2	3/26/2009	**53**	**1**	Inside office, men's restroom
IA-3	3/26/2009	**6**	0.52	Inside warehouse breakroom
IA-4	3/26/2009	2.7[1]	0.2	Upstairs, at top of stairwell
Ambient Air—Cascade Columbia				
AA-1	3/26/2009	0.46	<0.18	Ambient outdoor, SW of facility
AA-2	3/26/2009	0.58	<0.17	Ambient outdoor, NE of facility
AA-3	3/26/2009	0.37	<0.18	Ambient outdoor, NW of facility
AA-4	3/26/2009	2	0.37	Ambient indoor, center of warehouse
Soil Vapor—Cascade Columbia				
SV-1	3/26/2009	**47,000**	**1600**	In office, near sink area, sub-slab
SV-2	3/26/2009	**43,000**	**940**	In office, men's restroom, sub-slab
SV-3	3/26/2009	**43,000**	**2000**	In warehouse breakroom, sub-slab
Indoor Air—Seattle Boiler Works [2]				
SBW-IA-SSVB	12/12/2010	**2.9**[3]	**0.24**[2]	SE corner inside Pipe Bldg
SBW-IA-Lunch	12/12/2010	**3.0**[3]	**0.14**[2]	Employee lunch room, inside Pipe Bldg
SBW-IA-Center	12/12/2010	**2.5**[3]	**0.21**[2]	Central area within Pipe Bldg
Ambient Air —Seattle Boiler Works [2]				
SBW-IA-AMB	12/12/2010	**1.5**	**0.20**	Outside, E of Pipe Bldg
Soil Vapor—Seattle Boiler Works [2]				
SVA-A	10/28/2010	**1,600**	**<6.4**	SE corner of Fabrication Shop, sub-slab
SVA-B	10/28/2010	**5,100**	**220**	SE corner of Pipe Bldg, sub-slab
SVA-C	10/28/2010	**1,800**	**120**	NE corner of Pipe Bldg, sub-slab
SVA-D	10/28/2010	**2,800**	**96**	SW corner of Pipe Bldg, sub-slab
Applicable Regulatory Soil Gas Screening and Indoor Air Cleanup Levels				
MTCA Method B		**4.2**	**1**	Soil Gas Screening Level
MTCA Method C		**42**	**10**	Soil Gas Screening Level
MTCA Method B[4]		**0.42**	**0.1**	Unrestricted Use Indoor Air Cleanup Level
MTCA Method C[4]		**4.2**	**1**	Industrial Indoor Air Cleanup level

Notes:

Bold indicates an exceedance of appropriate MTCA standard (refer to Note 1).

1 The average ambient (outside) PCE air concentration was 0.47 μg/m3. The sample results were adjusted to account for background in accordance with Section 3.2.3 of Ecology's Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action,

2 Seattle Boiler Works soil gas and indoor air sampling was performed by URS. Data was presented in a Vapor Intrusion Assessment letter prepared by URS and dated February 2, 2011.

3 Ambient air samples collected at the Seattle Boiler Works facility in October 2010 indicated that ambient (background) PCE and TCE concentrations were above MTCA Method B CULs. Therefore, in accordance with Section 3.2.3 of Ecology's Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, Draft October 2009, concentrations were adjusted to account for background. Sample results will be adjusted to account for background during each sampling event.

4 MTCA Method B CULs are applied to the Seattle Boiler Works property assuming unrestricted future land use and MTCA Method C CULs are applied to industrial use.

Abbreviations:

μg/m^3 Micrograms per cubic meter
CUL Cleanup level
E East
ID Identifier
MTCA Model Toxics Control Act
NE Northeast

Table 3.1
Groundwater Cleanup Levels for Organic Compounds[1]

			Protection of Aquatic Species						Protection of Human Health										
			Federal Standards				Washington		Federal Standards		Washington								
			National Recommended Water Quality[2] Criteria CWA §304		National Toxics Rule[2] 40 CFR 131		Surface Water Quality Standards[2] WAC 173-201A		National Recommended Water Quality Criteria CWA §304	National Toxics Rule 40 CFR 131	MTCA Method B Surface Water WAC 173-340-730	Screening Criterion (Lowest Standard)	Maximum Detected in Groundwater Since Measurements Began			Maximum Detected Since 2007 (Post ChemOx Interim Measures)			Maximum Post-IM Concentration Exceeds Criterion?[5]
Chemical	CAS Number	Unit	Marine Chronic	Fresh Chronic	Marine Chronic	Fresh Chronic	Marine Chronic	Fresh Chronic	Marine (Organism Only)	Marine (Organism Only)	Fish Consumption		Value	Location	Date	Value	Location	Date	
Volatile Organic Compounds																			
Chlorinated Ethenes & Ethanes																			
Tetrachloroethene	127-18-4	µg/L	-	-	-	-	-	-	3.3	8.9	Use Standard	**3.3**	1,900,000	B-12	10/15/1990	64,000	B-46	1/28/2009	**YES**
Trichloroethene	79-01-6	µg/L	-	-	-	-	-	-	30	81	Use Standard	**30**	94,000	B-43	6/29/1993	44,000	GP-42	12/11/2008	**YES**
1,1-Dichloroethene	75-35-4	µg/L	-	-	-	-	-	-	7,100	3.2	Use Standard	**3.2**	810	B-43	6/29/1993	110	R1-IW2	7/23/2009	**YES**
cis-1,2-Dichloroethene	156-59-2	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	75,000	B-47	7/9/1993	50,000	GP-42	12/11/2008	**no**
trans-1,2-Dichloroethene	156-60-5	µg/L	-	-	-	-	-	-	10,000	No data	Use Standard	**10,000**	680	B-58	10/14/1999	240	GP-38	12/8/2008	**no**
Vinyl chloride	75-01-4	µg/L	-	-	-	-	-	-	2.4	530	Use Standard	**2.4**	25,000	B-33A	10/13/1999	15,600	PTM-2U	8/9/2007	**YES**
1,1,1-Trichloroethane	71-55-6	µg/L	-	-	-	-	-	-	-	-	930,000	**930,000**	18,000	B-31	9/15/1992	1,400	B-30	1/27/2009	**no**
1,1-Dichloroethane	75-34-3	µg/L	-	-	-	-	-	-	-	-		**No Tox Data**	2,500	B-08	9/28/1990	130	GP-38	12/8/2008	**no**
1,2-Dichloroethane	107-06-2	µg/L	-	-	-	-	-	-	37	99	Use Standard	**37**	300	B-10/10A	10/15/1990	29	GP-102	10/26/2010	**no**
Other Volatile Organic Compounds																			
1,2-Dichlorobenzene	95-50-1	µg/L	-	-	-	-	-	-	1,300	17,000	Use Standard	**1,300**	1,000	B-42	11/3/1998	400	B-47	1/29/2009	**no**
1,3-Dichlorobenzene	541-73-1	µg/L	-	-	-	-	-	-	960	2,600	Use Standard	**960**	91	B-29	5/6/1992	14	B-39	10/20/2010	**no**
1,4-Dichlorobenzene	106-46-7	µg/L	-	-	-	-	-	-	190	2,600	Use Standard	**190**	290	B-42	11/3/1998	58	B-39	10/20/2010	**no**
Acetone	67-64-1	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	30,000	B-30	9/17/1992	Not Measured			**no**
Chloroform	67-66-3	µg/L	-	-	-	-	-	-	470	470	Use Standard	**470**	13,000	B-07	10/8/1990	24	B-60	2/16/2010	**no**
Methyl ethyl ketone	78-93-3	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	170,000	B-15	4/29/1992	Not Measured			**no**
Methyl isobutyl ketone	108-10-1	µg/L	-	-	-	-	-	-	0	-	-	**No Tox Data**	12,000	B-30	9/17/1992	Not Measured			**no**
Methylene chloride	75-09-2	µg/L							590	1,600	Use Standard	**590**	43,000	B-08	9/28/1990	Non Detect			**no**
Total Petroleum Hydrocarbons, Benzene, Toluene, Ethylbenzene, Xylene & Alkylated Benzenes																			
Total Petroleum Hydrocarbons[2]																			
TPH-Mineral Spirits Range		µg/L	-	-	-	-	-	-	-	-	800	**800**	230,000	B-12	10/15/1990	6,400	B-30	1/29/2010	**YES**
TPH-Diesel Range		µg/L	-	-	-	-	-	-	-	-	500	**500**	5,000	B-30	9/17/1992	360	B-30	1/29/2010	**no**
TPH-Heavy Oil		µg/L	-	-	-	-	-	-	-	-	500	**500**	1,100	B-30	1/29/2010	1,100	B-30	1/29/2010	**YES, at 1 well**
Benzene, Toluene, Ethylbenzene, Xylene																			
Benzene	71-43-2	µg/L	-	-	-	-	-	-	51	71	Use Standard	**51**	53,000	B-49	10/25/1995	64	GP-26	12/1/2008	**YES**
Toluene	108-88-3	µg/L	-	-	-	-	-	-	15,000	200,000	Use Standard	**15,000**	1,500	B-30	9/17/1992	3,100	GP-38	12/8/2008	**no**
Ethylbenzene	100-41-4	µg/L	-	-	-	-	-	-	2,100	29,000	Use Standard	**2,100**	4,500	B-07	10/8/1990	1,000	MW-10	1/26/2009	**no**
Xylene (total)	1330-20-7	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	14,000	B-07	10/8/1990	920	GP-38	12/8/2008	**no**
Xylene (meta & para)		µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	5,300	B-47	6/22/1998	Not Measured			**no**
Xylene (ortho)	95-47-6	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	2,500	B-49	11/3/1998	Not Measured			**no**
Alkylated Benzenes																			
1,2,4-Trimethylbenzene	95-63-6	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	11,000	B-49	10/18/1999	Not Measured			**no**
1,3,5-Trimethylbenzene	108-67-8	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	9,600	B-49	10/18/1999	Not Measured			**no**
Styrene	100-42-5	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	1,800	B-49	11/3/1998	Not Measured			**no**
n-Propylbenzene	103-65-1	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	2,200	B-49	10/18/1999	Not Measured			**no**
iso-Propylbenzene	98-82-8	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	100	Multiple[3]	Multiple[3]	Not Measured			**no**
sec-Butylbenzene	135-98-8	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	2,300	B-49	10/18/1999	Not Measured			**no**
Semivolatile Organic Compounds																			
High Molecular Weight Polycyclic Aromatic Hydrocarbons																			
Benzofluoranthenes (total)	56832-73-6	µg/L										**No Tox Data**	2	B-12	12/19/1997	Not Measured			**no**
Pyrene	129-00-0	µg/L	-	-	-	-	-	-	4,000	11,000	Use Standard	**4,000**	23	B-12	6/29/1998	Not Measured			**no**
Low Molecular Weight Polycyclic Aromatic Hydrocarbons																			
2-Methylnaphthalene	91-57-6	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	130	B-10A	10/25/1995	Not Measured			**no**
Acenaphthene	83-32-9	µg/L	-	-	-	-	-	-	990	-	Use Standard	**990**	17	B-12	6/29/1998	Not Measured			**no**
Fluorene	86-73-7	µg/L	-	-	-	-	-	-	5,300	14,000	Use Standard	**5,300**	32	B-49	7/9/1993	Not Measured			**no**
Naphthalene	91-20-3	µg/L	-	-	-	-	-	-	-	-	4,900	**4,900**	6,700	B-44	6/22/1998	Non Detect			**no**
Phenanthrene	85-01-8	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	46	B-12	6/29/1998	Not Measured			**no**
Phthalates																			
bis(2-ethylhexyl)phthalate	117-81-7	µg/L	-	-	-	-	-	-	2.2	5.9	Use Standard	**2.2**	1,900	B-30	10/25/1995	Not Measured			**YES (old data)**
Butyl benzyl phthalate	85-68-7	µg/L	-	-	-	-	-	-	1,900	No data	Use Standard	**1,900**	400	B-27	9/3/1992	Not Measured			**no**
Diethylphthalate	84-66-2	µg/L	-	-	-	-	-	-	44,000	120,000	Use Standard	**44,000**	27	B-30	10/25/1995	Not Measured			**no**
Di-n-butyl phthalate	84-74-2	µg/L	-	-	-	-	-	-	4,500	12,000	Use Standard	**4,500**	880	B-30	9/17/1992	Not Measured			**no**
Chlorinated Phenols																			
Pentachlorophenol	87-86-5	µg/L	7.9	15.0	7.9	13.0	7.9	12.8	3.0	8.2	Use Standard	**3.0**	31,000	B-38	9/14/1992	116	B-49	8/6/2007	**YES**
2,4,5-Trichlorophenol	95-95-4	µg/L	-	-	-	-	-	-	3,600	-	Use Standard	**3,600**	5.1	B-20	10/21/1998	Not Measured			**no**
Tetrachlorophenols (total)	58-90-2	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	600	B-31	5/4/1992	Not Measured			**no**

Table 3.1
Groundwater Cleanup Levels for Organic Compounds[1]

			Protection of Aquatic Species						Protection of Human Health										
			Federal Standards				Washington		Federal Standards		Washington								
			National Recommended Water Quality[2] Criteria CWA §304		National Toxics Rule[2] 40 CFR 131		Surface Water Quality Standards[2] WAC 173-201A		National Recommended Water Quality Criteria CWA §304	National Toxics Rule 40 CFR 131	MTCA Method B Surface Water WAC 173-340-730	Screening Criterion (Lowest Standard)	Maximum Detected in Groundwater Since Measurements Began			Maximum Detected Since 2007 (Post ChemOx Interim Measures)			Maximum Post-IM Concentration Exceeds Criterion?[5]
Chemical	CAS Number	Unit	Marine Chronic	Fresh Chronic	Marine Chronic	Fresh Chronic	Marine Chronic	Fresh Chronic	Marine (Organism Only)	Marine (Organism Only)	Fish Consumption		Value	Location	Date	Value	Location	Date	
Other Semivolatile Organic Compounds																			
2,4-Dimethylphenol	105-67-9	µg/L	-	-	-	-	-	-	850	No Data	Use Standard	**850**	500	B-29	5/6/1992	Not Measured			**no**
2-Methylphenol	95-48-7	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	750	B-29	5/6/1992	Not Measured			**no**
3-Methylphenol	108-37-4	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	130	B-12	12/19/1997	Not Measured			**no**
4-Methylphenol	106-44-5	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	650	B-39	10/25/1995	Not Measured			**no**
Benzoic acid	65-85-0	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	1,700	B-39	8/13/1993	Not Measured			**no**
Benzyl alcohol	100-51-6	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	260	B-12	9/17/1992	Not Measured			**no**
Carbazole	86-74-8	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	23	B-49	7/9/1993	Not Measured			**no**
Dibenzofuran	132-64-9	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	24	B-49	7/9/1993	Not Measured			**no**
Phenol	108-95-2	µg/L	-	-	-	-	-	-	1,700,000	4,600,000	Use Standard	**1,700,000**	140	B-27	7/9/1993	Not Measured			**no**
Glycols & Alcohols																			
Glycols																			
Ethylene glycol	107-21-1	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	22,000	B-15	4/29/1992	Not Measured			**no**
Diethylene glycol	111-46-6	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	8,100	B-33A	9/21/1992	Not Measured			**no**
Alcohol																			
Methanol	67-56-1	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	72,000	B-30	9/17/1992	Not Measured			**no**
Ethanol	64-17-5	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	30,000	B-11	9/15/1992	Not Measured			**no**
iso-Propanol	67-63-0	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	23,000	B-30	9/17/1992	Not Measured			**no**
1-Propanol	71-23-8	µg/L	-	-	-	-	-	-	-	-	-	**No Tox Data**	6,700	B-11	9/15/1992	Not Measured			**no**

Notes:

1 The 2007–2010 maximum concentration is compared to the lowest screening criteria or background.
2 Criteria Chronic Concentration used unless otherwise noted.
3 No surface water criteria are available for the TPH fractions; therefore MTCA Method A values for groundwater have been used as surrogates.
4 Well B-47 (6/22/1998), Wells B-18, WH-10, WH-11, WH-12, and WH-8 (8/11/10).

Abbreviations:

CFR Code of Federal Regulations
CWA Clean Water Act
IM Interim measure
MTCA Model Toxics Cleanup Act
TPH Total petroleum hydrocarbons
WAC Washington Administrative Code

Table 3.2
Groundwater Cleanup Levels for Metals

Chemical	CAS Number	Unit	Lower Duwamish Corridor Groundwater Metals Background	Protection of Aquatic Species						Protection of Human Health			Screening Criterion (Lowest Standard Corrected for Background)	Maximum Detected in Groundwater Since Measurements Began			Maximum Detected Since 2007 (Post ChemOx Interim Measures)			Maximum Post-IM Concentration Exceeds Criterion?[4]
				Federal Standards				Washington Standards		Federal Standards		Washington								
				National Recommended Water Quality[1] Criteria CWA §304		National Toxics Rule[1] 40 CFR 131		Surface Water Quality Standards[1] WAC 173-201A		National Recommended Water Quality[1] Criteria CWA §304	National Toxics Rule[1] 40 CFR 131	MTCA Method B Surface Water[1] WAC 173-340-730								
				Marine Chronic	Fresh Chronic	Marine Chronic	Fresh Chronic	Marine Chronic	Fresh Chronic	Fish Consumption	Fish Consumption	Fish Consumption		Value	Location	Date	Value	Location	Date	
Antimony	7440-36-0	µg/L		-	-	-	-	-	-	640	4,300	Use Standard	**640**	3.0	B-34	1/26/2009	3.0	B-34	1/26/2009	No
Arsenic	7440-38-2	µg/L	8.0	36	150	36	190	36	190	0.14	0.14	Use Standard	**8**	8.8	B-15	9/14/1992	5.0	B-59	1/27/2009	No
Barium	7440-39-3	µg/L		-	-	-	-	-	-	-	-	No tox data	**No data**	80	B-29	5/6/1992	Not Measured			-
Beryllium	7440-41-7	µg/L		-	-	-	-	-	-	-	-	270	**270**	7.0	B-33A	1/26/2009	7.0	B-33A	1/26/2009	No
Cadmium	7440-43-9	µg/L		8.8	0.25	9.3	1	9.3	0.37	-	-	20	**0.25**	0.50	B-19	5/5/1992	Not Detected at 0.4 µg/L			No
Chromium	7440-47-3	µg/L		-	-	-	-	-	-	-	-	No tox data	**No data**	41	B-34	1/26/2009	41	B-34	1/26/2009	No
Copper	7440-50-8	µg/L	8.0	3.1	9	2.4	11	3.1	3.5	-	-	2,700	**8.0**	55	B-34	1/26/2009	55	B-34	1/26/2009	**YES**
Molybdenum	7439-98-7	µg/L		-	-	-	-	-	-	-	-	No tox data	**No data**	98	B-34	1/26/2009	98	B-34	1/26/2009	No
Nickel	7440-02-0	µg/L		8.2	52	8.2	160	8.2	49	4,600	4,600	Use Standard	**8.2**	90	B-15	9/14/1992	21	B-34	1/26/2009	**YES**
Selenium	7782-49-2	µg/L		71	5	71	5	71	5	4,200	-	Use Standard	**5.0**	4.0	B-33A	1/26/2009	4.0	B-33A	1/26/2009	No
Silver	7440-22-4	µg/L		-	-	-	-	-	-	-	-	26,000	**26,000**	0.40	B-65,B-60	1/26–27/2009	0.40	B-65,B-60	1/26–27/2009	No
Zinc	7440-66-6	µg/L		81	120	81	100	81	32	26,000	No data	Use Standard	**32**	110	B-15	9/14/1992	23	B-65	1/26/2009	No

Notes:

1 Criteria Chronic Concentration used unless otherwise noted.
2 Wells B-18, WH-10, WH-11, WH-12, and WH-8.
3 Well B-47 (6/22/1998), Wells B-18, WH-10, WH-11, WH-12, and WH-8 (8/11/10).
4 The 2007–2010 maximum concentration is compared to the lowest screening criteria or background.

Abbreviations:

CFR Code of Federal Regulations
CWA Clean Water Act
IM Interim measure
MTCA Model Toxics Cleanup Act
WAC Washington Administrative Code

Table 4.1
Preliminary Screening of Technologies

Remedial Technology	Media	Benefits	Constraints	Site-specific Considerations	Technology Retained/Rejected for Further Evaluation
No Action	• Soil • Groundwater	• No cost to implement. • No long-term monitoring cost. • Does not cause significant impacts to site operations.	• Does not reduce or remove chemical concentrations. • Does not protect human health and the environment. • Does not meet cleanup goals in a reasonable restoration time frame.	• Does not meet RAOs or minimum threshold requirements of the Model Toxics Control Act.	• **No Action is Rejected** as it does not meet RAOs.
Monitored Natural Attenuation	• Groundwater	• Low cost associated with implementation. • Does not cause impacts to site operations.	• Long-term monitoring required in perpetuity. • Does not increase rate of contaminant mass removal occurring through reductive dechlorination. • Does not control chemical migration.	• Chemicals in groundwater have migrated off-site. • Existing impacts to surface water (Duwamish River) will not be addressed by MNA.	• **Monitored Natural Attenuation is Retained** for application in combination with other more aggressive technologies, and as a baseline for comparison of other technologies, but as a stand-alone remedy, does not address RAOs, or achieve cleanup goals.
Permeable Reactive Barrier Wall	• Groundwater	• Passively treats contaminated groundwater as it passes through the reactive barrier area. • Can be straightforward to implement, except at significant depths. • Is relatively inexpensive to implement at shallow depths and does not cause significant disruption to site operations.	• PRB technology does not address cleanup of contaminated soil. • PRB can become "clogged" depending on migration of fines in groundwater and can be costly to maintain. • Depending on the concentrations in groundwater, the PRB may require replacement once the reaction capacity of the material in the wall is reached or the wall pores become clogged. • PRB does not address contamination that has already migrated past the point of treatment.	• Site conditions would require construction of a deep and wide PRB wall to capture all site groundwater exiting the source area. • Groundwater may require further downgradient treatment (ERD) to meet remediation objectives, and address contamination that has migrated off-site.	• **Permeable Reactive Barrier Wall is Retained** for further evaluation for shallow 1st WBZ groundwater, assuming design criteria for treatment of contamination does not make construction of the wall infeasible.
Low Permeability Barrier Wall	• Groundwater	• Attains RAOs by containing soil and groundwater contaminants, and restricting continued migration of contaminated groundwater.	• Is relatively costly to implement. • May impact site operations, or require relocation of existing operations and/or utilities. • Requires hydraulic control (pumping) inside the barrier wall to maintain an inward gradient of groundwater in perpetuity.	• Groundwater contamination has already migrated downgradient, so any containment wall installed would not fully encapsulate all contamination at the Site. • Site use and the location of multiple utilities surrounding the Site would complicate installation, and may require utility relocation or replacement. • Additional treatment technologies would be required to address the downgradient groundwater plume. • Site geology does not allow for complete isolation of COCs; hanging wall structure would be constructed and issues with groundwater migration would need to be addressed. • Pumping to maintain hydraulic control and an inward groundwater gradient would generate large volumes of contaminated groundwater requiring treatment and disposal in perpetuity.	• **Barrier Wall technology is Retained** for further evaluation as the only feasible containment technology proposed, assuming construction of a hanging wall system is feasible, and hydraulic control is obtainable.
Surface Capping	• Soil	• Contains contaminated soil below the ground surface and provides protective barrier from surface water infiltration.	• Chemicals remain in place and are not removed/destroyed. • Surface Cap maintenance required in perpetuity.	• The Site is currently nearly 100 percent paved or covered by existing structures.	• Surface Cap technology is Retained for further evaluation.

Table 4.1
Preliminary Screening of Technologies

Remedial Technology	Media	Benefits	Constraints	Site-specific Considerations	Technology Retained/Rejected for Further Evaluation
Pump and Treat	• Groundwater	• Removes dissolved-phase chemicals from groundwater. • Technology will result in minimal impacts to site operations.	• Does not treat soil source contamination. • High groundwater pumping rates may be required resulting in high volumes of groundwater for treatment and disposal. • Significant cost associated with treatment and discharge of treated waste stream. • Long-term operation and maintenance required for extraction system in perpetuity.	• A high volume of mass present in soil will not be addressed by this technology alone. • The groundwater plume footprint is expansive at this Site, and treatment of the entire plume area would generate large volumes of water.	• **Pump and Treat is Rejected** from further evaluation because the technology is not effective at treating soil source, the volume of water extracted across the entire groundwater plume would be substantial, is expensive to treat and dispose, and this technology does not meet the RAOs.
Thermal Treatment	• Soil • Groundwater	• Capable of removal of majority of CEA contaminant mass within treatment area. • Can be implemented in 1–2 years. • Proven effective at sites with similar conditions. • Can be implemented at depth. • Treats both soil and groundwater contamination simultaneously. • No long-term maintenance required.	• High cost associated with implementation. • Does not treat pentachlorophenol or metals contamination, or heavy end mineral spirits. • Polishing with another remedial technology may be required following thermal treatment to further reduce chemical concentrations to achieve cleanup goals.	• Requires temporary relocation of some site activities (i.e., flammables storage and rail loading/unloading over heated area). • Installation complicated by active facility.	• **Thermal Treatment is Retained** for further evaluation. Technology has been proven effective at sites with similar conditions and COCs.
Excavation and Landfill Disposal	• Soil	• Results in immediate removal of chemicals from the Site, reducing mass in a short time frame. • Effectively removes all COCs associated with soil contamination. • Does not require long-term moni-toring and maintenance.	• Expensive to implement due to high landfill disposal costs of hazardous materials. • Technology is limited by contaminant depth. • May require shoring for stability if open cuts cannot be made. • Can present short-term risk to workers via exposure to contaminated soil, groundwater, and DNAPLs. • Technology does not address remediation of groundwater beyond the excavation area.	• Large percentage of contaminant source area is located beneath active facility buildings and active rail spurs. • Technology requires destruction and relocation of all operational areas where it will be implemented. • Site structures will require removal/replacement for access to source area contamination. • Shoring and building support will be required for excavations near structures left in place.	• **Excavation and Landfill Disposal is Rejected** because the majority of shallow source soils are located beneath buildings and are inaccessible. Excavation of limited areas would still require implementation of other remedial actions for the remainder of the soil and groundwater plume, and excavation of these limited areas would not improve the environmental benefit of applying other technologies site wide. Excavation is also infeasible for removal of deep soil contamination.
Soil Vapor Extraction	• Soil	• Can be implemented with limited disturbance to existing facilities. • System can be easily turned on and off to optimize performance and cost.	• Limited to treatment of vadose zone soils. • Relatively expensive to install and maintain. • Does not address groundwater contamination.	• The majority of the Site contains contamina-tion that is below groundwater and unaffected by this technology. • SVE may be applicable in areas where low to moderate amounts of vadose zone contamination is present, such as the NW Corner plume. • Site also contains soil and groundwater contamination that cannot be addressed by SVE.	• **Soil Vapor Extraction is Retained** for site areas with shallow, vadose zone soil contamination only that have not yet been subject to SVE and where SVE may be used in conjunction with other technologies for remediation of the Site.

Table 4.1
Preliminary Screening of Technologies

Remedial Technology	Media	Benefits	Constraints	Site-specific Considerations	Technology Retained/Rejected for Further Evaluation
Chemical Oxidation / Permanganate Injection	• Soil • Groundwater	• Technology reduces chemical concentrations and mass in place. • Low cost associated with implementation (i.e., no landfill disposal fees). • Technology does not cause significant impacts to site operations.	• Technology does not treat all soil—injected solutions can follow preferential pathways. • Effectiveness limited by subsurface conditions and site heterogeneity. • Requires multiple rounds of injection. • Contaminant rebound may be observed when source concentrations and volume are elevated and insufficient source treatment has occurred.	• Chemical Oxidation as been implemented unsuccessfully at the Site in the past and did not reduce chemical concentrations to acceptable levels.	• **Chemical Oxidation is Rejected** from further evaluation because the technology has been applied at the Site in the past and did not result in measurable reduction of chemical concentrations/mass.
Soil Flushing	• Soil	• In-situ technology that can be implemented with minimal disturbance to existing operations.	• Requires injection of large volumes of water and surfactant to release soil contamination into groundwater. • Requires downgradient capture via pumping and treatment of impacted water. • High risk associated with capturing all downgradient groundwater/surfactant to insure chemicals are not mobilized, then transported downgradient. • Technology is expensive to implement due to requirement for pumping and treatment of water.	• Depth of contamination at this Site will require significant volumes of water to be pumped for flushing treatment. • Subsurface conditions are not supportive of a downgradient groundwater capture system due to depth and wide extent of contamination. • High risk associated with inability to capture downgradient groundwater due to the Site's location relative to a surface water body.	• **Soil Flushing is Rejected** from further evaluation because of the significant level of pumping and treatment that would be required (resulting in excessive waste streams and difficulty of flushing chemicals from siltier soil lenses), and the risk associated with capture of all downgradient groundwater.
Soil Mixing by Auger	• Soil	• Technology promotes in-situ destruction of contaminant mass by addition of zero-valent iron or oxidants directly to contaminated soil brought up by augers. • Can reach soil contamination at depth.	• Technology will require destruction and relocation of facility operations during implementation. • Technology results in generation of excess contaminated soil that must be disposed of in a landfill facility. • Disposal of contaminated material at a landfill facility can result in significant cost. • Wedges of contaminated material may be left in place between auger locations, depending on the degree of overlap of locations.	• Site operations will be difficult to relocate to accommodate full implementation of this remedy. • Depth of contamination will result in generation of significant volumes of contaminated soil requiring landfill disposal.	• **Deep Soil Mixing is Rejected** from further evaluation because of the impracticability of relocating site facilities and disposing of contaminated soil. Deep soil mixing would also likely not be effective in meeting site RAOs.
Dual-phase Extraction	• Soil • Groundwater	• Removes contamination from vadose zone soil and shallow groundwater. • Technology is moderate in cost to implement. • Technology is capable of treating source soils together with groundwater at shallow depth.	• Implementation results in extraction of contaminated groundwater that requires treatment prior to disposal. • Cost of treatment and disposal of extracted water can be significant. • Technology typically has high maintenance costs. • Technology cannot treat source at deeper intervals in primary source area.	• Technology will not be beneficial for treatment of the primary source area because contamination extends to depths greater than 20 feet below ground surface. Significant water volumes would be generated and require treatment if this technology was selected for implementation.	• **Dual Phase Extraction is Rejected** from further evaluation because this technology is not applicable to DNAPL contamination and would only be applicable in very limited areas of the Site for vadose soil treatment only.

Table 4.1
Preliminary Screening of Technologies

Remedial Technology	Media	Benefits	Constraints	Site-specific Considerations	Technology Retained/Rejected for Further Evaluation
Enhanced Reductive Dechlorination	• Soil • Groundwater	• Technology will result in minimal impacts to site operations. • Technology is comparatively inexpensive to implement. • ERD can serve as a long-term treatment technology when used in combination with other aggressive source control remedial technologies. • Technology is an effective treat-ment mechanism for groundwater contamination.	• The effectiveness of ERD for treatment of soils with DNAPL-level concentra-tions is unknown, but not expected to be effective in a reasonable restoration time frame. • Technology takes a long period of time to meet remediation levels or cleanup levels when used as a stand-alone technology. • Technology is still in the development stage.	• ERD is currently being implemented for treatment of downgradient groundwater at the Site, and data indicates accelerated destruction of dissolved plume contamination is occurring.	• **ERD is Retained** for further evaluation because current implementation suggests ERD is effectively reducing chemical concentrations at the Site in downgradient groundwater.
Air Sparging	• Groundwater	• Removes dissolved-phase chemicals from groundwater. • Strips dissolved-phase chemicals from groundwater and transmits to vadose soil. • Relatively low cost to implement technology.	• Technology has limited benefit in areas with elevated groundwater contamination concentrations. • Implementation does not result in destruction of contamination. • Significant reductions in contamination concentration may be difficult to achieve. • Air sparge points typically have a small radius of influence, requiring a large network of wells to implement.	• Technology is not efficient at treating to the depths of contamination at the Site. • Technology may be applicable in limited applications such as a point of discharge treatment option in shallow groundwater. • Technology adds oxygen to subsurface so does not work well with ERD.	• **Air Sparging is Retained** for further evaluation as a point of discharge treatment in a curtain or wall type scenario for 1st WBZ groundwater only.

Abbreviations:

COC	Chemical of concern
CVOC	Chlorinated volatile organic compound
DNAPL	Dense non-aqueous phase liquid
ERD	Enhanced reductive dechlorination
LNAPL	Light non-aqueous phase liquids
MNA	Monitored Natural Attenuation
PRB	Permeable reactive barrier
RAO	Remedial Action Objective
SVE	Soil vapor extraction
WBZ	Water Bearing Zone

Table 4.2
Summary of Retained Technologies by Cleanup Action Area

Remedial Technology	Main Source Area	Downgradient Groundwater Plume	Northwest Corner Plume
Monitored Natural Attenuation *(retained for baseline comparison)*	X	X	X
Permeable Reactive Barrier Wall		X	X
Low Permeability Barrier Wall	X		
Surface Capping	X		
Thermal Treatment	X		
Soil Vapor Extraction	X		X
Enhanced Reductive Dechlorination	X	X	X
Air Sparging		X	X

Table 6.1
Summary of Cleanup Action Compliance Testing and Contingencies by Media

Impacted Media	Pathway/Exposure	Primary Chemicals of Concern	Proposed Media Cleanup Level	Proposed Point of Compliance	Compliance Measured By	Remediation By	Remediation Level	Expected Restoration Time Frame	Contingency Action[1,2]
Air	Inhalation	PCE, TCE	MTCA Method C Air: Cascade Columbia Standard MTCA Method B Air[3]: Seattle Boiler Works	Site-wide indoor air at Cascade Columbia and Seattle Boiler Works	Direct sampling of indoor air at each facility[4]	Thermal and post-thermal ERD in Main Source Area and Downgradient Plume	None, thermal and ERD expected to result in achievement of applicable cleanup levels in air	Cascade Columbia: 1 year—using thermal to meet MTCA Method C Seattle Boiler Works: 10–15 years of post-thermal ERD to meet Standard MTCA Method B	Sealing of floor cracks, upgraded passive or active building or sub-slab ventilation; further treatment of soil or groundwater sources. Refer to Notes 3 and 4 for contingency action trigger levels.
Soil	Direct contact by ingestion, industrial worker	PCE	MTCA Method C Ingestion (240 mg/kg)	Upper 15 feet site-wide	Sampling in source areas following thermal	Thermal in Main Source Area	None needed, the thermal remediation level is less than the direct contact cleanup level	1 year—thermal	Capping, institutional controls.
	Cross Media: Soil vapor in contaminated vadose zone soils causing vapor intrusion to indoor air for industrial worker at Cascade Columbia	PCE, TCE	Empirical demonstration (i.e., no numeric value) that indoor air is in compliance with MTCA Method C levels	Indoor air at Cascade Columbia	Compliance in indoor air empirically demonstrates vadose zone soil concentrations are protective site-wide	Thermal in Main Source Area	None needed, indoor air expected to achieve cleanup level using thermal to remediate source soils	1 year—thermal	Cascade Columbia: Upgraded ventilation.
	Cross Media: Soil leaching to groundwater	PCE, TCE, DCE, TPH	Empirical demonstration (i.e., no numeric value) by testing groundwater for chemicals of concern at POC	Groundwater at Fox Avenue	Compliance in groundwater empirically demonstrates soil concentrations throughout the aquifer are protective	**Source Area:** Thermal followed by ERD then MNA **Downgradient:** ERD followed by MNA	**Soil RL for Thermal:** Average soil concentration in each thermal zone of 10 mg/kg PCE +TCE **Post Thermal and ERD Groundwater RL:** < 250 µg/L total CEAs	**Soil RL:** 1 year—thermal **Groundwater RL:** 10–15 years of post-thermal ERD	Continued ERD in Main Source Area, and/or 1st WBZ PRB wall in localized areas of groundwater remediation level exceedance.
Surface Water	Aquatic species AND human health through the consumption of contaminated fish/shellfish	PCE, TCE, VC	Lowest of federal/state surface water ARARs	Surface water column	None planned at this time	None planned at this time	None, surface water currently meets cleanup level	S. Myrtle Street Embayment surface water already in compliance	None needed.
Groundwater	Direct ingestion, drinking water (NOT APPLICABLE)	The groundwater at this Site is considered non-potable and its maximum beneficial use is discharge into a tidal estuary, which is also non-potable (refer to RI/FS text for details).							
	Cross Media: Groundwater causing vapor intrusion—inhalation	PCE, TCE	Empirical demonstration (i.e., no numeric value) that indoor air is in compliance with proposed indoor air CULs	Indoor air at Cascade Columbia Facility and Seattle Boiler Works	Compliance in indoor air at both facilities demonstrates that 1st WBZ groundwater is in compliance site-wide	Thermal followed by ERD then MNA	**Post Thermal/ERD Groundwater RL:** Less than 250 µg/L (total CEAs) at Fox Avenue and in downgradient wells	10–15 years of post-thermal ERD	Continued ERD in downgradient plume in localized plume hot spot areas that may be contributing to vapor intrusion.

Table 6.1
Summary of Cleanup Action Compliance Testing and Contingencies by Media

Impacted Media	Pathway/Exposure	Primary Chemicals of Concern	Proposed Media Cleanup Level	Proposed Point of Compliance	Compliance Measured By	Remediation By	Remediation Level	Expected Restoration Time Frame	Contingency Action[3,4]
Groundwater	**Cross Media:** Groundwater discharges to surface water via seeps into the S. Myrtle Street Embayment—POC at the seeps	PCE, TCE, VC	Lowest of federal/ state surface water ARARs	**Seeps:** Location of groundwater discharge into Lower Duwamish Waterway	Seeps	Thermal followed by ERD then MNA	None, groundwater will meet surface water CUL at seeps	15 years to reach CULs in seeps	Re-evaluation of potential exposure pathway that assumes bioconcentration in fish/shellfish (i.e., new science, clam survey/testing, impact of fishing restriction, etc.).
Groundwater	**Cross Media:** Groundwater discharges to surface water into the S. Myrtle Street Embayment conditional POC at Fox Avenue	PCE, TCE, VC, DCE, TPH (as mineral spirits), Penta	Lowest of federal/ state surface water ARARs, MTCA Method A for TPH (as mineral spirits)	Conditional POC at Fox Avenue	Groundwater samples from monitoring wells along the west side of Fox Avenue and on Seattle Boiler Works property	Thermal followed by ERD then MNA	**Post Thermal/ERD Groundwater RL:** Less than 250 µg/L (total CEAs) at Fox Avenue and Downgradient Groundwater Plume wells	10 years to reach RLs at Fox Avenue and Downgradient Groundwater Plume wells Approximately 50 years to meet CULs at Fox Avenue and Downgradient Groundwater Plume wells	Continued ERD in downgradient plume in localized areas of groundwater RL exceedance. Both the groundwater RL and the approximate 50-year restoration time frame to reach CULs result in no unacceptable risk and/or exposure.

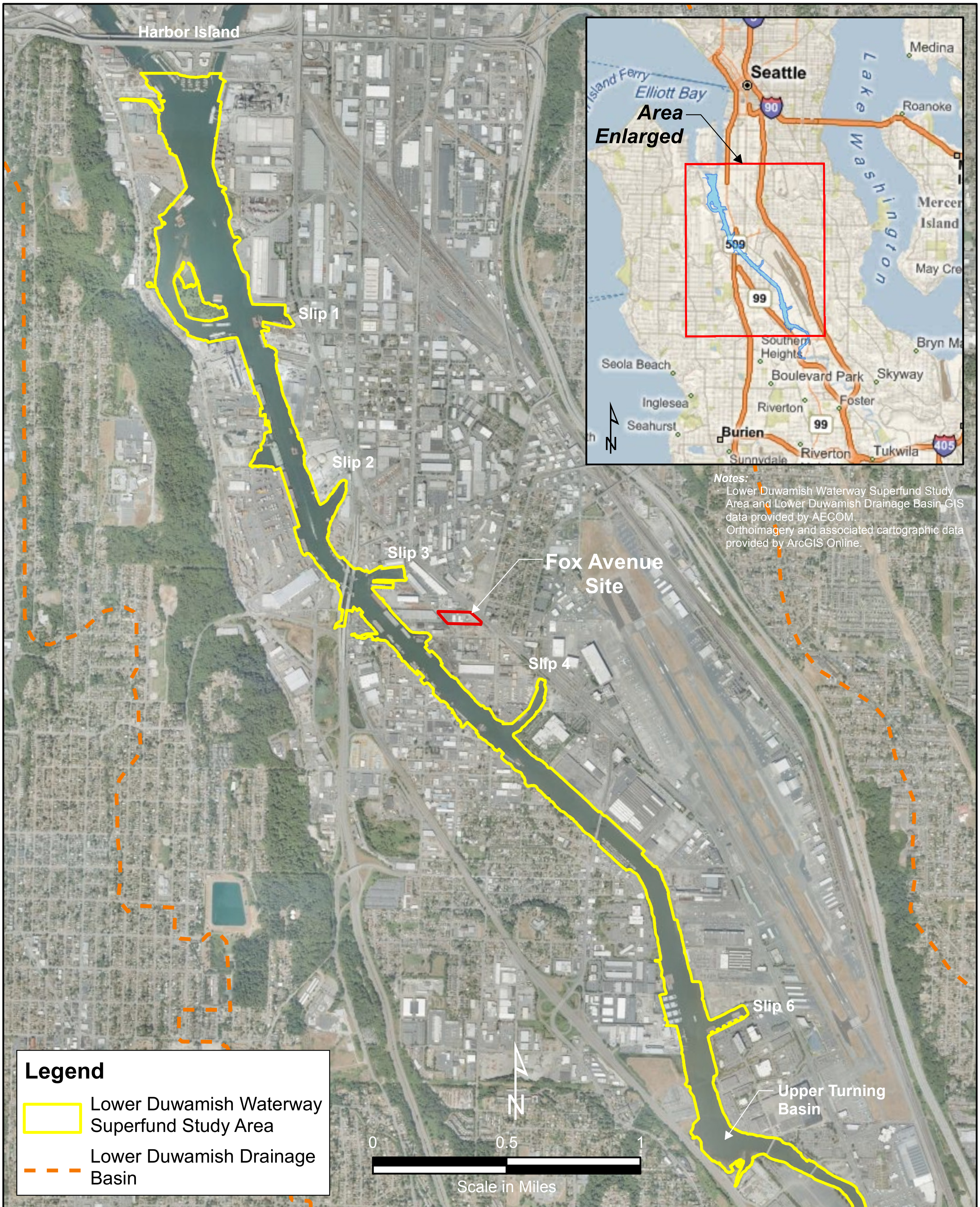
Notes:
1 If indoor air levels are found to exceed MTCA Method C at the Cascade Columbia property, then contingency measures as described in Section 6.6 of this document will be evaluated and implemented.
2 If indoor air levels are found to exceed Modified MTCA Method B CULs at Seattle Boiler Works during active remediation (thermal and ERD) or exceed standard MTCA Method B CULs following active remediation or if land use at any time changes to residential then contingency measures as described in Section 6.6 of this document will be evaluated and implemented. Modified MTCA Method B concentrations account for worker exposure based on 8 hours per day exposure for 5 days per week for 49 weeks per year for 15 years. The expected restoration time frame for indoor air to achieve standard MTCA Method B CULs is 15 years.
3 MTCA Method B CULs are being used for the indoor air at Seattle Boiler Works property because the property owner will not accept institutional controls.
4 Contaminant concentrations in indoor air will be adjusted downward to account for ambient concentrations of PCE and TCE in accordance with Ecology's 2009 Draft Guidance for Vapor Intrusion (Ecology 2009).

Abbreviations:
ARAR Applicable or relevant and appropriate requirement
CEA Chlorinated ethene and ethane
CUL Cleanup level
DCE Dichloroethene
Ecology Washington State Department of Ecology
ERD Enhanced reductive dechlorination
MNA Monitored natural attenuation
MTCA Model Toxics Control Act
PCE Tetrachloroethene
Penta Pentachlorophenol
POC Point of compliance
PRB Permeable Reactive Barrier
RL Remediation level
TCE Trichloroethene
TPH Total petroleum hydrocarbons
VC Vinyl chloride
VOC Volatile organic compound
WBZ Water Bearing Zone

Fox Avenue Site
Seattle, Washington

Cleanup Action Plan

Figures



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Cleanup Action Plan
Fox Avenue Site
Seattle, Washington

Figure 1.1
Lower Duwamish Industrial Corridor

Path: F:\projects\FoxAve-RA\GIS\MXD\Cleanup Action Plan 2011\Figure 1.1 (Lower Duwamish Industrial Corridor).mxd 5/6/2011

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Cleanup Action Plan
Fox Avenue Site
Seattle, Washington

Figure 2.1
Area Map

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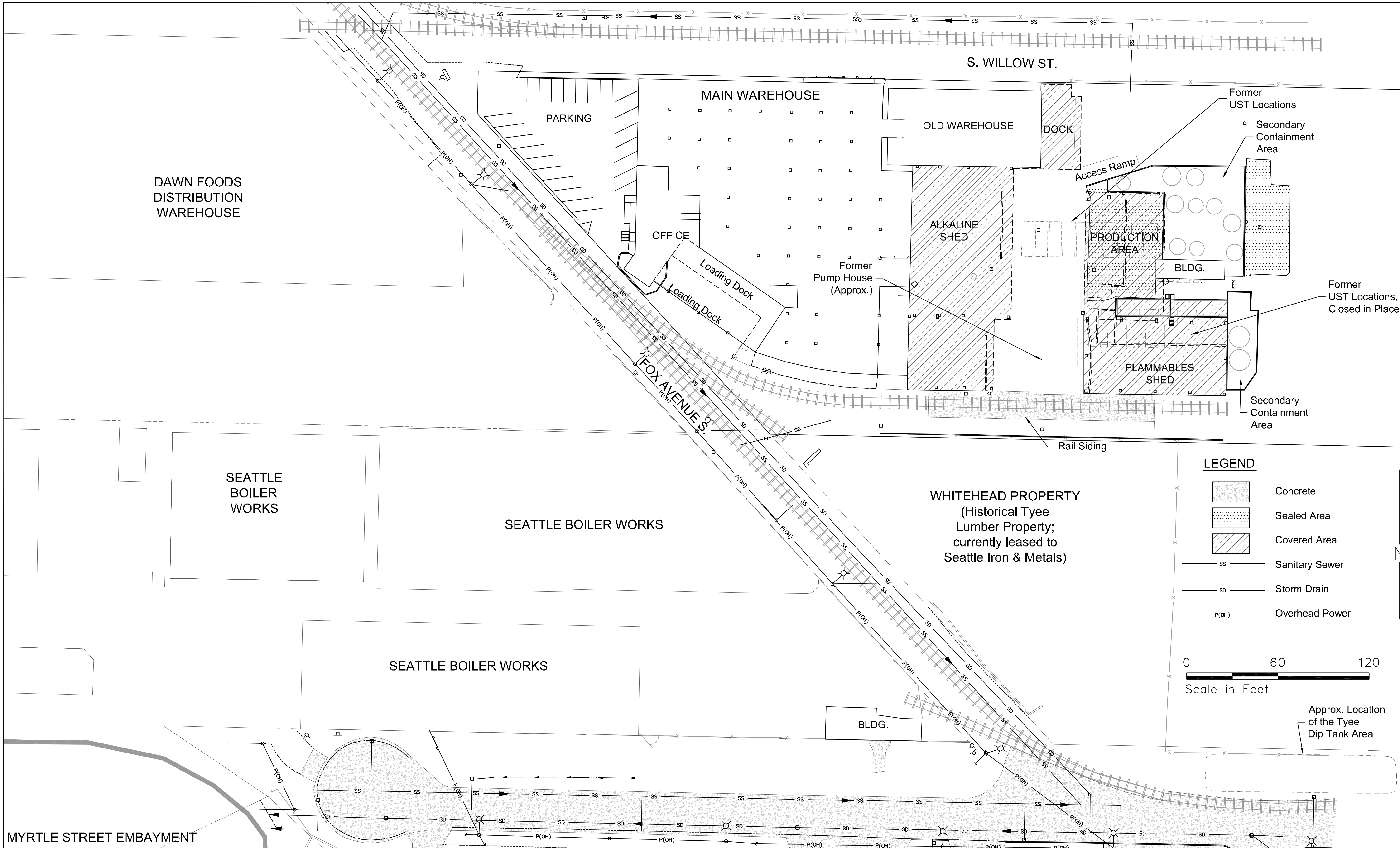
5/18/2011



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Fox Avenue Site
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Figure 2.2
Site Plan

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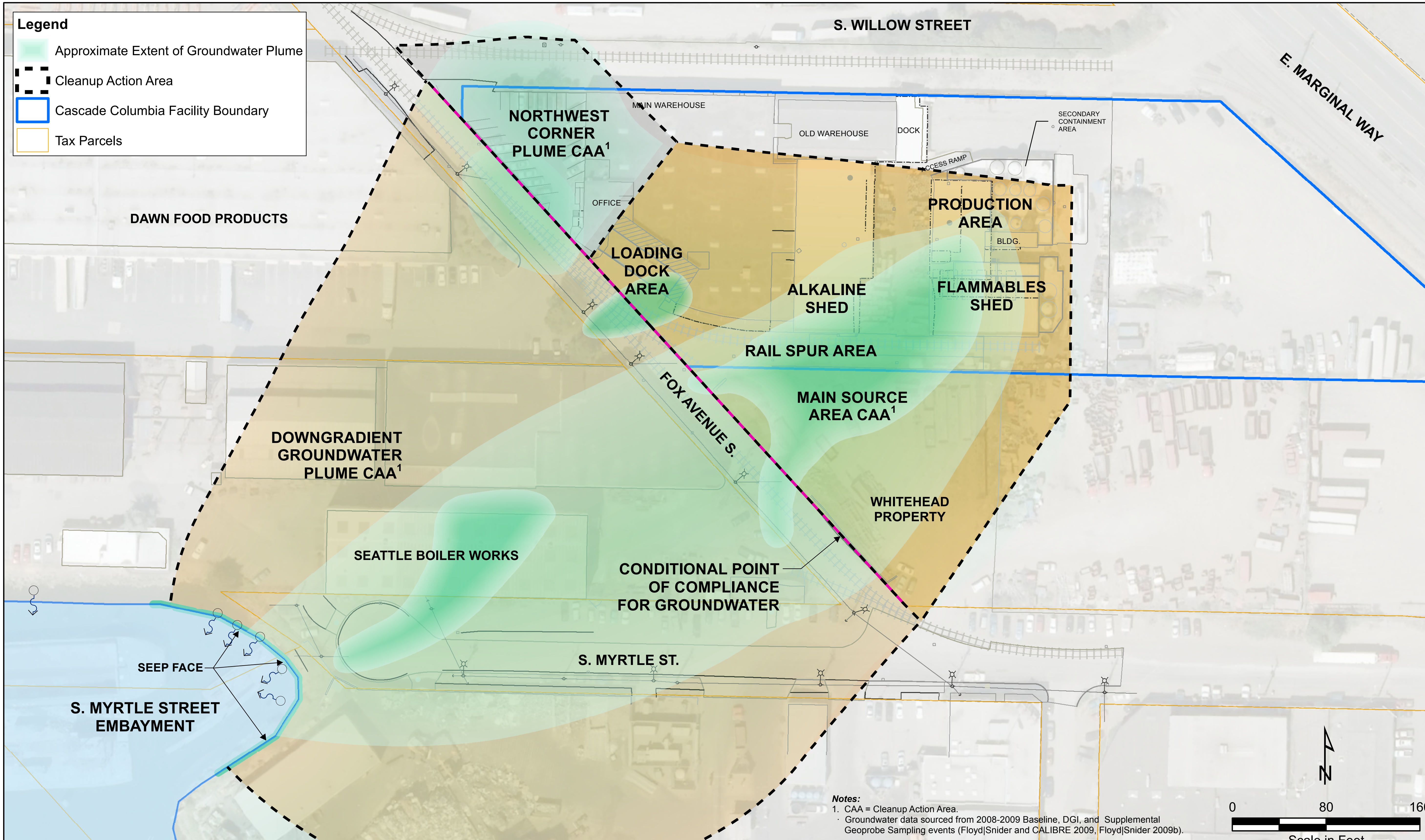

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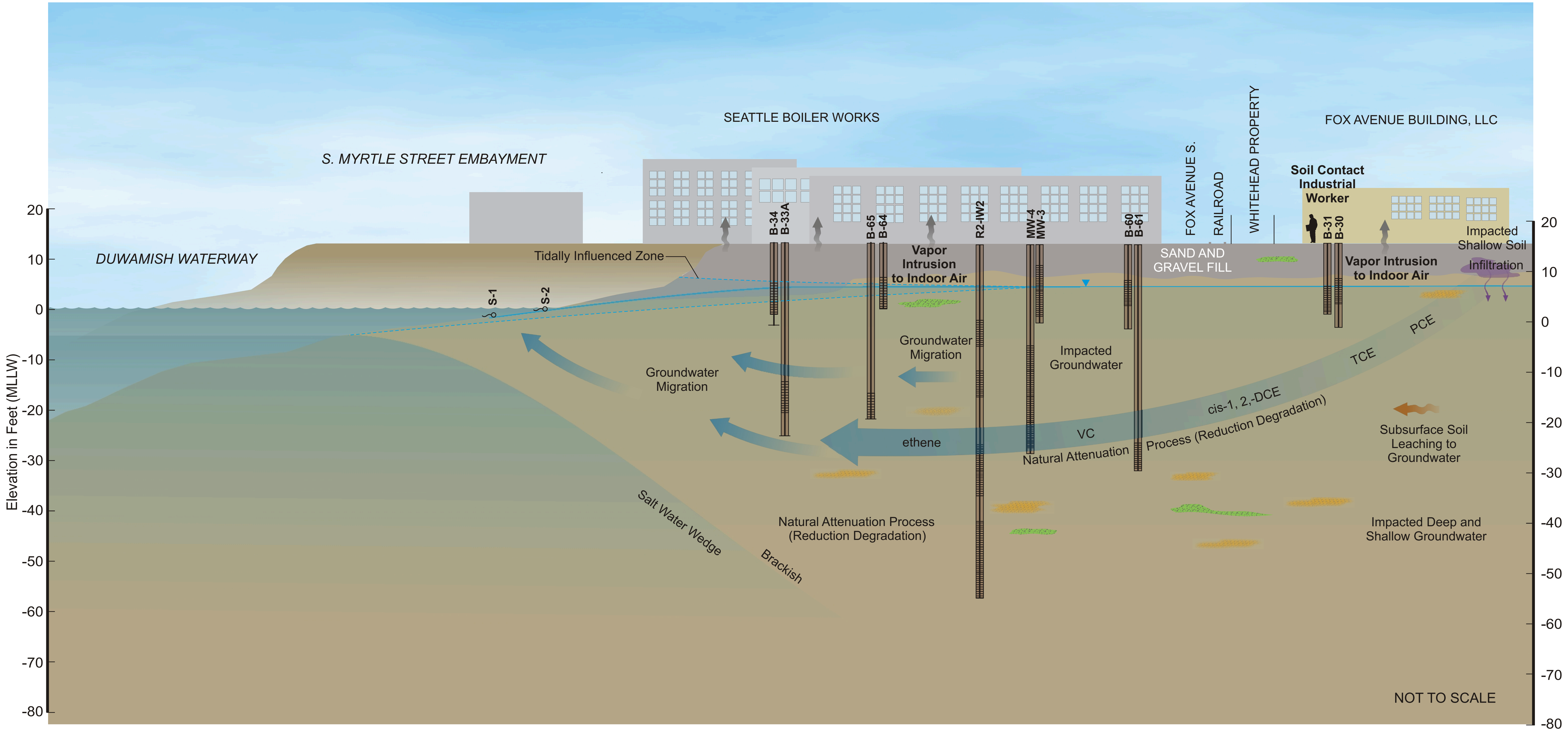
Figure 2.3
Cleanup Action Areas

F:\projects\FoxAve-RA\GIS\MXD\Cleanup Action Plan 2011\Figure 2.3 (Cleanup Action Areas).mxd
6/1/2011



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Fox Avenue Site
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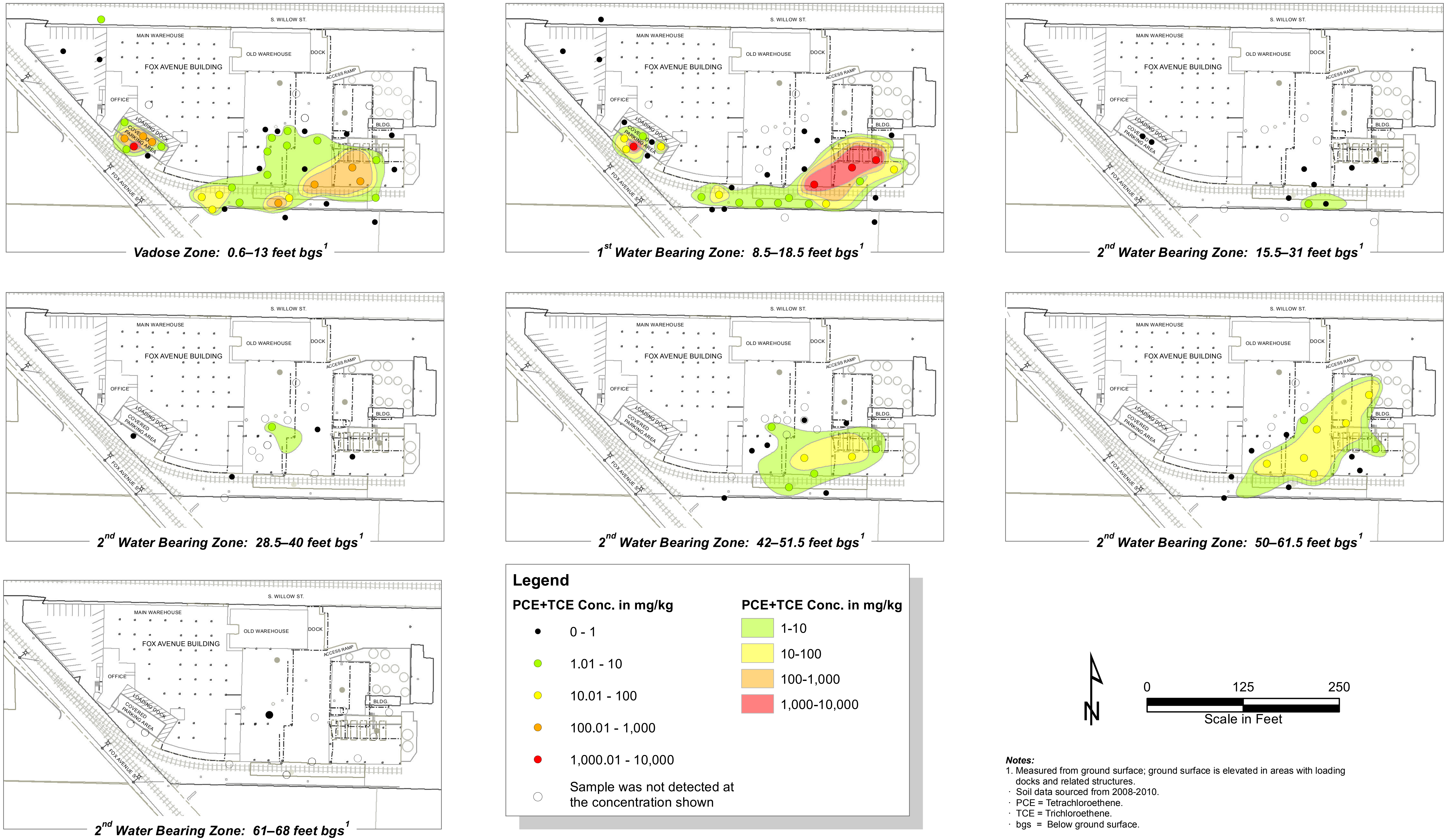
Figure 2.4
Conceptual Site Model

G:Project\Clients\Floyd Snider\Fox Avenue\2010\Geologic Cross Section B-B'



Notes:

1. Measured from ground surface; ground surface is elevated in areas with loading docks and related structures.

· Soil data sourced from 2008-2010.
· PCE = Tetrachloroethene.
· TCE = Trichloroethene.
· bgs = Below ground surface.

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Fox Avenue Site
Seattle, Washington

Figure 2.5
Current Conditions: Maximum PCE+TCE Concentrations in Soil 0.6 to 68 Feet Below Ground Surface

File: F:\projects\FoxAve-RA\GIS\MXD\RIFS\2011 RIFS\Figure 5.5 (PCE plus TCE Variation with Depth - Multiple Frames).mxd
Date: 2/9/2011

Legend

Concentration in Groundwater in µg/L

- 0 - 1
- 1 - 10
- 10.01 - 100
- 100.01 - 1,000
- 1,000.01 - 10,000
- > 10,000

- Location where Analyte was Not Detected
- Concentration Contour in µg/L
- Myrtle Street Embayment

N

0 125 250 500

Scale in Feet

Notes:
- Groundwater data sourced from 2008–2010.
- The 1st Water Bearing Zone is defined as the vertical region >= -2.346 ft. NAVD 88.
- The 2nd Water Bearing Zone is defined as the vertical region < -2.346 ft. NAVD 88.
- PCE = Tetrachloroethene.
- TCE = Trichloroethene.
- cis-1,2-DCE = cis-1,2-Dichloroethene.
- VC = Vinyl Chloride.

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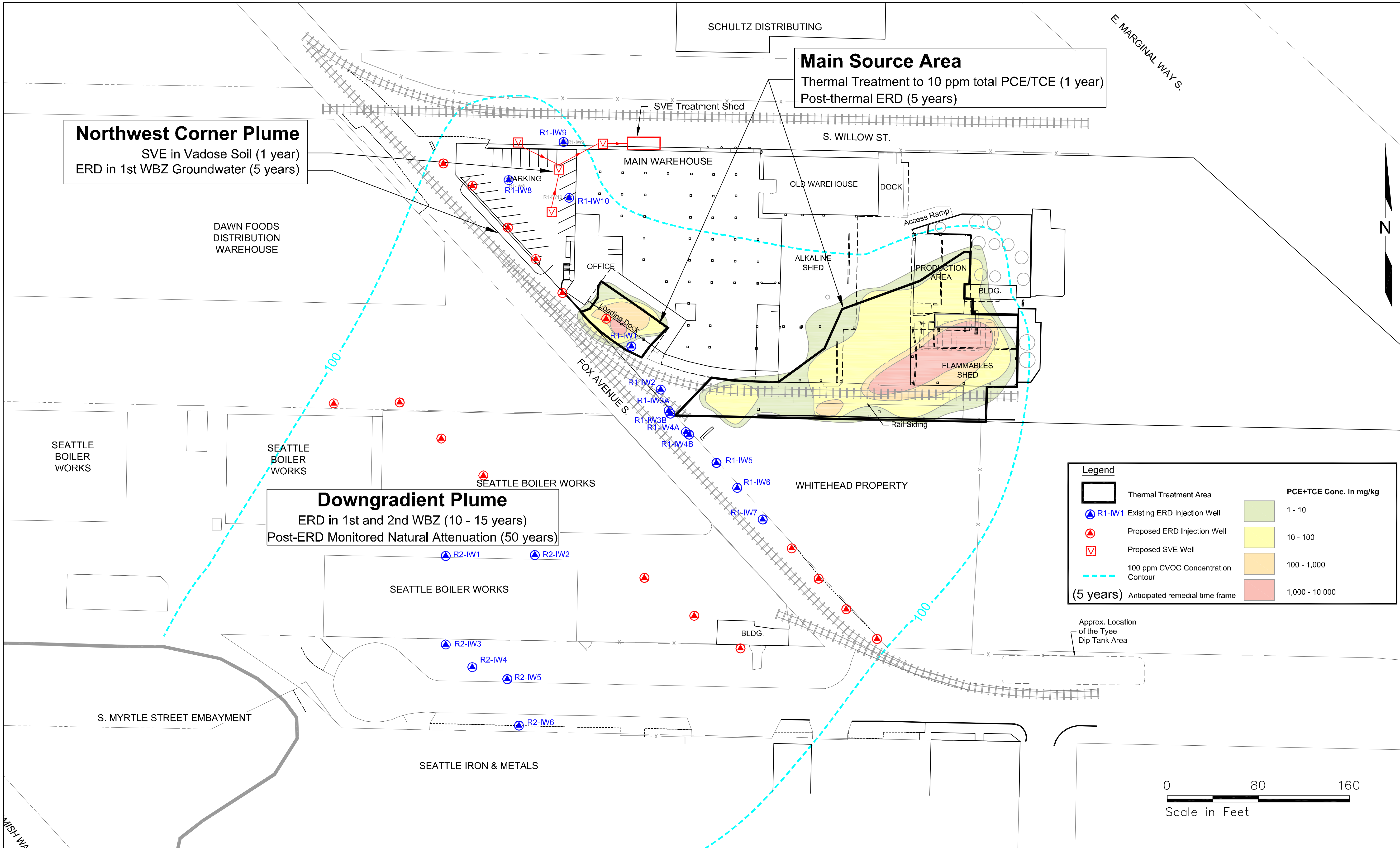
Figure 2.6
Current Conditions: Maximum PCE+TCE, Maximum cis-1,2-DCE, and Maximum VC Concentrations in Groundwater

F:\projects\FoxAve-RA\GIS\MXD\Cleanup Action Plan 2011\Figure 2.6 (VOCs in GW - Multiple Frames Compilation).mxd 6/1/2011



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Fox Avenue Site
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Figure 4.1
Selected Remedy Elements

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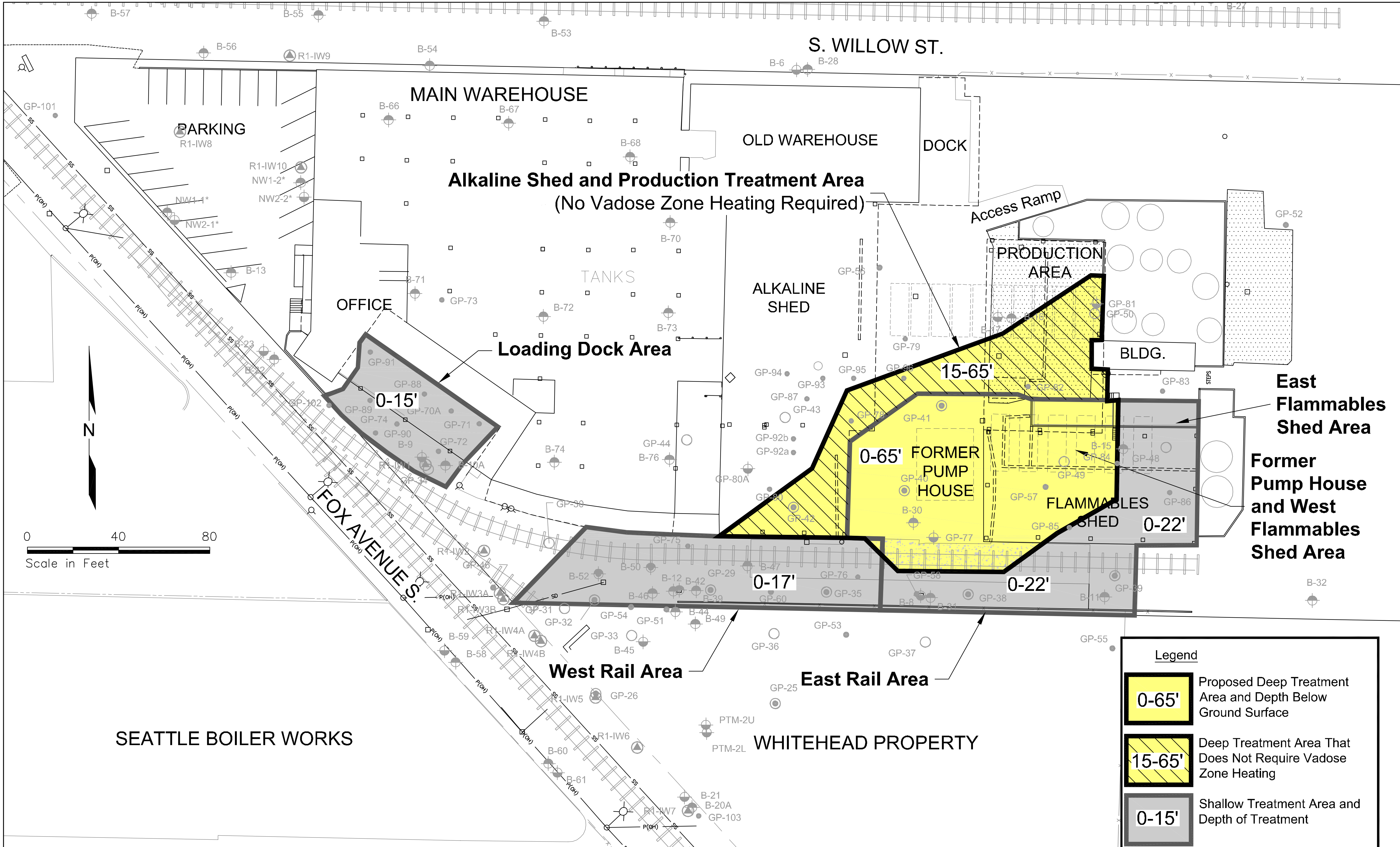

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Fox Avenue Site
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Figure 5.1
Thermal Treatment Areas

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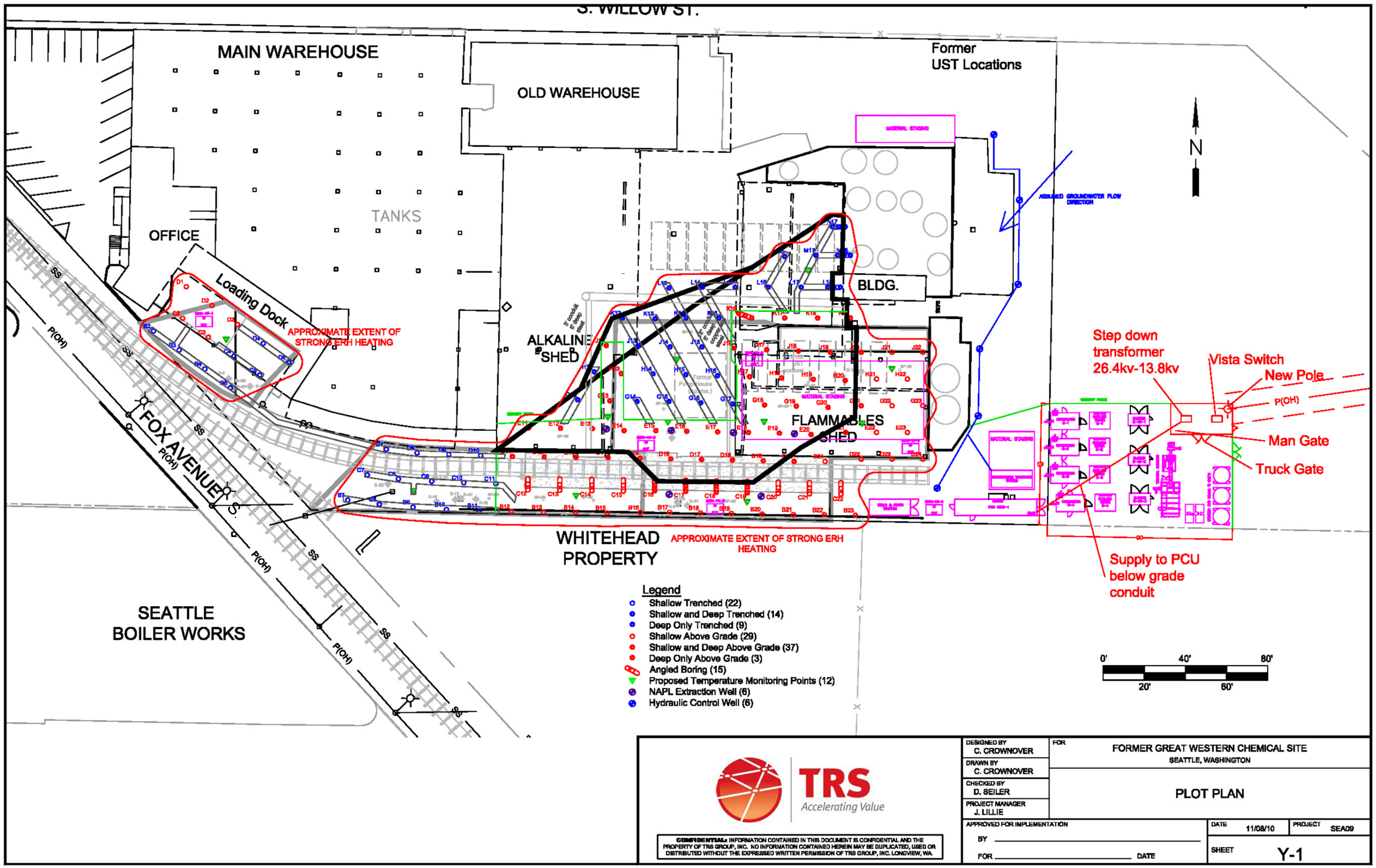

Note: Provided by TRS as part of initial planning.

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Figure 5.2
Layout of Thermal Electrodes and Support Equipment

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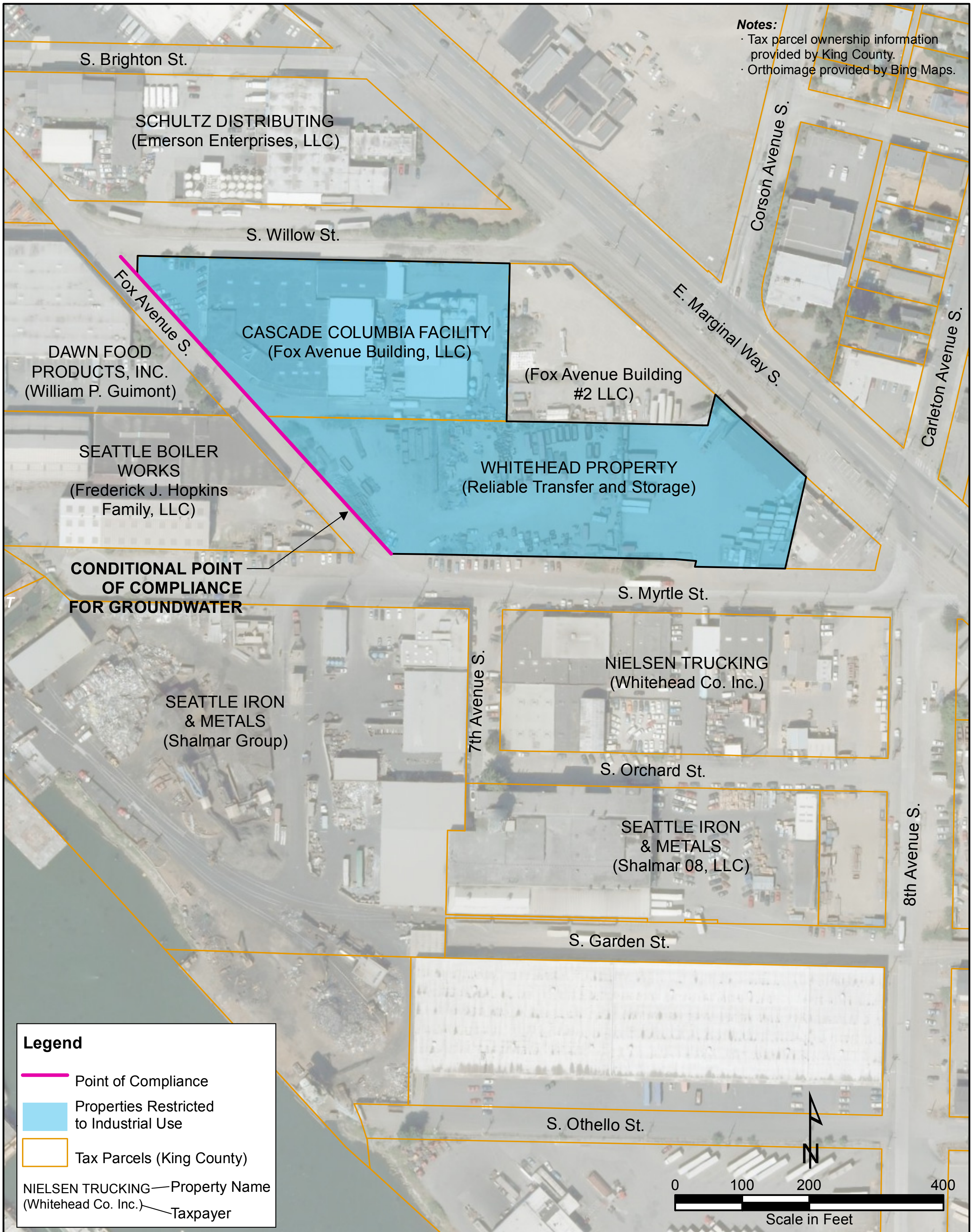

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Fox Avenue Site
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Figure 5.3
Properties Restricted to Industrial Use

F:\projects\FoxAve-RA\GIS\MXD\Cleanup Action Plan 2011\Figure 5.3 (Properties Restricted to Industrial Use).mxd
6/13/2011