DEPARTMENT OF ECOLOGY
State of Washington

DRAFT CLEANUP ACTION PLAN

Rainier Mall Property

4208 Rainier Avenue South, Seattle, WA 98118

King County Parcel #7950301480 and #7950301485

CSID: 4187, FSID: 88987973

September 23, 2021

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Acronyms and Abbreviations

3DME	3D Micro Emulsion
AMSL	Above Mean Sea Level
AS	Air Sparging
BGS	Below Ground Surface
BDI	Bio-dechlor Inoculum
CDF	Controlled Density Fill
Cis-1,2-DCE	cis-1, 2-Dichloroethylene
CM/S	Centimeters Per Second
COC	Contaminant of Concern
CSM	Conceptual Site Model
DCA	Disproportionate Cost Analysis
DCAP	Draft Cleanup Action Plan
DO	Dissolved Oxygen
DPE	Dual Phase Extraction
EC	Environmental Covenant
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
ERD	Enhanced Reductive Declhorination
ERH	Electrical Resistive Heating
ESA	Environmental Site Assessment
FS	Feasibility Study
GAC	Granular Activated Carbon
Hahn	Hahn and Associates, Inc.
HASP	Health and Safety Plan
ISCO	In-Situ Chemical Oxidation
ISCR	In-Situ Chemical Reduction
LBA	Lot Boundary Adjustment

LUP	Lake Union Partners
Mg/Kg	Milligrams per Kilogram
Mg/L	Milligrams per Liter
µg/L	Micrograms per Liter
Ml/min	Milliliters per Minute
MNA	Monitored Natural Attenuation
mV	Millivolts
ORP	Oxygen-reduction Potential
PAH	Polycyclic Aromatic Hydrocarbon
PCE	Tetrachloroethylene (Perchloroethylene)
PCU	Power Control Unit
POC	Point of Compliance
PPCD	Prospective Purchaser Consent Decree
MTCA	Model Toxics Control Act
RAO	Remedial Action Objective
RCW	Revised Code of Washington
RI	Remedial Investigation
ROW	Right-of-Way
SF	Square Feet
SMZVI	Sulfidated Micro Zero Valent Iron
TCE	Trichloroethylene
TMP	Temperature Monitoring Point
Trans-1,2-DCE	trans-1,2-Dichloroethylene
UEP	Urban Environmental Partners
USGS	United States Geological Survey
VC	Vinyl Chloride
VCP	Voluntary Cleanup Program
WAC	Washington Administrative Code

Executive Summary

This draft Cleanup Action Plan (dCAP) describes the cleanup actions selected by the Washington State Department of Ecology (Ecology) for the Rainier Mall site (Site), generally located at 4208 Rainier Avenue South in Seattle, Washington, and as shown on Figures 1 and 2.

This dCAP was prepared by Ecology in collaboration with Urban Environmental Partners llc (UEP) working on behalf of Rainier & Genesee, LLC and Lake Union Partners (LUP) Affiliates.

This dCAP was prepared in compliance with the Model Toxics Control Act (MTCA), the Revised Code of Washington (RCW) 70A.305, Washington Administrative Code (WAC) ch. 173-340. This dCAP describes Ecology's proposed cleanup actions for this Site and sets forth the requirements that the cleanup must meet.

Soil explorations, monitoring well installations, and soil, groundwater, and soil gas sampling were completed at the Site as part of the Remedial Investigation (RI) to characterize the nature and extent of the contamination throughout the Site.

A Feasibility Study (FS) was also completed to evaluate potential remedial alternatives for the Site based on proven remedial technologies. The FS included a disproportionate cost analysis (DCA) of remedial alternatives to evaluate the ratio of environmental benefit to cost.

As discussed in the draft RI/FS Report, cleanup is warranted to remediate contaminated soil, and groundwater at the Site (UEP, 2021). Ecology's selected remedial action, as described in this dCAP, includes targeted contaminated soil removal, soil heating and contaminated vapor removal, and injection to promote chemical and biological breakdown of contaminants dissolved in groundwater.

1.0 Introduction

This dCAP describes the cleanup action selected by Ecology for the Site (Voluntary Cleanup Program [VCP] ID NW3261) generally located at 4208 Rainier Avenue South in Seattle, Washington (Property) as shown on Figures 1.

As established in WAC Chapter 173-340-200, a "Site" is defined by the full vertical and lateral extent of contamination that has resulted from the release of hazardous substances into the environment. For the purposes of this cleanup action plan, the Site is defined by the following two remedial action areas:

1. Soil and groundwater impacted by the historical release of chlorinated volatile organic compounds (CVOCs) associated with former dry-cleaning operations on the southern portion of the Property and adjacent rights-of-way (ROWs); and,

2. Soil impacted by creosote treated wood pilings used for the construction of a retail building on the northern portion of the Property.

1.1 Document Purpose

This dCAP was prepared in compliance with MTCA RCW 70A.305, and WAC Chapter 173-340. This dCAP describes the cleanup actions selected by Ecology for the Site and provides additional information in accordance with WAC 173-340-380(1)(a).

The purpose of the dCAP is to identify the selected cleanup actions for the Site and to provide an explanatory document for public review. More specifically, this dCAP:

- Describes the Site;
- Summarizes current Site conditions;
- Summarizes the cleanup action alternatives considered in the remedy selection process;
- Describes the selected cleanup action for the Site and the rational for selecting this alternative;
- Identifies Site-specific cleanup levels and points of compliance for each hazardous substance and medium of concern for the proposed cleanup action;
- Identifies applicable state and federal laws for the proposed cleanup action
- Identifies residual contamination remaining on the Site after cleanup and restrictions on future uses and activities at the site to ensure continued protection of human health and the environment;
- Discusses compliance monitoring requirements; and,
- Presents the proposed schedule for implementing the CAP.

2.0 Site Description

The Property consists of a two King County Tax Parcels (#7950301480 and #7950301485), comprising 2.33 acres, addressed at 4208 Rainier Avenue South in Seattle, Washington (Figures 1 and 2). The Property is located at the northeast corner of South Genesee Street and Rainier Ave South.

The following is an abbreviated legal description of the Property as provided by the King County Department of Assessments:

SQUIRES LAKESIDE ADD & POR VAC ALLEY ADJ LESS ST
Plat Block: 9
Plat Lot: 7 THRU 38

The Site is defined as areas where contamination has come to be located because of releases from the subject Property. The Site comprises the Property (4208 Rainier Avenue South), part of the Rainier Avenue and South Genesee Street ROWs adjacent to the Property, and a small portion of the property to the south of Genesee.

2.1 Current Condition

The Property is currently vacant and all on-site structures and improvements are unoccupied and sealed from access and use. A 36,071 square foot (sf) vacant, former retail structure located on the northern portion of the Site and associated asphalt parking lot to the south covers the Property. Except for small landscape planting areas within the parking lot, the entire Site is capped with either concrete or asphalt cover.

The primary topographic gradient at the Site is gently sloped from west to east, with a localized depression throughout the central portion of the parking area. Elevations range from approximately 47 feet above mean sea level (AMSL) (NAVD 88 datum) near the western Property boundary, to approximately 42 feet AMSL within the localized depression.

2.2 Historical Land Use Summary

According to historical land use research conducted by Hahn and Associates, Inc. (Hahn) in 2000 as part of Phase I and Phase II Environmental Site Assessments (ESAs), the Property was formerly developed with up to three separate dry-cleaning facilities on the southwestern portion of the Property as shown on Figure 2. These historical dry-cleaners reportedly operated in three distinct locations between approximately 1930 and 1968. The buildings were removed from the Property between 1967 and 1978.

According to Hahn's Phase I ESA, the current single-story retail building was constructed on the north end of the Property around 1967 and was initially occupied by a Safeway Store No. 441 (Safeway No. 441). Safeway No. 441 ceased operations in approximately 1998, and the structure was then expanded and converted into a mixed-use mall (Rainier Mall) supporting multiple retail tenants. Rainier Mall closed in August of 2016 and has remained vacant since that time.

Historical building plans associated with the construction of the Safeway No. 441 indicate the building was constructed on approximately 174 treated wooden piles (Figures 3 and 4). Wooden piles of this era were commonly treated with creosote, which contains chemical compounds such as polycyclic aromatic hydrocarbons (PAHs).

2.3 Groundwater Use Assessment

Seattle Public Utilities provides the potable water supply to the City of Seattle. According to King County's Interactive Map for the County's Groundwater Program, there are no designated aquifer recharge or wellhead protection areas within several miles of the Site (King County iMAP 2020). There are no active water supply wells within a 0.5-mile radius of the Property (Ecology 2020).

The King County Board of Health requires connection to an existing water system where available (BOH-Code-Title-12, Section 12.32.010). The City of Seattle supplies potable water to the entire City; therefore, groundwater cannot be used as a potable water supply within the City limits. Local groundwater, both shallow and deeper occurrences, in the vicinity of the Property does not serve as a source of drinking water.

3.0 Summary of Site Contamination

This section describes the contamination found at the Site and human health and environmental concerns resulting from this contamination.

The primary contaminants of concern (COCs) associated with the dry-cleaning operations include the chlorinated volatile organic compounds (CVOCs): tetrachloroethylene, also known as perchloroethylene (PCE) and its degradation compounds trichloroethylene (TCE), cis-1, 2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), and vinyl chloride (VC) in soil and groundwater. The COCs associated with creosote treated woodpiles are the carcinogenic PAHs in soil. Figure 16 depicts the conceptual site model (CSM) from the RI. The CSM figure illustrates that CVOCs and PAHs in soil have complete exposure pathways for ingestion, dermal contact, and inhalation for present and future Site occupants. Figure 16 also shows a complete exposure pathway for CVOCs in groundwater through potential inhalation and dermal contact exposures for present and future occupants of the Site.

Between 2017 and 2020, multiple environmental investigations were performed on the Site to evaluate the nature and extent of the release(s) on the Site. Detailed summaries of these investigations are presented within UEPs draft RI/FS Report, dated April 3, 2021.

The types and locations of the historic explorations from the investigations are depicted on Figure 5, while the cumulative soil, groundwater and soil gas data results from the studies are tabulated on Tables 1 through 8.

The data results for soil, groundwater and soil gas samples from the studies are depicted by location on plan view Figures 6 through 9, and select data is depicted on cross sectional Figures 11 through 14.

The RI was performed to collect data necessary to adequately characterize the release(s) at the Site for the purposes of developing and evaluating remedial alternatives consistent with WAC 173-340-350(7). The release characterization is commonly referred to as the CSM, which is summarized below.

3.1 Source Areas

3.1.1 CVOCs

The results of the RI indicate that the CVOC impacts confirmed in soil and groundwater beneath the Site are the result of dry-cleaning facilities that operated in the southwest corner of the Property. A minor surficial release may have also occurred near the northern dry-cleaning operation, but shallow soil in this area shows minimal impacts and does not appear to represent a significant source of CVOC impacts at the Site.

No chlorinated solvent releases from the former dry cleaner(s) are ongoing at the Site (all historical dry-cleaning machinery and operations are gone). The highest soil and groundwater concentrations of CVOCs indicate the source area is generally defined by locations of MW01, MW05, MW13, MW25, MW30, and MW31. The contaminated soil in this area continues to act as a source of CVOCs to groundwater and soil gas. Contaminated groundwater in these areas also continues to act as sources to soil gas.

3.1.2 PAHs in Soil

A second source area of the Site is associated with treated wood piles that support the vacated Safeway building on the north half of the Property. The pile layout, circa 1967, is shown on Figure 3. As shown on Figure 9, the presence of PAH compounds above cleanup levels was localized to a few inches around each treated pile. Groundwater data from monitoring wells (MW32 and MW33) downgradient from the pile system under the building provide empirical evidence that groundwater is not likely impacted by the presence of the treated piles (Table 8).

3.2 Contaminants of Concern

Based on the results of the RI, the COCs for the southern portion of the Site include PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and VC from the historic dry cleaner operations. PAHs in soil directly adjacent to the creosote treated piles were also identified as a COC in the northern portion of the Site.

3.3 Media of Concern

Soil and groundwater are the confirmed media of concern for the Site. Soil vapor will be retained as a media of concern for future on-Site structures. CVOC concentrations detected in shallow groundwater exceed the MTCA Method B Groundwater Screening Level for indoor air risks associated with potential vapor intrusion. However, soil gas/vapor sampling results have not indicated an elevated risk for vapor intrusion for current on-Property structures (Figure 8; Table 7).

3.4 Subsurface Conditions

3.4.1 Soil Conditions

The Seattle Geologic Map indicates the Site is underlain by fill over Recessional Lacustrine soil. Based on the Site explorations, the fill consists of a highly variable mixture of gravel, sand, clay, and silt; and wood and concrete debris have been observed in places. The thickness of the fill ranges from approximately 8 to 17 feet below ground surface (bgs).

Underlying the fill in some explorations, an organic-rich silty sand to sandy silt was observed, generally less than 1-foot thick. This soil is likely a recent wetland deposit associated with the former stream.

The fill and wetland deposit are underlain by Recessional Lacustrine soil. The Recessional Lacustrine soil consists of mostly a silty clay although in some areas silt is the predominate soil type. In several explorations the clay was relatively plastic. Reddish brown mottling was observed in the upper portions of the deposit, likely due to iron oxide staining, which indicates the movement of water through the soil. The Recessional Lacustrine deposit ranges in thickness from approximately 10 to 20 feet.

In the central portion of the CVOC impacted area, a sand layer with varying amounts of silt and occasional gravel is present below the Recessional Lacustrine deposit, and likely represents Recessional Outwash. The Recessional Outwash forms a channel-like structure running from northwest to southeast as shown on Figure 10. Also shown on Figure 10, the sand channel thickens from just a couple of feet in the northwest to approximately 15 feet to the southeast, with a decrease in the silt content to the southwest area of the Site.

Underlying the Recessional deposits are glacially consolidated soils. Based on the Seattle Geologic Map and our experience in the Seattle area, these soils are likely Pre-Vashon in age. In general, these soils consist of clay and silt, with some of the silt deposits exhibiting a till-like texture. These deposits are hard to very hard.

Although it was not observed on the Site, the Seattle Geologic Map shows a bedrock outcropping approximately 2 blocks south of the Site roughly parallel to South Alaska Street.

3.4.2 Groundwater Conditions

The depth to groundwater was measured in each of the Site monitoring wells and, the depth to groundwater ranges from approximately 6 to 15 feet bgs. The depth to water measurements were converted to elevations based on the recent survey of the wells. Groundwater elevations range from approximately 32 to 37 feet AMSL across the Site.

The groundwater elevations were contoured to identify groundwater flow patterns using data collected on April 14, 2020, as shown on Figure 15. The groundwater contours indicate that groundwater flows toward the primary area of soil contamination at the Site, then flows to the southeast toward monitoring well MW20. This flow pattern is a function of the sand channel observed at the Site, which provides a lower resistance to flow than the clay and silt, and serves as a preferential pathway for groundwater flow.

The hydraulic gradient across the Site ranges from approximately 0.1 feet per foot between monitoring wells MW05 and MW12 to 0.005 feet per foot between monitoring wells MW10 and MW20. These gradients are consistent with the soil conditions at the Site, with higher resistance to flow within the silt and clay resulting in higher gradients, and lower hydraulic gradients within the sand channel.

Monitoring wells that are known to be screened within the Recessional Outwash unit (MW09, MW25, and MW26) produced mean hydraulic conductivity values ranging from 0.0008 to 0.0018 centimeters per second (cm/s). While those that appear to be screened within the Recessional Lacustrine unit (MW16 and MW18) produced slow recovery and low mean hydraulic conductivity values between 0.00019 and 0.000024 cm/s, which indicate that the sand layer is likely not present in this area, or is relatively thin at these locations. This data is consistent with the relatively low levels of contamination in groundwater in MW16 and MW18 when compared to other wells on Site.

3.5 Distribution of Contamination in Soil

CVOC concentrations in soil were identified in two areas: a) the primary source area, which contains concentrations ranging from 0.049 milligrams per kilogram (mg/kg) to 510 mg/kg and may support some, but limited areas of residual PCE in soil, which could be contributing to groundwater impacts; and b) the leading plume edge that contains detectable PCE concentrations in saturated soil ranging from 0.027 mg/kg to 2.2 mg/kg which is likely more representative of impacted groundwater coming into contact with the soil. This soil area is not considered a continued source of groundwater impacts.

The lateral extent of CVOC soil contamination within the source area is limited to the southwestern corner of the Property, potentially extending underneath Rainier Avenue S (Figure 6). The northern limit is defined by the absence of impacts in borings B-6, B-8, B07, B08, and UB17; the eastern limit is defined by the absence of impacts in borings B09, UB18, and UB19; the southern limit is defined by the absence of impacts in borings SB05, TB07, B-2, and B13; and the western limit is defined by the absence of impacts in the angle borings B12 and B16 at locations beneath the western adjacent ROW. It should be noted that shallow soil samples, between approximately 0 and 16 feet bgs beneath the western adjacent ROW could not be collected due to the presence of multiple utilities.

The lateral extent of CVOC soil contamination within the leading plume edge is limited to the southcentral portion of the Property, the southern adjacent ROW, and the northern portion of the adjacent property to the south. These impacts are bounded laterally by the lack of soil contamination within the saturated Recessional Outwash sand in borings UB21 through UB23 (Figure 6).

The vertical extent of CVOC soil contamination within the source area ranges from approximately 10 feet bgs to approximately 35 feet bgs, while the vertical extent of soil contamination within the leading plume edge ranges from approximately 25 to 35 feet bgs within the saturated Recessional Outwash sand. The vertical extents in both zones are limited by the presence of glacially consolidated silt and clay consistently encountered around 35 to 40 feet bgs (Figures 11 through 14).

As explained in Section 4.4 and Section 6.1.4 below, there is also a small and isolated area of shallow soil with PCE at boring UB15 at a depth of 6 feet bgs on the north, central portion of the Site as shown on Figure 6. This soil will be excavated for off-site disposal as a simple source removal effort.

The lateral extent of PAH soil contamination associated with the creosote treated pile assemblage is limited to approximately 3 inches from the surface of each pile, with the vertical extent limited to the depth of the piles.

3.6 Distribution of Contamination in Groundwater

The lateral extent of groundwater contamination at the Site is limited to the southwestern portion of the Property, extending south beneath the adjacent ROW to the northern portion of the south adjacent property.

The northern plume boundary is defined by the absence of impacts in monitoring well MW03; the eastern leading plume edge is represented by the slight concentrations detected in MW02; the southeastern plume boundary is defined by the absence of impacts in monitoring well MW24, and the southern plume boundary is defined by the absence of impacts in monitoring wells MW21 through MW23 (Figure 7). The most recent groundwater sampling events did not detect CVOC concentrations in monitoring wells MW10 or MW20, indicating the groundwater plume may not extend far beyond the southern Property boundary, however this Site area will be considered impacted until four consecutive quarters of compliant groundwater data can be obtained.

The western plume boundary had previously been defined by the absence of CVOC contamination in the groundwater collected from MW06 and MW07. However, CVOC concentrations were recently detected in MW06 during the March 12, 2020 sampling event; the groundwater collected from MW07 contained no detectable concentrations of CVOCs, consistent with previous sampling results. Access limitations due to utilities within the ROW of Rainier Avenue South prohibit the collection of more meaningful data (Figure 7) further to the west of MW06. Based on the CSM, the contaminant transport mechanisms at the Site (fill depth, groundwater gradient and flow direction) do not support a westerly migration of contaminants, therefore MW06 will be used to monitor the western plume boundary in combination with monitoring of vapors in the adjacent sewer main. The minor PCE concentrations recently shown in groundwater in this area will be treated by the selected remedial approach for the Site.

3.7 Contaminant Fate and Transport

3.7.1 Chlorinated Solvent

The understanding of the CVOC transport at the Site is based on soil and groundwater conditions observed during the RI and the distribution of contamination in the subsurface. Contamination appears to have moved through the fill material to the top of the native soil, which generally consists of silt and clay, then contamination has generally migrated from west to east on top of this confining layer.

Over time, the chlorinated solvents have migrated downward through the upper native silt and clay into variable lenses of sand. These sand layers have been shown to be less continuous within the source area, and then are more continuous to the south and east. In a number of explorations, the sand lens is observed at a depth ranging from approximately 20 to 35 bgs as shown on Figure 10. This sand channel provides a pathway for contaminants in groundwater to migrate vertically downward, and downgradient to the southeast from the major area of soil contamination.

The sand channel is underlain by dense, hard glacially consolidated till and fine-grained soil. These soils have a low hydraulic conductivity and serve to reduce the downward migration of contamination. UEP identified that the glacially consolidated soils served as the downward limit of Site contamination.

The downgradient extent of groundwater contamination above cleanup levels is the south edge of the Property at the South Genesee Street boundary based on the most recent groundwater sampling data (monitoring wells MW10, MW11, and MW20).

The general absence of off-Property groundwater contamination (with the exception of very low levels within and across South Genesee Street) is attributed to anaerobic degradation that is occurring at the dissolved phase plume edge. Once PCE enters the subsurface, chemical processes such as hydrolysis, direct mineralization, and/or reductive dehalogenation by endemic bacteria facilitates a natural reduction or breakdown of the PCE into non-hazardous components. Biological attenuation processes such as reductive dechlorination and cometabolic degradation may also affect the reduction of PCE under conducive subsurface conditions. As reductive biodegradation of PCE occurs, we find the PCE degradation compounds in the plume to include TCE, cis-1,2-DCE, trans-1,2-DCE, and VC. In most of the monitoring wells where PCE has been detected in groundwater at the Site, these degradation products are present, including TCE, cis-1,2-DCE, and VC, demonstrating the biological degradation and possibly chemical attenuation processes are occurring at the Site. This process is most evident in the samples collected from monitoring wells MW01, MW05, MW09, MW12, MW13, MW16, MW18, MW25, MW26, MW30, and MW31, which all show the presence of these degradation compounds.

In addition, during the August 2020 groundwater sampling event, the average dissolved oxygen (DO) and oxidation-reduction potential (ORP) values within the primary area of groundwater contamination were approximately 0.57 milligrams per liter (mg/l) and -8.2 millivolts (mV), respectively, as shown by data presented in Table 9. These values for these groundwater parameters indicate that there is anaerobic biological activity occurring. According to United States Geological Survey (USGS) Scientific Investigations Report 2006-5030, dissolved-oxygen concentrations greater than 1 mg/L generally indicate aerobic conditions and concentrations less than 1 mg/L indicate one of the anaerobic conditions. Regarding the ORP values, a positive value is representative of an oxidized state and a negative value indicates a reduced state.

3.7.2 Evaluation of Empirical Data for PAHs Associated with Treated Wood Piles

Under WAC Chapter 173-340-747(9), Ecology allows for empirical demonstrations to show that minor cleanup level exceedances in soil have not, and will not, cause an exceedance of applicable groundwater cleanup levels and that no exposure scenarios are represented by the environmental conditions on the Property. WAC 173-340-747(9) states the following:

(b) **Requirements**. To demonstrate empirically that measured soil concentrations will not cause an exceedance of the applicable ground water cleanup levels established under WAC 173-340-720, the following shall be demonstrated:

(i) The measured ground water concentration is less than or equal to the applicable ground water cleanup level established under WAC 1733-340-720; and

(ii) The measured soil concentration will not cause an exceedance of the applicable ground water cleanup level established under WAC 173-340-720 at any time in the future. Specifically, it must be demonstrated that a sufficient amount of time has elapsed for migration of hazardous substances from soil into ground water to occur and that the characteristics of the site (e.g., depth to ground water and infiltration) are representative of future site conditions. This demonstration may also include a measurement or calculation of the attenuating capacity of soil between the source of the hazardous substance and the ground water table using site-specific data.

(c) **Evaluation criteria**. Empirical demonstrations shall be based on methods approved by the department. Those methods shall comply with WAC-173-340-702(14), (15), and (16).

As shown on Figure 9 and tabulated on Table 4, the PAH impacts in soil associated with the treated piles are present above cleanup levels within a limited 3-inch radius around each timber pile. However, the Site meets the empirical demonstration requirements for groundwater stated above. The limited PAH-impacted soil that is present immediately adjacent to the piles has not and will not cause exceedances of the applicable groundwater cleanup levels. This scenario is shown based on the following conditions:

- Soil samples and multiple groundwater samples collected from UB32/MW32 and UB33/MW33 installed in the downgradient direction from the treated pile assemblage, have not exhibited detectable concentrations of PAHs. To date, four consecutive quarterly groundwater samples have been collected from MW32 and MW33 (Table 8). These compliant soil and groundwater results for properly placed monitoring wells indicate that soil impacts associated with the creosote-treated timber piles beneath the existing building have not leached and have not caused exceedances of applicable groundwater cleanup levels; and,
- Since the 1968 construction of the retail structure, the Property has remained developed with the existing building encompassing a treated wood pile foundation. Property conditions have been consistent over that time; therefore, the creosote-treated wood timber piles have been in place for over 52 years. This period is a sufficient amount of time for the PAHs present in soil to have leached into groundwater, however the data collected from monitoring wells MW32 and MW33 show that leaching has not occurred at the Site, and is not likely to occur in the future.

Based on these results, the soil to groundwater pathway is incomplete. Human exposure scenarios including direct contact can be managed through targeted remediation efforts and implementation of engineering and institutional controls where appropriate.

3.8 Proposed Cleanup Levels

The following soil, groundwater, and soil gas cleanup levels were utilized to determine the extent of contamination at the Site subject to remedial action under MTCA. The Site RI/FS contains specific details surrounding the development and selection of the proposed cleanup levels.

3.8.1 Soil Cleanup Levels

Cleanup levels for soil are based on MTCA Method A levels for Unrestricted Land Use or the most conservative Method B calculated values. Cleanup levels for COCs in soil at the Site are presented in the table below, and shown on attached Tables 1 and 4 with the cumulative soil sample data.

Contaminant of Concern	**MTCA Method A or B Cleanup Level** Milligrams per kilogram (mg/kg)	**Sources**
PCE	0.05	MTCA Method A Soil Cleanup Levels for Unrestricted Land Use; WAC 173-340-740(2)(b)(i); Table 740-1; and Method B – CLARC (2021)
TCE	0.03	
cis-1,2-DCE	160	
trans-1,2-DCE	1,600	
1,1-DCE	4000	
VC	0.67	
PAHs	0.1*	

*Total concentrations that all carcinogenic PAHs (cPAHs) must meet using the toxicity equivalency methodology.

3.8.2 Groundwater Cleanup Levels

Cleanup levels for groundwater are based on MTCA Method A Cleanup Levels (if established) or MTCA Method B Cleanup Levels (for drinking water use). Cleanup levels for COCs in groundwater at the Site are presented in the table below, and are also shown on attached Tables 5, 6, and 8 with the cumulative Site groundwater data.

Contaminant of Concern	**MTCA Method A or B Cleanup Level** Microgram per liter (ug/L)	**Sources**
PCE	5.0	MTCA Method A Groundwater Cleanup Levels for Unrestricted Land Use; WAC 173-340-740(2)(b)(i); Table 720-1; and Method B – CLARC (2021)
TCE	5.0	
cis-1,2-DCE	16.0	
trans-1,2-DCE	160.0	
1,1-DCE	400.0	
VC	0.2	
PAHs	0.1*	

*Total concentrations that all cPAHs must meet using the toxicity equivalency methodology.

3.8.3 Soil Gas Screening Levels

Soil gas screening levels are based on MTCA Method B calculated values considered protective of indoor air. These values are presented on Table 7 and vary based on the depth at which the gas sample is collected.

3.9 Points of Compliance

The point of compliance is the location where the cleanup level shall be attained.

3.9.1 Point of Compliance for Soil

The standard point of compliance (POC) for direct contact is throughout the Site, from ground surface to 15 feet bgs. This is the depth at which one would reasonably assume workers could encounter contaminated soil during construction or development activities. In situations where achieving the standard POC is not practicable, a conditional POC may be established and institutional controls implemented to prevent direct contact and protect human health and the environment.

UEP proposed a standard POC for CVOC contamination in soil in the southern portion of the Site and a conditional POC for the PAH contaminated soil adjacent to the treated wood piles beneath the existing retail structure on the northern portion of the Site. The conditional POC for PAHs in the soil is supported through empirical demonstration discussed in the FS and summarized in Section 4.3 below.

3.9.2 Point of Compliance for Groundwater

The standard POC for groundwater is throughout the Site from the uppermost saturated zone extending vertically to the lowest depth, which could potentially be affected by the release at the Site.

3.9.3 Point of Compliance for Soil Vapor

The POC for soil vapor is throughout the Site and will be achieved when concentrations of COCs in soil gas and groundwater are below the vapor intrusion screening levels considered protective of indoor air, or when engineering controls are in place to prevent exposure. If engineering controls are used due to soil gas or groundwater detections, analytical sampling will be required to show exposure through vapor intrusion to indoor air is not present.

3.10 Exposure Pathways

This section discusses the confirmed and potential human health and ecological exposure pathways at the Site.

3.10.1 Soil Pathway

Potential exposure pathways for soil contamination include: volatilization into soil vapor and subsequent exposure through the vapor pathway discussed below; via the direct contact pathway, which comprises direct contact via dermal contact with and/or ingestion of soil beneath the Site; and soil to groundwater transport and subsequent exposure through the groundwater pathway discussed below.

Contamination at the Site is currently capped with asphalt or concrete. Until such time that the soil contamination is removed, remediated or institutional controls are in place to prevent direct contact, this pathway will be considered complete.

3.10.2 Groundwater Pathway

Potential exposure pathways for groundwater contamination include volatilization into soil vapor and subsequent exposure through the vapor pathway discussed below, or via the direct contact pathway, which comprises both the dermal contact and ingestion pathways.

Dermal contact scenarios could include construction workers encountering shallow seated groundwater during remediation or utility work, therefore this exposure pathway will remain complete until contamination is remediated or institutional controls are in place to prevent direct contact.

Based on the groundwater use assessment discussed in Section 2.3, the risk of ingestion of contaminated groundwater at the Site is low; however, this aquifer represents a potential future source of drinking water and cannot be deemed non-potable based on current conditions. Therefore, this exposure pathway will remain complete until contamination is remediated or institutional controls are in place to prevent potable groundwater classification and use.

3.10.3 Vapor Pathway

The air-filled pore space between soil grains in unsaturated soil is referred to as soil gas or soil vapor. Soil vapor can become contaminated from the volatilization of contaminants adsorbed to soil mineral surfaces and/or dissolved in groundwater and can pose a human exposure risk via inhalation.

The CVOC concentrations detected in shallow groundwater exceed the MTCA Method B Groundwater Screening Level for indoor air risks associated with potential vapor intrusion through typical off-gassing, in addition to vapor transport within utility lines such as the adjacent sewer main. Therefore, this pathway will remain complete until soil and groundwater contamination no longer present a threat of volatilization or engineering controls are in place to prevent exposure.

Soil gas samples previously collected adjacent to the existing structure and within the sewer main are too far from the primary source area to be representative of conditions in that area, where future structures may be erected.

4.0 Feasibility Study Summary

The purpose of the FS was to develop and evaluate remedial alternatives for the Site and to select the most appropriate alternative based on the procedures in WAC 173-340-350(1) through (8). The FS process is briefly summarized below, while the detailed analysis is presented in UEPs RI/FS Report.

4.1 Justification for Selection of Remedy

The selected cleanup action is a comprehensive final remedy for the Site that complies with all the applicable remedy selection requirements under MTCA. Specifically, the MTCA regulation, WAC 173-340-360(2)(a) provides that a cleanup action must include the following threshold remedial action objectives (RAOs):

- **Protects 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 and the environment, both in its current and future uses.
- **Comply with Cleanup Standards outlined in WAC 173-340-700 through 173-340-760**: The selected remedy is expected to comply with the cleanup standards for groundwater and soil at the POCs within a reasonable timeframe.

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

- **Provides Compliance Monitoring**: The selected remedy will include compliance monitoring for soil and groundwater to assess the performance, effectiveness, and permanence of each remedy element.

MTCA (173-340-360(2)(b) also requires that the cleanup alternative:

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

The overall RAO for the Site is to address impacted subsurface soil and groundwater that represent potentially complete contaminant exposure pathways identified in the CSM and as shown on Figure 16. Due to planned residential uses, the Site will satisfy the unrestricted land use requirements. Therefore, the cleanup objectives for the Site will address the following potential exposure pathways of Site COCs for current and future site uses:

- Direct contact with contaminated soil in the saturated and unsaturated zones;
- Groundwater for drinking water use; and,
- Soil gas (from impacted groundwater and soil) and vapor intrusion to indoor air.

4.2 Remedial Action Areas

For development and cleanup considerations, including duration of cleanup implementation and timing, the Site is divided into two separate Remedial Action Areas (RAAs). The two RAAs are distinguished by the extent of impacts associated with the CVOC release(s) and the extent impacts associated with the creosote treated piles; based on our understanding of the CSM, these RAAs do not overlap.

4.3 Lot Boundary Adjustment

The development construction work on the Property is expected to proceed as two separately permitted and phased developments. The first development will occur on the southern portion of the Property and consist of a mix of underground parking, at-grade retail, and several floors of multi-family apartments. The second development will occur on the northern portion of the Property and consist of a slab-on-grade, multi-family housing unit. The Property has been separated into two parcels with a Lot Boundary Adjustment (LBA) as shown on Figures 17 and 18.

This LBA division has created a 43,754 square foot (SF) “North Parcel” as shown on Figure 17. The remaining area of the Property comprises the 67,589 SF “South Parcel”. The planned redevelopment uses of the North Parcel and South Parcel are depicted on Figure 18. Note on Figure 18 the location of the shared “drive aisle” that is located on the South Parcel, but intended to support access to parking for both planned developments.

The two RAAs do not coincide with the Lot Boundary Adjustment. The extent of impacts associated with the creosote treated piles covers portions of both the North Parcel and South Parcel. The extent of impacts associated with the CVOC release covers a portion of the South Parcel and extends to the west and south of the South Parcel.

4.4 Creosote Treated Piles – Focused Feasibility Study Summary

A focused feasibility analysis was conducted and compared three remedial alternatives (P1, P2 and P3) for addressing soil contamination related to the presence of treated wood piles on the Property. The piling plan presented on Figure 3 shows the foundation system for the original construction of the Safeway building. This plan shows 3 sets of 3 piles, 20 sets of 2 piles, and 125 individual piles for a total of 148 pile systems, and a total of 174 individual piles beneath the original building.

Alternative P1 involved the full removal of all 174 existing piles and associated contaminated.

Alternative P2 involved the removal of the top 4 feet from all 174 existing piles and associated contaminated soil; this removal would also facilitate utility infrastructure installation for the proposed new building.

Alternative P3 involved the repurposing of serviceable, existing wooden piles into the structural system for the slab-on-grade concrete floor of the planned new building on the North Parcel. As described in the RI/FS Report, the development team and their structural and geotechnical engineers assessed the structural conditions of the existing pile system in representative areas within the vacant Safeway building and concluded that the piles were in a satisfactory structural condition and could be repurposed to support the new building floor slab. Any piles that would not serve a structural purpose would be removed under this remedial action alternative. Under the current development plan, this would include 16 piles located beneath the proposed drive isle on the South Parcel.

The three alternatives were evaluated based on Ecology’s criteria in MTCA, which include: protectiveness, permanence, effectiveness over the long term, management of short-term risk, technical and administrative implementability, and public concerns.

Based on the evaluation, Alternative P3 – Repurpose for Re-Use Existing Piles, was determined to have the highest environmental benefit per dollar spent, while still providing an approach that is protective of human health and the environment. The cost-to-benefit analysis is presented on Table 10. From the FS, a summary of the main elements of Alternative P3 include:

- The pile and cap and surrounding soil (approximately 1 to 3-feet bgs) will be exposed and removed and replaced with a new pile cap system;
- A new concrete foundation, reinforced with rebar spanning the repurposed piles, will be poured and connected to the piling system;
- The new concrete slab will act as a barrier from contacting the residual PAH contaminated soil that will remain after development (Engineering Control);
- An Environmental Covenant that documents and records the existence of residual PAH contaminated soil on the North Parcel will be filed with King County; and,
- Piles that would not serve a structural purpose will be removed completely, along with the halo of contaminated soil around each pile. This would include 16 piles located beneath the proposed drive isle on the South Parcel. No additional action, including Engineering Controls or Covenant will be required for this area.

4.5 CVOC Plume – Feasibility Study Summary

Each potentially applicable technology for addressing chlorinated solvents has limitations, they were initially screened for the highest likely success at the Site in accordance with guidance in WAC 173-340-350(8)(b), with an emphasis on protectiveness, permanence, as well as the ability to be integrated with a post cleanup development use of the Property:

- Monitored Natural Attenuation (MNA) was retained as a viable alternative, but only for use in combination with another technology (excavation), which would eliminate the source area.
- Soil Vapor Extraction (SVE) was retained for use in combination with other technologies (Dual Phase Extraction [DPE] and Electrical Resistive Heating [ERH]) and is intended to be an ancillary part of the treatment system to address volatized organics.
- Air sparging has been shown to be effective in treating contaminated groundwater, and so was retained for use in combination with other technologies. Air sparging could be applied as the primary treatment method to address the dissolved phase organics in groundwater.
- Traditional groundwater pump and treat was rejected because it would be operationally difficult to integrate into the residential development, creating equipment access issues, odors/vapors, and disruption of normal residential activities.
- The DPE technology was retained for consideration in use with a combination of similar technologies that are effective at addressing high concentration contaminants in groundwater.

- In-situ reactive barriers were rejected as they generally serve as a boundary treatment technology to prevent further migration of a contaminant plume.
- In-situ thermal treatment was retained because it provides permanent, expeditious and reliable treatment of CVOCs, regardless of concentration or environmental media.
- Excavation and off-Site disposal was retained because it is permanently effective and reasonable expeditious, depending on the accessibility of the impacted media.
- In-Situ Chemical Oxidation (ISCO) and In-Situ Chemical Reduction (ISCR) both appear to be viable alternatives based on the pilot test results discussed in the RIFS report; however, only ISCR was retained due to the anaerobic environment that already exists at the Site.

Utilizing the retained technologies above, five remedial alternatives were developed for further evaluation. Each of the five remedial alternatives include the excavation of shallow (6 feet bgs) CVOC impacted soil near UB15 (in the northwest corner of the southern parcel, see Figure 22). Source removal was the most permanent approach in this limited isolated area during preliminary remedial alternative screening and a feasibility level assessment was not performed. As such, the remedial alternatives evaluated for the southern portion of the Property in the FS were focused on the CVOC release from the southern dry-cleaning operation(s) only.

Below is a detailed description of each alternative along with, when appropriate, a qualitative statement of the effectiveness of the selected technologies.

4.5.1 Alternative 1 (Baseline): Excavation and Disposal of Soil with In-Situ Chemical Reduction (ISCR) using SZVI

Alternative 1 was developed as the baseline for comparison with other alternatives, as it was considered the most practicable permanent solution for the Site. Its objective was to permanently remove, through excavation, the Site's source of CVOCs in a very short timeframe, before site development begins. Following source removal by excavation, residual groundwater impacts would be treated at a relatively short time period through in-situ chemical reduction using sulfidated micro ZVI (SMZVI).

Compliance groundwater monitoring would potentially continue for about two years during or after development of the Property. The estimated cost of this alternative was $6.7 million.

4.5.2 Alternative 2: Excavation and Disposal of Soil with MNA of Groundwater

Alternative 2 objective is to permanently remove the Site's source of CVOCs in a very short timeframe, before site development begins. Following source removal by excavation, residual groundwater impacts would be managed by MNA in accordance with Ecology guidance.

The remediation timeframe after source removal for the groundwater to reach cleanup levels under MNA conditions was estimated at 10 to 15 years.

This remedial alternative also included the following elements:

- Installation of soil vapor controls in the future building;
- Periodic indoor air monitoring of the new building; and,
- Institutional Controls, such as deed restrictions due to the prolonged restoration timeframe.

The scope and cost for this alternative was not dependent on development plans, since this work would be performed either before development (excavation) or after construction of the building (MNA process). The vapor mitigation features would be integrated into the architectural designs for the building. The estimated cost of this alternative was approximately $6.9 million.

4.5.3 Alternative 3: Dual Phase Extraction (DPE) with Air Sparging (AS)

Alternative 3 applied a DPE technology to remediate soil and groundwater.

Because the recovery of CVOCs by groundwater pumping alone is generally not cost-effective, this technology is often applied in conjunction with air sparging to provide additional groundwater treatment. This alternative did not include a MNA task, as the alternative assumed that DPE would continue until soil and groundwater had achieved their Cleanup Levels.

The rate of treatment for this technology is slow and would likely to lead to a long restoration timeframe. Once the DPE equipment is in place, development in the treatment zone could not begin until cleanup goals are met.

This remedial alternative also included the following elements:

- Installation of soil vapor controls in the future building;
- Periodic indoor air monitoring of the new building; and,
- Institutional Controls, such as deed restrictions due to the prolonged restoration timeframe.

Alternative 3 installation and operation costs were estimated at $4.4 million and assumed 10 years of operation.

4.5.4 Alternative 4: Electrical Resistive Heating (ERH) with Soil Vapor Extraction (SVE)

Cleanup Action Alternative 4 utilized ERH/SVE to treat all of the Site CVOC contaminated soil and groundwater that exceeds cleanup levels in the impacted areas.

The ERH technology applies high electricity voltages to a network of subsurface electrodes, and the resistance to electrical conductance heats soil and groundwater in the treatment area between electrodes to close to the boiling point of water (100°C) when enough energy is applied. Soil vapors containing the volatilized contaminants are then collected by SVE and treated.

The ERH/SVE system would operate for a period of about 6 months, with daily/weekly/monthly operations, monitoring, maintenance, and air and water discharge compliance sampling.

This alternative did not include a MNA task, as the alternative assumes that ERH/SVE would continue until soil and groundwater had achieved their cleanup levels in the source area. Due to access issues, active ERH/SVE was not planned for impacted groundwater at the southern ROW at Genesee; however, performing cleanup of the upgradient source area would enhance the attenuation in this area within the operation timeframe.

The scope and cost for this alternative was not dependent on development plans, since this ERH would be completed prior to groundbreaking for development. The implementation of this remedial alternative assumed that post cleanup site conditions would not require vapor mitigation features for the development. The estimated cost of this alternative was $5.0 million.

4.5.5 Alternative 5: Electrical Resistive Heating (ERH)/SVE with In-Situ Chemical Treatment by Reduction/ISCR and Enhanced Reductive Dechlorination (ERD)

Remedial Alternative 5 incorporated ERH/SVE technology at the primary source area and in-situ chemical treatment by injection into the dissolved phase groundwater plume outside the primary source area to augment the enhanced biological reductive dechlorination (ERD) and degradation of the CVOCs. ISCR/ERD would be performed using the injection of electron donor chemicals into the trailing plume (e.g., downgradient of the source area) of the CVOC impacted groundwater. The assumed radius of influence for the injected chemical is 20 feet. ISCR/ERD would be use an aqueous solution of SMZVI combined with a bio-degradation enhancer compound called 3D micro-emulsion (3DME) with bio-dechlor inoculum (BDI), which is a proprietary and patented blend of oleic acids and lactates/polylactates plus an engineered dehalococcoides dechlorinating bacteria species, which are injected as an aqueous emulsion. The goal of ERH combined with ISCR/ERD is to restore the Site source soil and impacted groundwater to concentrations that are below the Site cleanup levels within a reasonable timeframe (before development construction) and not require long term monitoring (e.g., MNA) .

The ERH/SVE with ISCR system was anticipated to occur over a total 8 to 12-month period, which would include two rounds of ISCR injection events.

The scope and cost for this alternative was not dependent on development plans, since the work would be completed before development begins. Compliance groundwater monitoring could continue during or after development of the Property. The estimated cost of this alternative was $3.2 million.

4.6 Evaluation and Selection of Remedial Alternative

A comparative benefit analysis was performed for the five remedial alternatives in accordance with WAC 173-340-350(8) and WAC 173-340-360[3][f], which resulted in the following comparative benefit scores:

- Alternative 1 – 8.4
- Alternative 2 – 6.3
- Alternative 3 – 4.2
- Alternative 4 – 6.8
- Alternative 5 – 7.4

The analysis indicates that Alternative 1 has the highest benefit to the environment, however this is prior to consideration of cost.

Cost. The relevant project cost to consider for evaluation includes the cost of design, construction, operation and maintenance and long-term monitoring. Cost estimates for treatment technologies shall describe pretreatment, analytical, labor, and waste management costs. The design life of the cleanup action shall be estimated, and the cost of replacement or repair of major elements shall be included in the cost estimate.

The total estimated life-cycle costs (e.g., design, implementation, O&M and closure) for Alternatives 1 through 5 were estimated as follows:

- Cleanup Action Alternative 1— Excavation and Disposal of Soil with Treatment of Residual Groundwater using ISCR: $6.7 million. This alternative represented the second highest cleanup cost, although this cost was essentially equal to Alternative 2.
- Cleanup Action Alternative 2— Excavation and Disposal of Soil with Monitored Natural Attenuation of Groundwater: $6.9 million. This alternative represented the highest cleanup cost.
- Cleanup Action Alternative 3 – Air Sparge/Soil Vapor Extraction (AS/SVE) and Groundwater Extraction (Dual Phase Extraction): $4.4 million. This alternative represents a relatively moderate cleanup cost.
- Cleanup Action Alternative 4— Electrical Resistive Heating (ERH): $5.0 million. This alternative represented a relatively moderate to high cleanup cost.

- Cleanup Action Alternative 5— Electrical Resistive Heating (ERH) with In-Situ Chemical Treatment: $3.2 million. This alternative represented the most moderate cleanup cost. The cost was less than Alternative 4 due to the focusing of the ERH treatment within the primary source area and implementing a more cost effective but successful technology (ISCR) within the dissolved phase plume.

Utilizing the comparative benefit scores and estimated costs, a DCA was conducted in general accordance with methodology provided by Ecology WAC 173-340-360(3)(e). A benefit-to-cost ratio was developed for each alternative by dividing the numeric comparative benefit score total by the estimation of cost (in millions). The larger value is considered greater benefit per dollar spent. Tables 11 and 12 provide a summary and graphic representation of this relationship. The results of the DCA showed that Alternative 5 – ERH/SVE with ISCR/ERD is the preferred remedial alternative for the Site.

5.0 Preferred Remedy from FS Summary

5.1 CVOCs in the Southern Portion of the Site

Alternative 5 is the preferred alternative resulting from the DCA. It includes the application of ERH/SVE to the primary source area of highest soil and groundwater contamination and the injection of chemical treatment in the dissolved portion of the groundwater plume. The results of the ISCO and ISCR pilot tests discussed within the RI/FS Report also confirmed the use of injection technology into the dissolved phase contaminants in the sand aquifer reaches the desired radius of influence.

Monitoring well data shows the presence of PCE degradation products in the monitoring wells downgradient from the primary source area. The average dissolved oxygen and oxidation reduction potential content in the dissolved phase plume area shows anaerobic conditions that could readily be enhanced. Based on these factors, an in-situ injection technology involving SMZVI to support and continue the ZVI process from the ERH electrodes, coupled with injection of 3DME/BDI solutions to enhance the biological degradation activity already present at the Site was selected for the ISCR injectates. Additional details of this enhanced reductive dechlorination process are presented in Section 6.1.2 below.

5.2 PAHs in the Northern Portion of the Site

The selected remedy for the PAHs in the northern portion of the Site is Alternative P3 – repurposing of the existing piles for reuse as the foundation support for the slab-on-grade floor of the planned building. The existing pile caps and surrounding shallow contaminated soil will be removed to prepare the piles for reuse. The selection of this remedial alternative will require a covenant on that portion of the development site.

Piles that do not serve a structural purpose for the new development, such as those in the drive-aisle area of the southern parcel, the remedy is large diameter auger excavation and full removal of piles and impacted soil as a performance based remedial action.

5.3 PCE Contaminated Soil in the Area around UB -15

The shallow soil in and around boring UB-15, which contains PCE above cleanup levels, have been bounded using soil data from UB27, UB28, UB29, and B10. The impacted material is less than 6-feet deep. The soil in this area will be excavated and properly disposed. Subsequently, soil confirmation samples will be collected to show compliance in this area (Figure 22).

6.0 Description of the Cleanup Action Plan

This section presents the Ecology selected cleanup action for the site. These are the components that will be implemented in order to cleanup and confirm the remediation of soil and groundwater beneath the site containing concentrations of COCs exceeding the cleanup levels. More specific plans including the basis for design for ERH, and for the ISCR groundwater treatment are provided in technical supporting documents from selected remedial subcontractors in Appendices A and B, respectively. Compliance monitoring is required for all cleanup activities.

The final design of the ERH system, ISCR/ERD treatment program, excavation, and pile and surrounding soil removal will be presented in an Engineering Design Report (EDR). The EDR will be prepared prior to initiating cleanup construction activities.

6.1 Cleanup Action Components

6.1.1 Electrical Resistive Heating/Soil Vapor Extraction (ERH/SVE)

The ERH/SVE system will encompass approximately 9,000 square feet and consist of 54 electrodes and 8 temperature monitoring points (TMPs) that will be installed at the approximate locations shown on Figure 19. The planned uniform spacing for electrodes is approximately 15-feet in the full treatment area, but the electrode depths vary by treatment interval, from 10 to 35 feet bgs in the center of the primary source area – Area A (green), from 10 to 30 feet bgs in Area B (red), and from 10 to 20 feet bgs in Area C (brown) to the north. The treatment intervals are consistent with the intervals in which CVOCs were detected during the Site investigation.

The electrodes are comprised of a conductive, and permeable backfill material with copper wires placed at intervals in the un-cased backfill material, as shown in a schematic of the electrode construction provided in Appendix A. The backfill material in each electrode consists of ZVI filings and granular iron shot mixed with graphite as filler. The electrodes serve to heat the impacted soil and groundwater area for the ERH/SVE treatment as described below. The ZVI component of each electrode also functions to promote the electrochemical abiotic reduction of chlorinated contaminants to benign, non-toxic end products (ethene and chlorine ions), as shown in the following chemical equations:

$Fe^{o} \rightarrow Fe^{2+} + 2e(-)$ and PCE + 8e(-) + 4H(+) → Ethene + 4 Cl(-)

The ZVI electrochemical treatment of dissolved phase chlorinated solvents is on-going after ERH energy is turned off, and the electrode system in the treatment area serves as a long-term groundwater polishing stage to address potential irregularities of the ERH treatment process.

In the ERH/SVE stage of treatment, soil and groundwater is heated to an average temperature of approximately 100 degrees Celsius to convert the CVOCs to vapor phase for subsequent recovery by soil vapor extraction at the top of each electrode. During heating, the subsurface temperature is constantly monitored at the TMPs located within the treatment area. As shown in the electrode diagram, steel pipes under vacuum are installed at the top of each electrode for the collection of generated soil vapor. These vacuum extraction pipes capture and convey soil vapor and steam from the subsurface treatment area to an on-site, above-ground and secure treatment building. The treatment building consists of a power control unit (PCU), steam condenser, two SVE blowers and carbon units to treat the recovered condensate and soil vapor generated by the vacuum system. The carbon treated condensate water is returned to the electrode system to keep the soil treatment area moist, and facilitate additional vapor recovery processes.

ERH Construction Activities

TRS Group is a company that specializes in thermal remediation technologies. TRS will be directing the design, installation, operation, and removal of the ERH system. The following major activities will be planned and completed in sequence to perform ERH treatment of soil and groundwater within the indicated area:

- ERH construction drawings will be finalized and used for bidding electrode and temperature monitoring probe installation as per the TRS plan. Bids for installation will be obtained from licensed drillers;
- A thermal treatment system Operations and Maintenance Plan (O&M Plan) will be prepared;
- A suitable power drop for the system design will be permitted and installed under SCL oversight;
- Air permit and treated water discharge permits will be obtained;

- Traffic control plans and street use permits will be obtained as required for planned ROW activities, such as loading and unloading of equipment, and removal of excavated soil;
- Mobilization of equipment and materials will commence once suitable site security fencing and monitoring surveillance with trespass sensors are installed;
- Waste containment/storage bins will be supplied to collect/store drilling cuttings from installation of electrodes in the ERH treatment area;
- Two additional monitoring wells will be installed with stainless steel well screens in the ERH treatment are for compliance monitoring;
- Completed electrodes and TRS power control units will be tested and approved with SCL participation; and,
- An interlock security connection will be made from security monitoring sensors and the ERH PCU to prevent contact voltage with trespassers or unauthorized access.

System Start Up

Once all system components are installed and checked, the following protocol will be completed to initiate ERH treatment:

- Complete third-party electrical inspection (if required, by SCL);
- Provide and install flow measuring devices and vacuum gauges to ensure data collection outlined in this technical approach. Please note: flow cannot accurately be determined in pipes or other locations containing steam;
- Supply vapor-phase granular activated carbon (VGAC) vessels for vapor treatment. TRS will provide design specifications for vessels at completion of 100 percent design;
- Supply two 200-pound liquid-phase granular activated carbon (LGAC) vessels for liquid treatment;
- Provide design specifications for vapor-phase carbon treatment;
- Equipment operational verification;
- Data acquisition verification. TRS will confirm that all electronic data collection is occurring according to the design;
- ERH system interlock verifications and safety checks;
- ERH system voltage safety checks and required corrections;

- Pre-start-up equipment function testing; and,
- Completion of Start-up Checklist. TRS safety procedures require completion of an extensive checklist before the first application of ERH power to the treatment volume, including:
    - Site access controls, security system components and confirmation of interlock testing of the operations system in the event of a security breach;
    - Site-specific hazards and mitigation techniques;
    - Inspection of all emergency response equipment and completion of training for all project team members (both TRS and non-TRS staff) on emergency response;
    - TRS will provide written notification to Rainier & Genesee, LLC, that TRS must be notified before any digging occurs on the Site or within 50 feet of the property;

      This "pre-dig" requirement is also described on warning signs that TRS will post on the remediation area fence at the Site; and,
    - TRS will need to periodically complete testing to confirm that surface voltages are safe for public access. These measurements will be made within 20 feet of the treatment area.

System Operations, Monitoring, and Reporting

Once installation and system startup operation checks and testing are completed, power application to the treatment area will be continuous (24 hours/7 days) except for system adjustments, maintenance, or scheduled soil and groundwater performance/compliance sampling events, until the performance goals are accomplished. The SVE system will be operated for approximately 14 days following electrical shutdown to the ERH probes. Shut-down of the SVE system will be based on assessment of the air monitoring results of the influent air concentrations.

The following monitoring and reporting operations will be completed during the ERH treatment period:

- ERH system application verification. TRS will confirm through manual readings that energy application is occurring according to the ERH system design. TRS will continue to optimize the approach throughout operations;
- Establishment of baseline vapor recovery flow and subsurface vacuum conditions;
- Provide operational oversight and monitoring of the heating, vapor capture, and temperature monitoring systems. TRS will collect and record temperature readings at least once a day;

- On-site checks, including electrode current surveys and voltage safety surveys will occur weekly;
- ERH Equipment maintenance, including PCU, condenser, and blower, and TRS-owned liquid carbon treatment vessels. UEP is responsible for maintaining the vapor carbon treatment equipment;
- Provide Bi-weekly operational status reports provided in electronic format. Reports include temperature, power, energy, and condensate rates along with recommendations for performance sampling and system optimization;
- Provide estimation of the appropriate schedule to collect performance soil and groundwater samples. Each TRS weekly report will include an updated estimate of the optimal time to conduct the next round of groundwater and soil sampling events;
- Provide alarm or emergency response. In the event of an emergency situation, TRS will either respond in person or direct emergency responders to the Site within 4 hours. TRS will identify and appropriately respond to non-emergency alarm conditions within 48 hours; and,
- Coordinate change-out of VGAC after a vessel show signs of breakthrough, and change-out of the LGAC after the first vessel shows signs of breakthrough. Prior to the first change-out event for both VGAC and LGAC, UEP staff will collect a sample for analysis for profiling and disposal. TRS expects change-outs to occur with the system shut down for less than 8 hours.

Demobilization and Final Reporting

The power inputs to the ERH system will be turned off when groundwater data for indicated compliance monitoring wells in the ERH treatment area are confirmed to meet MTCA Method A cleanup levels. Approximately 60 days from ERH completion and power cut-off, demobilization of the TRS treatment system will be initiated. The field activities and reporting will include the following:

- Power cables and all power control units and other TRS operations equipment will be removed;
- The SVE components of each electrode will be removed and annular space will be grouted;
- The subsurface component of the ERH electrodes containing ZVI and graphite will be left to continue as an ISCR groundwater treatment polishing step;
- TRS will prepare a final report that summarizes the ERH system installation, power application to the subsurface over time, subsurface temperatures over time, and CVOC

extraction data. The report will include the following information, records, and measurements:

- As-built drawing package;
- Site background and construction description;
- Total energy application;
- Power delivery and energy usage summaries;
- Temperature profiles at various points during operations;
- A summary of pneumatic control throughout operations;
- Vapor stream parameters including flow, vacuum, and volume;
- Condensate production, blow down discharge, and water balance;
- Any major operational changes;
- Soil result analysis (based on samples collected and analytical results provided by others); and,
- Tabulated analytical data and mass removed calculations.

Summary of ERH Plan

After installation of the electrodes, TMPs, and the vapor extraction mechanical and treatment equipment, the system will undergo startup and testing. After system testing, electrical power will be applied to the Site ERH treatment zone continuously except during system adjustments and routine maintenance. Thermocouples in the TMPs will be monitored continuously using the PCU and remote monitoring systems, to allow power distribution adjustments to effect even soil heating. The PCU is a variable transformer system capable of providing three simultaneous power outputs and automatically adjusting applied voltages. During operations, the heating contractor will monitor the system remotely and perform site visits every other week for visual inspection and maintenance of the ERH components of the system. Additional trips would be made as necessary to ensure that the ERH system is functioning efficiently and effectively, as designed. Upon completion of design heat temperature and electrical power inputs, confirmation monitoring will be completed.

The total treatment time for ERH is expected to be between 140 and 180 days to achieve the cleanup levels.

6.1.2 In-Situ Chemical Reduction/Enhanced Reductive Dechlorination (ISCR/ERD)

ISCR/ERD is a process that involves the injection of electron donor chemicals into groundwater and/or soil for the purpose of rapid contaminant destruction, first with electrochemical reduction by ZVI contact, and then biological degradation by enhanced bacterial action. Regenesis is the supplier of SMZVI and 3DME/BDI and the anticipated vendor for injecting the treatment chemicals to accomplish ISCR/ERD. Technical documents regarding this technology provided by Regenesis is included in Appendix B.

The proposed ISCR/ERD application treatment areas are shown on Figure 19. The primary treatment area downgradient of the source area measures approximately 6,000 square feet with a treatment thickness of up to 15 feet in the saturated sand layer. A total of 6,000 pounds of SMZVI and 6,000 pounds of 3DME/BDI will be injected into approximately 19 injection points/wells as shown with their overlapping radius of influence. The concentrated injectates will be mixed on site with potable water for a total injection volume of 18,000 gallons, or about 950 gallons per injection point. The product application will target an injection interval within the sand channel approximately 20 to 35 feet below ground surface, from the southern edge of the ERH treatment zone to the south property line at South Genesee Street. In addition to the downgradient groundwater plume, ISCR/ERD will be used to target several smaller areas of groundwater contamination. These include:

- Two injection points near monitoring well MW08 along Rainier Avenue South with a total injection volume of about 2,000 gallons;
- Two injection points near monitoring well MW17 in the middle of the site with a total injection volume of about 2,000 gallons; and,
- Three injection points near monitoring well MW20 on the south side of South Genesee Street with a total injection volume of about 3,000 gallons.

The depth interval for injection at smaller areas will depend on the subsurface conditions observed during drilling of the injection wells, and depth of observed contamination from previous explorations.

The 19 injection point locations are anticipated to be installed using direct push drilling methods with the injection points consisting of 1-inch diameter schedule 40 PVC or stainless steel depending on their proximity to the ERH treatment area. We anticipate that the primary injection area in the sand channel would be injected into at a rate of 4 to 8 gallons per minute and at pressures between 5 to 20 psi at the wellhead. During the full ISCR treatment, at least 4 injection points will be injected into simultaneously. For the other injection areas to be treated by ISCR/ERD, we anticipate the flow rates will be lower and injection pressures higher depending on the soil conditions at each location. The injection project is estimated to take up to 10 field days to complete.

Injection methodology will be similar to that used during the pilot tests discussed in the RI/FS Report, with up to 4 injections performed simultaneously to better control the distribution of SMZVI and 3DME/BDI in the subsurface.

Injection for the main area of ISCR/ERD within the sand channel will start at the downgradient edge of the groundwater plume along South Genesee Street, and along the east boundary, and move northward toward the center of the Site for the subsequent injection rows. The goal of this injection sequencing is to start the injection rows from the downgradient side of the plume, and proceed with injections moving in the upgradient direction, which will reduce the potential for the injection process to cause any plume migration in the downgradient direction.

The field injection will be performed using similar equipment and procedures utilized during the pilot tests. Specific target depths, pressures, and flow rates at each injection point will be assessed at the time of injection. Optimal injection conditions will be present within the Recessional Outwash sand channel observed at a depths ranging from approximately 20 to 35 bgs, which corresponds to the distribution of contamination down-gradient of the source area.

During ISCR/ERD injection, existing monitoring wells that have not been utilized for injection will be periodically monitored to observe the progress and radius of influence of the injection; specifically, this involves visual observations for discoloration of groundwater, indicating the presence of injectate, and monitoring of DO and ORP values.

6.1.3 PAH Contaminated Soil Remediation

The proposed remedy for addressing the creosote treated piles beneath the existing retail structure is to repurpose the serviceable, existing wooden piles into the structural system for the slab-on-grade concrete floor of the planned new building on the north portion of the Property. However, piles that are located outside of the footprint of the new development, which do not serve a structural purpose, will be removed as discussed below.

Figure 20 depicts the location of the 16 piles present in the proposed drive isle and Figure 21 illustrates the methods to be used to remove the piles and associated halo of contaminated soil. After the former Safeway building and floor slab are demolished, the extent of PAH impacts in soil around the piles in the drive aisle will be confirmed by representative sampling using geoprobe borings as shown on Figures 20 and 21. At each proposed location for Borings UB43, UB44, and UB45 on the figures, a 2-inch soil core will be collected at a vertical distance of 5-feet bgs, and at a horizontal distance 6 inches away from the outer edge of the pile as illustrated on Figure 21. For example, if the pile is 2 feet (24”) in diameter as illustrated, then the soil core will be collected at a distance of 18-inches to 20-inches from the center of the pile, placing the sample adjacent to the outside diameter of a 3-foot diameter caisson, and 6-inches away from the outer edge of the pile. The soil samples collected in this manner at UB43-45 will provide soil confirmation data for the removal of treated piles and impacted soil in the drive aisle area of the parcel.

After soil confirmation samples are collected, each pile within the drive isle will then be extracted using a vibration hammer clamped to the pile, which will be vibrated out of the ground to full removal. Next a large diameter caisson pipe will be vibrated down around the pile extraction hole. As shown on the Figure 21 insets, a large diameter augur will advance through the caisson to remove the halo of impacted soil to a stockpile and then off-site to proper disposal. The soil removal process by auger is facilitated by the caisson. After soil removal, the caisson is slowly extracted by the vibration hammer as controlled density fill (CDF) is placed in the augured opening. The caisson controls sidewall caving in the saturated zone, and keeps the drilled pile hole open for complete filling to depth.

This field method of using pile extraction and contaminated soil auguring facilitated by a caisson pipe does not allow access to the sidewalls for each pile that is removal. Consequently, the soil confirmation samples will be acquired before pile removal at the outer limit of the planned caisson, using the exploration method as described above, and as presented on Figures 20 and 21.

6.1.4 Excavation of PCE Contaminated Soil in the Area at UB-15

Shallow soil containing PCE to approximate depths of 6-feet bgs in this location will be excavated with conventional means and transported as Contained-In Waste to an appropriate municipal Subtitle D landfill, permitted to accept this material. The extent of the excavation will be confirmed with performance/compliance soil samples in all four sidewalls and the bottom of the excavation. Impacted soil will be removed until remaining soil meets the cleanup levels.

6.1.5 Engineering Controls

The selected remedy for the CVOC plume is intended to meet cleanup levels for unrestricted land use. If confirmation monitoring indicates cleanup levels have been met, no engineering controls are proposed for this area of the Site. If confirmation monitoring has not been completed before redevelopment begins, a vapor barrier and passive venting will be incorporated into building design plans.

The concrete slab on grade for the future building in the area of the existing former Safeway structure is intended to act as a barrier to direct contact exposure to PAH contaminated soil left in place.

6.1.6 Institutional Controls

Areas of the Site where contamination is left in place above cleanup levels will require an environmental covenant (EC). The EC will restrict excavation activities in the vicinity of known contamination and will restrict the use of groundwater for any purpose without prior authorization from Ecology.

As discussed in Section 4.3, the Property has been separated into two, legal parcels with a lot line boundary adjustment as shown on Figure 17 (North Parcel and South Parcel). Under this proposed cleanup plan, no contamination will remain above cleanup levels on the South Parcel, therefore only the North Parcel is planned to be subject to an EC. If CVOC concentrations on the South Parcel are detected in excess of Method A Cleanup Levels during confirmation monitoring, an environmental covenant may be required on the South Parcel until cleanup levels are met.

6.1.7 Project Timeline

The remedial cleanup as described has numerous component activities that will take about 12 months to complete, including final design, mobilization, and implementation. The ISCR GW injection phase will come first. The soil removal at UB15, and then the ERH treatment in the source area will follow the ISCR injection. The pile removal in the drive aisle will be integrated with development activities in the South Parcel. A tentative project schedule for the component activities of the remedial process is provided as Appendix D. It should be noted that the scheduled start date is driven by the completion of a prospective purchaser consent decree (PPCD), and is therefore subject to change.

7.0 Compliance Monitoring

There are three types of compliance monitoring identified for remedial cleanup actions performed under MTCA (WAC 173-340-410): protection, performance, and confirmation monitoring. A paraphrased definition for each is presented below (WAC 173-340-410[1]).

- **Protection Monitoring**—To evaluate whether human health and the environment are adequately protected during construction and the operation and maintenance period of an interim action or cleanup action.
- **Performance Monitoring**—To document that the interim action or cleanup action has attained cleanup standards.
- **Confirmation Monitoring**—To evaluate the long-term effectiveness of the interim action or cleanup action once cleanup standards or other performance standards have been attained.

7.1 Protection Monitoring

A Site-Specific Health and Safety Plan (HASP) will be prepared for the cleanup action that meets the minimum requirements for such a plan identified in federal (Title 29 of the Code of Federal Regulations) and state regulations (WAC 296). The HASP identifies known Site hazards and monitoring protocols to mitigate these hazards for on-Site workers. The plan will also address the concern over the potential for large-scale vapor transport within adjacent sewer conduit during ERH operation. Increased CVOC concentrations in sewer gas are not anticipated given the limited operational downtime of the ERH vapor capture system and understanding that the side sewer lines on the Property have been previously capped; however, this will be verified with empirical data.

During operation of the ERH system, sewer gas samples will be collected at the locations shown on Figure 5 (Sewer North and Sewer South) to assure that the CVOC volatilization is not producing a vapor encroachment condition for adjacent structures. This sampling will be conducted on a bi-weekly basis using the methodology discussed below:

The sewer gas samples will be prepped for collection by lowering a section of rigid inert tubing to the approximate depth of each sewer main (~10 feet bgs).

The samples will be collected utilizing 1-liter Summa canisters fitted with flow regulators calibrated to a rate of between 150 to 200-milliliters per minute (ml/min).

The gas samples will be analyzed for target list VOCs by EPA Method TO-15 and concentrations will be compared to MTCA Method B Screening Levels for sub-slab soil gas.

7.2 Performance Monitoring

Performance monitoring includes the collection of soil samples from within the ERH/ISCR Treatment Areas in representative areas to show that treatment of soil is being accomplished by the remedial methodology. Performance monitoring for soil conditions will be conducted in the primary source area during the operations of the ERH treatment period.

7.2.1 Soil Performance Monitoring

Performance monitoring for ERH treatment will be conducted throughout the treatment period by daily monitoring of the temperature probes recording the soil treatment process, and by regular testing of CVOC content in the SVE condensate. When the temperature monitors for the treatment area show that average soil temperatures have met a temperature of 88 degrees Centigrade (~ 190 degrees Fahrenheit), then 2 performance borings will be drilled within the central core area of the ERH treatment area to test soil and check ERH treatment progress. Soil samples will be collected in the two soil borings to depths of 30 feet in the approximate locations shown on Figure 22.

<u>Sampling Methods</u>

Soil sample collection will follow the TRS protocol supplied as Appendix C.

<u>Sample Analysis</u>

Soil samples will be submitted to an Ecology-accredited analytical laboratory for the following analytical methods:

- CVOCs by EPA Method 8260C

Concentrations will be compared to the MTCA Method A cleanup levels for soil (Table 740-1 of WAC-173-340). The laboratory detection limits will be sufficient to detect the COCs at concentrations at, or below the MTCA cleanup levels.

7.2.2 Groundwater Performance Monitoring

Pre-Treatment Monitoring Round

Prior to groundwater treatment by ERH and ISCR, all existing wells on the Property within the Site (inclusive of MW20) will be sampled to establish pre-treatment groundwater baseline conditions. For performance and compliance purposes, the existing monitoring wells MW02, MW03, MW04, MW06, MW07, MW10, MW11, MW20, MW25, MW30 and MW31 as shown on Figure 23 will be tested for CVOCs.

In addition, for performance and compliance sampling, two additional monitoring wells will be installed in the ERH treatment area (MW36 and MW37, constructed with stainless steel well screens and riser pipes to withstand ERH temperatures), and one additional PVC monitoring well (MW38) will be installed in the ISCR area. Locations of these 3 additional compliance monitoring wells are shown on Figure 23.

Groundwater Performance Monitoring Round

Performance monitoring will commence once multiple lines of evidence indicate that the ERH remediation is complete. Multiple lines of evidence include, but are not limited to, subsurface temperatures, PCE vapor extraction rates, and performance monitoring results. Wells to be sampled will include those sampled in the pre-treatment monitoring round (Figure 23). When the analytical data results from the performance monitoring has met MTCA Method A cleanup levels, the data will indicate that the remedial action objectives (MTCA Compliance) have been achieved. If the first round of performance monitoring does not indicate cleanup to remedial action objectives, the ERH runtime will be extended based on monitoring results. Additional performance monitoring will be completed as necessary to show remedial action objectives have been met.

Groundwater Sampling Methods

Groundwater well purging and sampling will be performed using the TRS hot water sampling protocol as provided in Appendix C. This is to ensure that sampling methodology is consistent with those utilized during ERH operations.

The general procedures to be followed are described below:

- Connect ¼-inch Teflon sample tubing from a pre-installed valve on the head of the well, to a cooling coil and place the coil in a bucket or cooler with ice to form an ice bath.

- Connect a pump to the cooling coil and connect the cooling coil discharge tubing to a flow-through cell with calibrated meter probes/sensors securely held in the flow-through cell.
- Connect tubing from the discharge of the flow-through cell to the purge water collection bucket.
- Groundwater samples will be collected following stabilization of temperature, pH, specific conductance, turbidity, dissolved oxygen, and oxidation-reduction potential. If the monitoring well is completely dewatered during purging, samples will be collected when the groundwater in the well has recovered to at least 80 percent of the pre-purge casing volume.
- Each sample container will be labeled with the date and time sampled, well identification number, project number, and preservative(s), if any. All sample collection information will be documented on a sample COC form; the sample will be placed in a cooler chilled to near 4 degrees Celsius and transported to the laboratory. The COC protocols will be maintained during sample transport and submittal to the laboratory.
- Purge water will be temporarily stored in an appropriately labeled container at the Property pending receipt of waste profiling results. An estimated volume of 10 gallons of purge and decontamination water is anticipated to be generated during each performance sampling event.
- Non-reusable sampling and health and safety supplies and equipment will be disposed of in an appropriate waste dumpster at the Property.
- The well cap and monument will be secured following sampling. Damaged or defective well caps or monuments will be noted and scheduled for replacement, if necessary.

<u>Sample Analysis</u>

Samples will be submitted to an Ecology-accredited analytical laboratory, on a standard turnaround time. Groundwater performance and confirmation samples will be analyzed for CVOCs by EPA Method 8260C.

Concentrations will be compared to MTCA Method A cleanup levels for groundwater (Table 720-1 of WAC-173-340) to evaluate the groundwater conditions beneath the Site.

7.3 Confirmation Monitoring

Confirmation monitoring will commence a minimum of three months following ERH system shutdown.

7.3.1 Soil Confirmation Monitoring

Groundwater quality will be used to empirically demonstrate that soil compliance has been achieved at the Site. Monitoring wells MW25, MW31, MW36, and MW37 will be used as the compliance monitoring locations for the ERH treatment area; while monitoring wells MW02, MW03, MW04, MW06, MW10, MW11, MW20, MW30, and MW38 will be used as compliance monitoring locations for the ISCR treatment area.

The groundwater quality for the Site will serve as empirical evidence that soil compliance conditions have been met.

To confirm that cleanup levels have been achieved, the concentrations of COCs will be compared to their respective cleanup levels and, if applicable, evaluated in accordance with the Ecology document *Statistical Guidance for Ecology Site Managers* (Ecology 1992). As detailed in the guidance, confirming whether the Site is clean is based on a comparison of the 95th percent upper confidence limit on the mean (UCL_{95}) with the defined cleanup level. Each sample collected will be analyzed at detection limits low enough to detect compliance with the cleanup levels. The resulting data will then be tested for conformance with distributional assumptions (normal versus lognormal) and the UCL_{95} calculated based on the methods described in Ecology's 1992 guidance document.

If the UCL_{95} for a specific chemical does not exceed the cleanup level, then the Site is considered clean; otherwise, it is still considered contaminated. The Site is considered clean when the UCL_{95} for each COC is less than its respective cleanup level.

7.3.2 Groundwater Conformation Monitoring

Once the performance monitoring suggests that the MTCA compliance has been met, groundwater samples will be collected on a quarterly basis from each compliance monitoring well (same wells as the Pre-Treatment monitoring round) as shown on Figure 23. During ERH treatment and then the subsequent development construction, the indicated monitoring wells will be protected, or if damaged, replaced. Monitoring well MW03 will be used as an upgradient well for compliance evaluation. Sampling and analytical methods will be the same as for the performance monitoring (Section 7.2.2).

Once four consecutive post-remediation groundwater sampling events are completed with CVOC concentrations below the established cleanup levels are obtained, groundwater beneath the Site will be considered to have met the point of compliance.

7.3.3 Soil Vapor Conformation Monitoring

After the ERH treatment and ISCR injections, and prior to development activities, two soil vapor probes will be advanced within the footprint of the future structure. The probes will be positioned adjacent to historical exploration points that exhibited the highest levels of pre-remediation groundwater contamination within the two remediation areas: MW31 within the ERH treatment area, and MW30 within the ISCR treatment area.

The two soil vapor probes will be advanced using an electric rotary impact drill, equipped with a 1-inch spline bit. The borings will be advanced to depths of approximately 12-16 inches below bgs. Rigid 3/16-inch inch tubing will be cut to length and inserted to the bottom of the borings. Sand will then be poured into the holes around the tubing and hydrated granular bentonite chips will be used to seal the top of the holes from the atmosphere. The existing air within the tubing and core annulus will then be purged prior to sample collection and a tracer gas shroud, utilizing isopropyl alcohol, will be placed around the boring locations to evaluate the potential for surface breach/ambient interference.

The samples will be collected utilizing 1-liter Summa canisters fitted with flow regulators calibrated to a rate of between 150 to 200 ml/min.

The soil vapor samples will be analyzed for target list VOCs by EPA Method TO-15 and will be compared to MTCA Method B Screening Levels for sub-slab soil gas.

Once COC concentrations in soil vapor are below applicable screening levels, no further mitigation measures would be necessary.

7.3.4 Contingency Actions

Contingency cleanup action will be implemented if analytical data indicates CVOC contaminants in excess of cleanup levels remain at the site following four post-remediation sampling events. The contingency cleanup will include additional targeted ISCR injections to breakdown remaining contamination. If contingency cleanup action is required, confirmation groundwater monitoring will resume a minimum of 3 months following the injection event.

8.0 References

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- U.S. Geological Survey, 1955, *Washington – Seattle Quadrangle 1908 Topographic Map*, Washington D.C., U.S. Department of Interior, 1955.
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Exhibit A: Figures

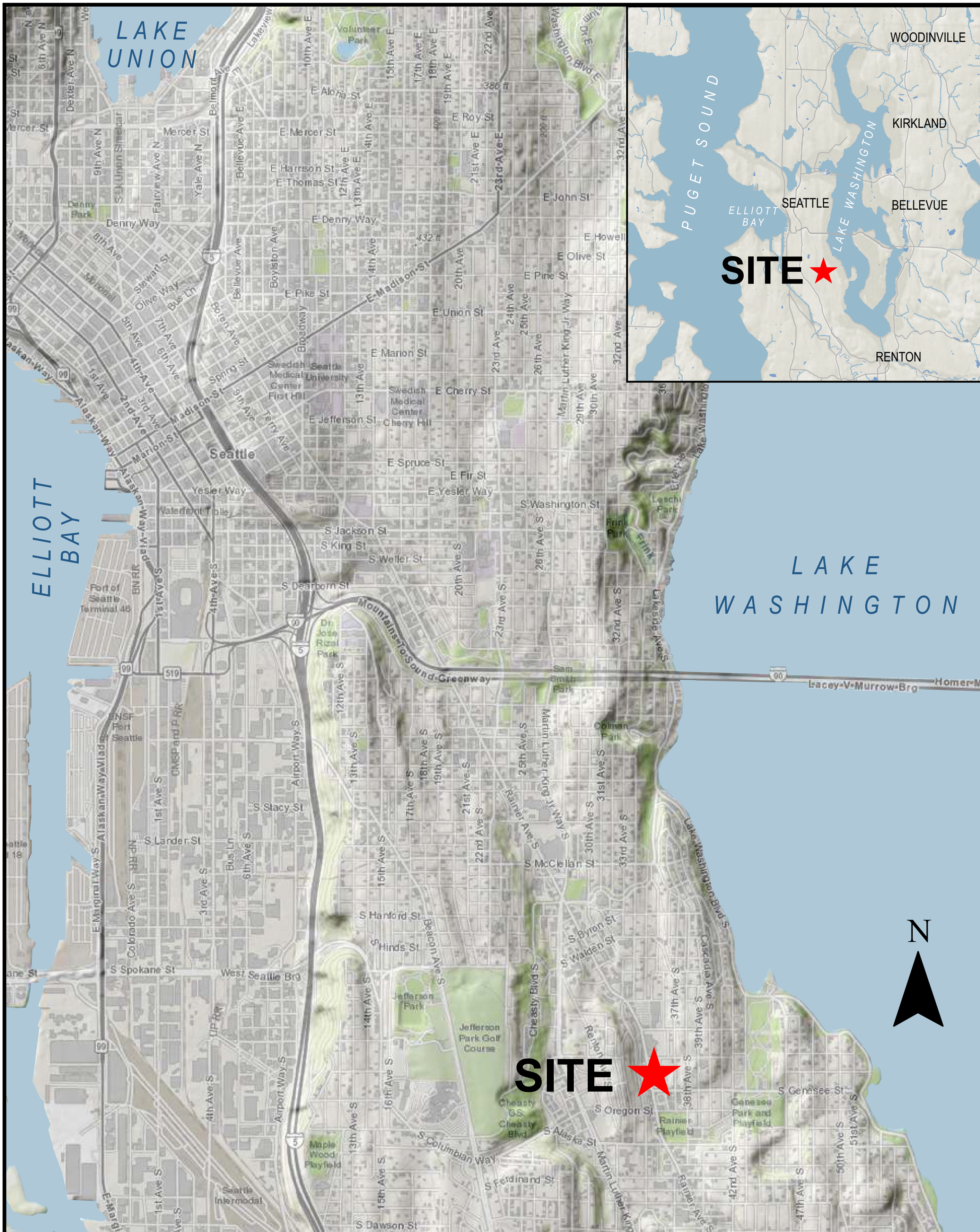

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Figure 1
Site Location Map

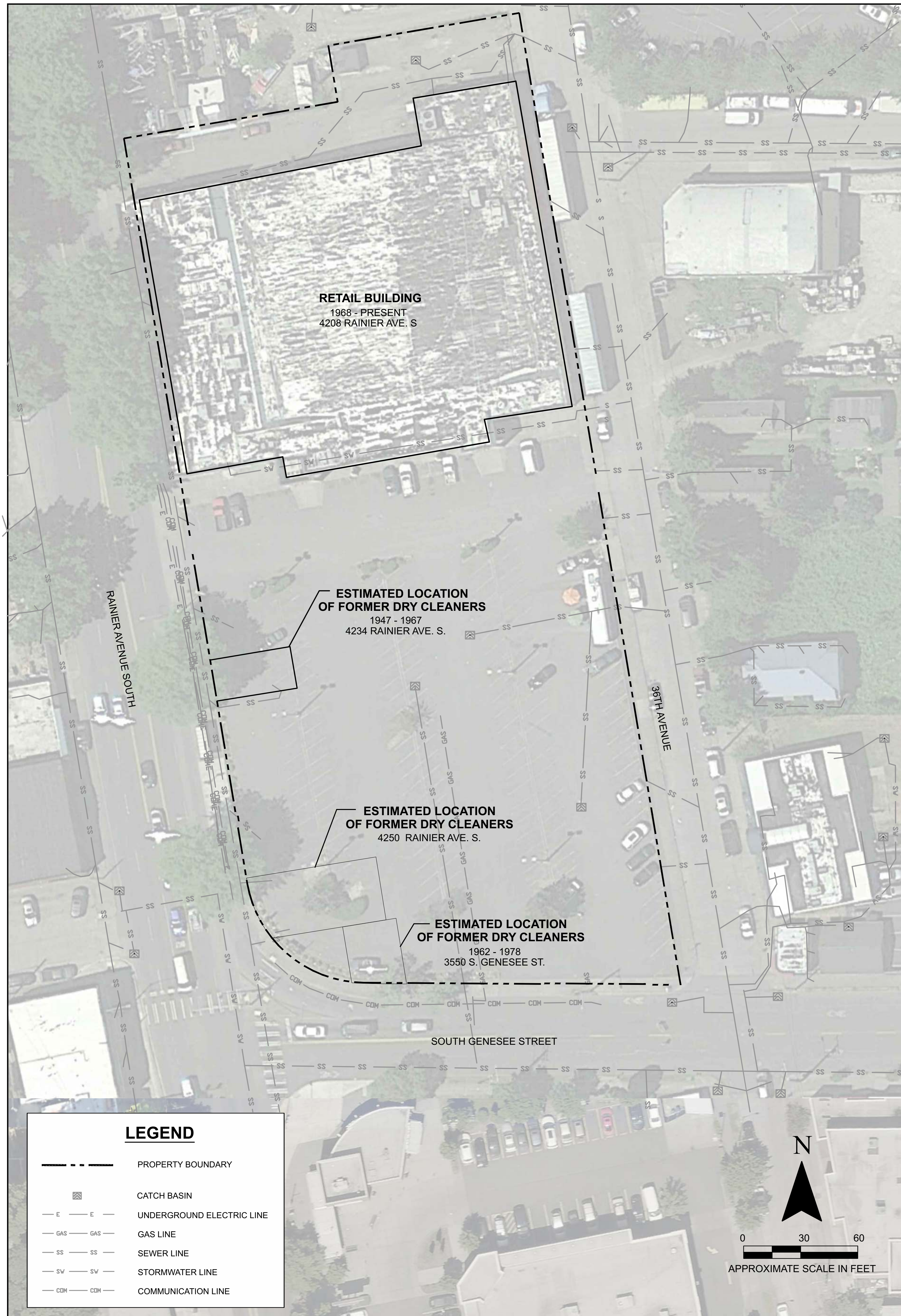

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Figure 2
Site Features

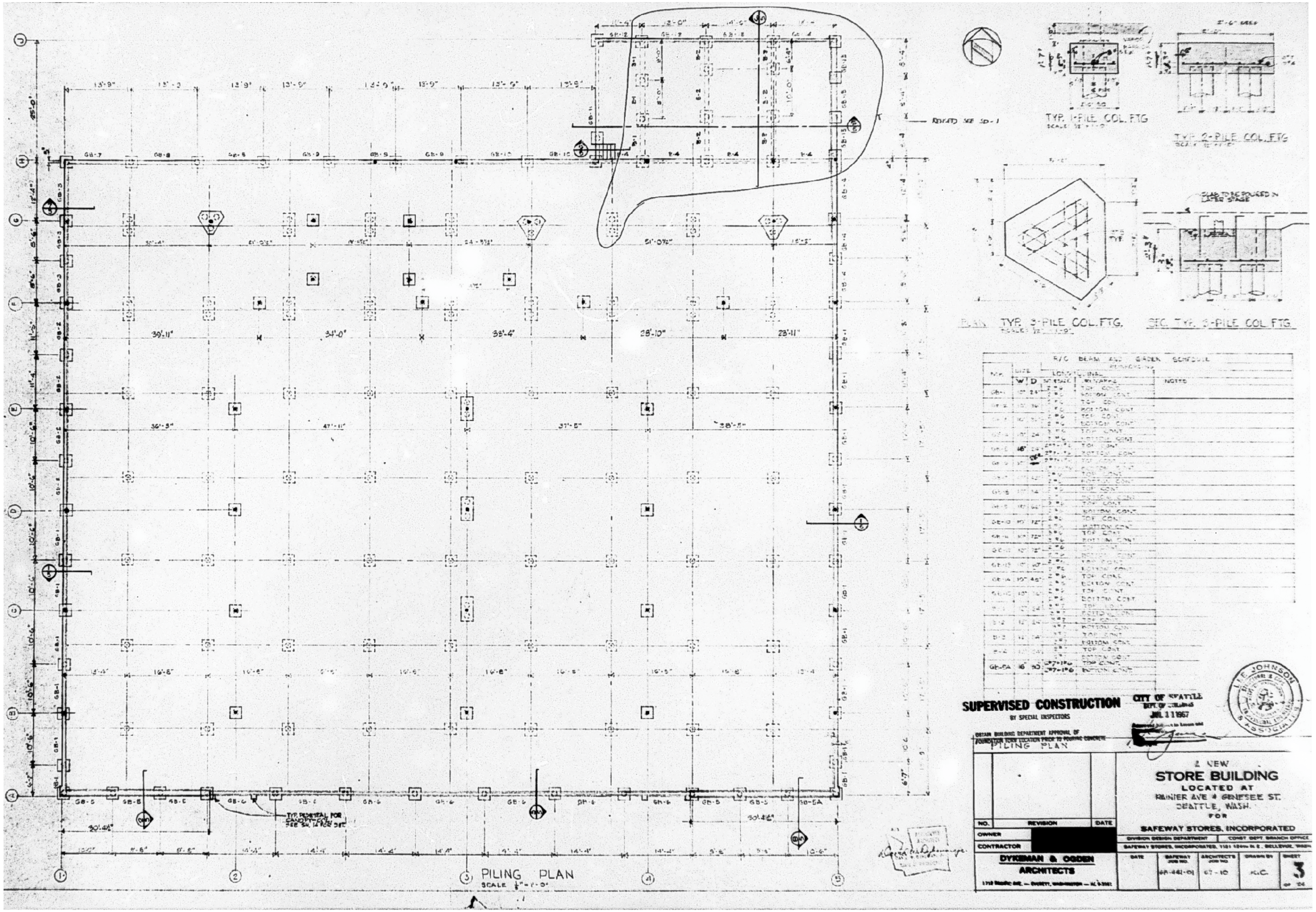

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Figure 3
Pile Layout Plan for
Safeway Building - 1967

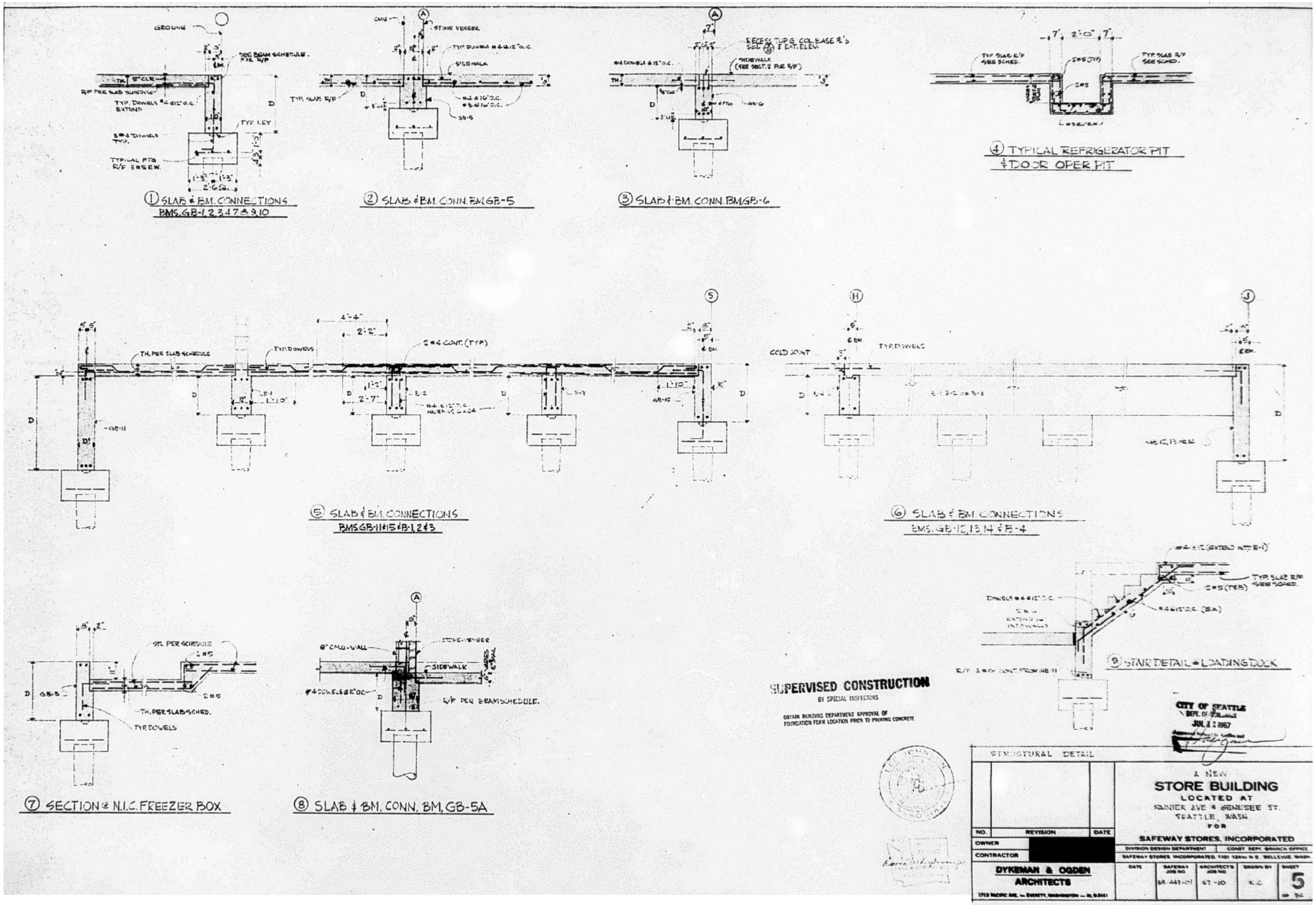

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Figure 4
Safeway Foundation and Pile Construction Details

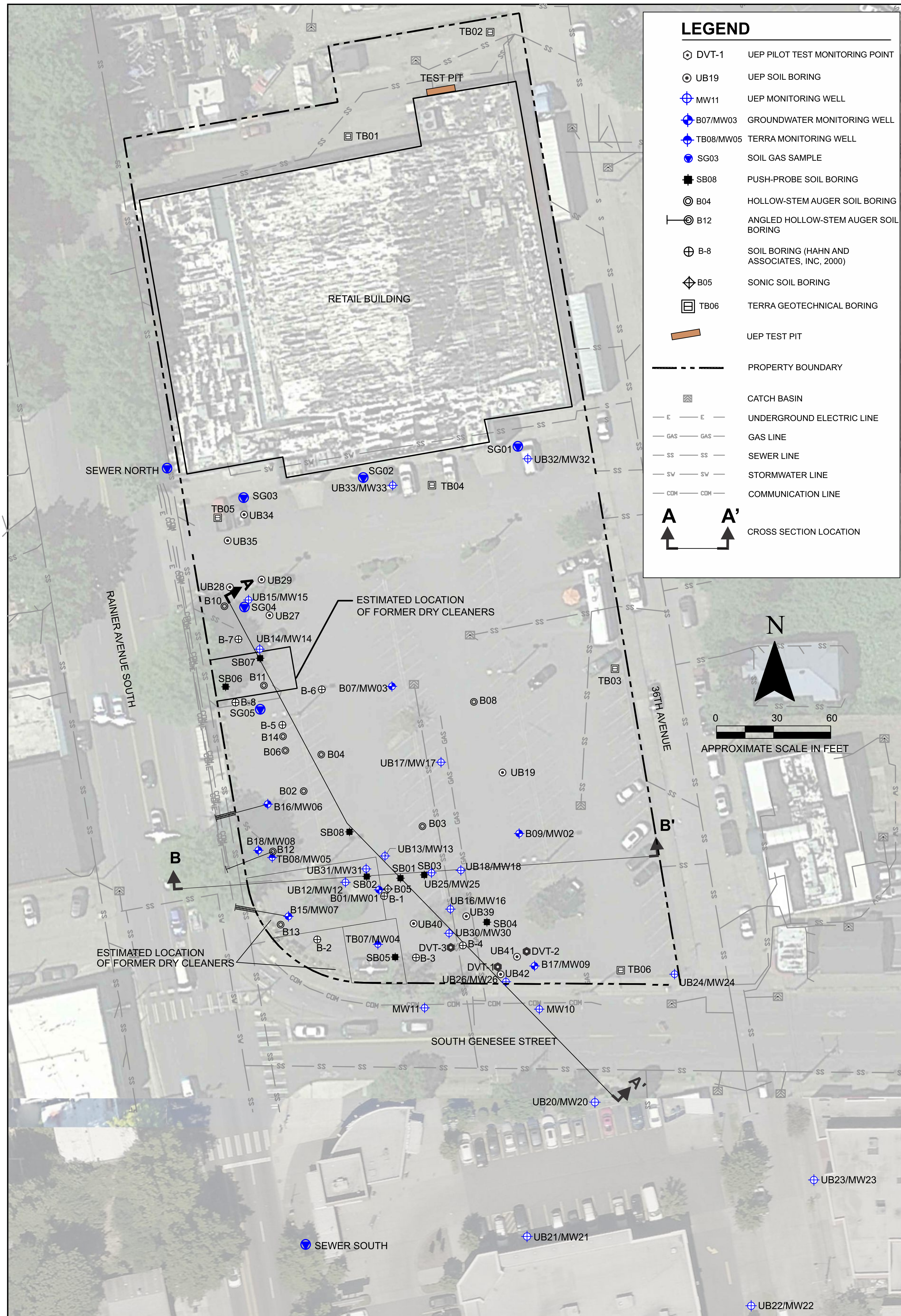

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Figure 5
Exploration Location Plan

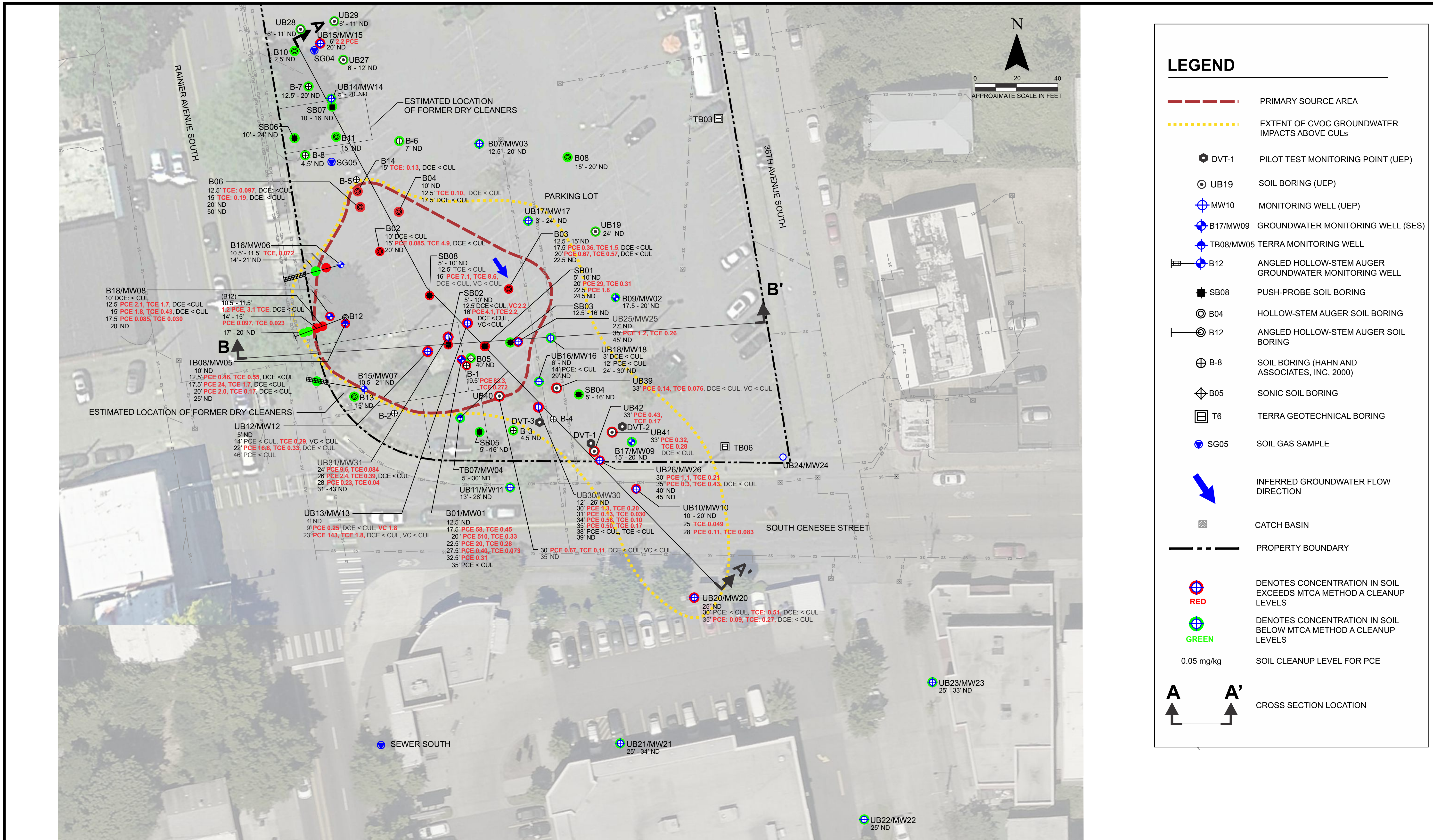

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Figure 6
CVOC Concentrations in Soil

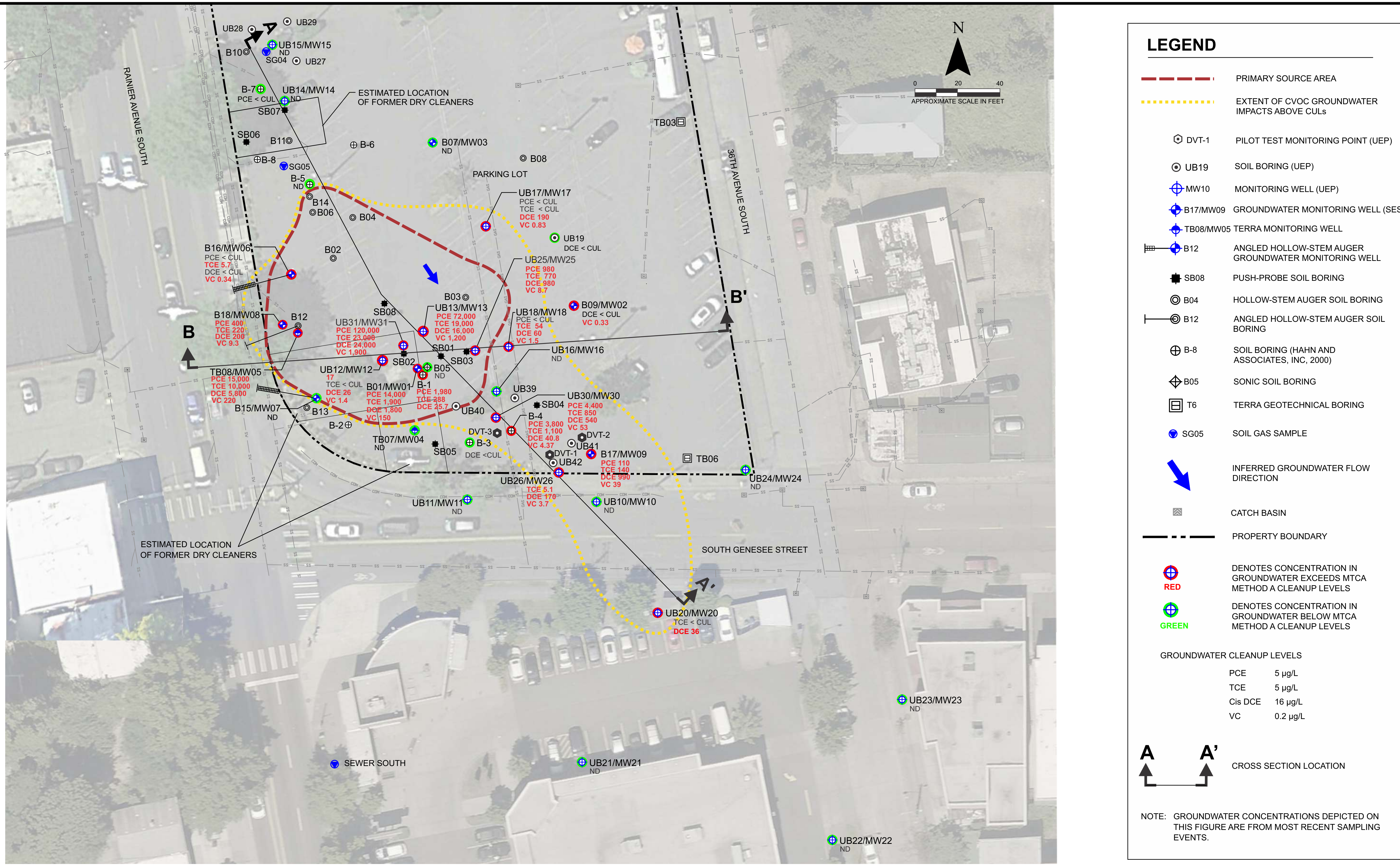

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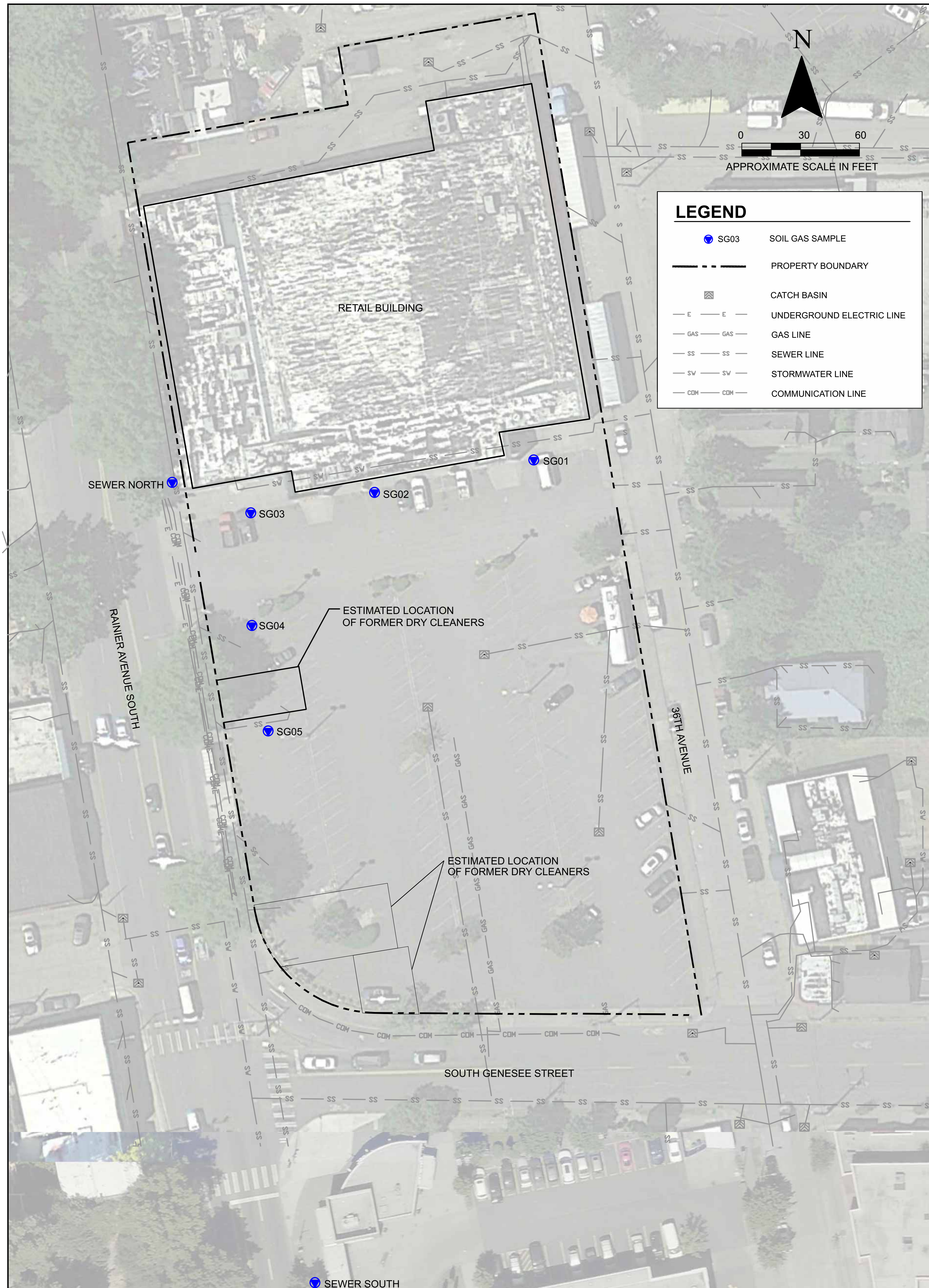
Figure 7
CVOC Concentrations in Groundwater



Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results - Micrograms per Cubic Meter (µg/m³)										
				PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC	Chloroethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1,1-Trichloroethane	1,1,2-Trichloroethane
SG01	SoundEarth	1/2/2018	8	**48**	<5.4	<4	<4	<4	<2.6	<2.6	<4	<4	<5.5	<5.5
SG02	SoundEarth	1/2/2018	8	**38**	<5.4	<4	<4	<4	<2.6	<2.6	<4	<4	<5.5	<5.5
SG03	SoundEarth	1/2/2018	8	**25**	<5.4	<4	<4	<4	<2.6	<2.6	<4	<4	<5.5	<5.5
SG04	UEP	4/10/2020	1.5	<110	<4.3	<6.3	<6.3	<6.3	<4.1	<42	<6.5	<0.65	<8.7	<1.7
SG05	UEP	4/10/2020	1.5	<110	<4.3	<6.3	<6.3	<6.3	<4.1	<42	<6.5	<0.65	<8.7	<1.7
Sewer South	UEP	5/15/2020	10	**270**	**69**	**340**	**3.7**	<3	**22**	<20	<3.1	<0.31	<4.1	<0.83
Sewer North	UEP	5/15/2020	10	<54	<2.1	<3.2	<3.2	<3.2	<2	<21	<3.2	<0.32	<4.4	<0.87
Ecology MTCA Method B Screening Levels for Sub-Slab Soil Gas				**320**	**11**	**NE**	**NE**	**3,000**	**9.50**	**NE**	**52**	**3.2**	**76,000**	**5.20**
Ecology MTCA Method B Screening Levels for Deep Soil Gas				**960**	**33**	**NE**	**NE**	**9,100**	**28**	**NE**	**160**	**9.6**	**230,000**	**16.00**

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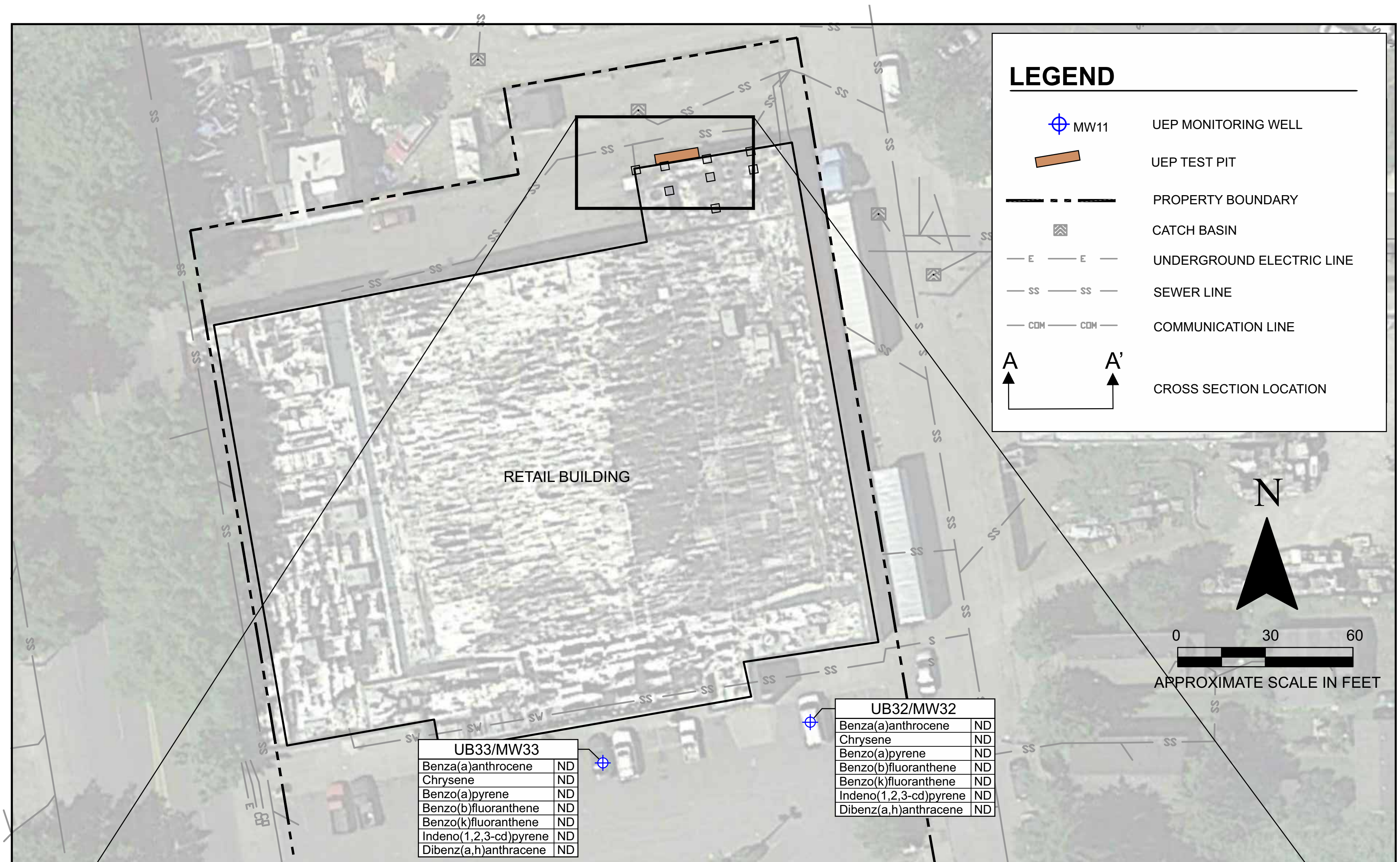
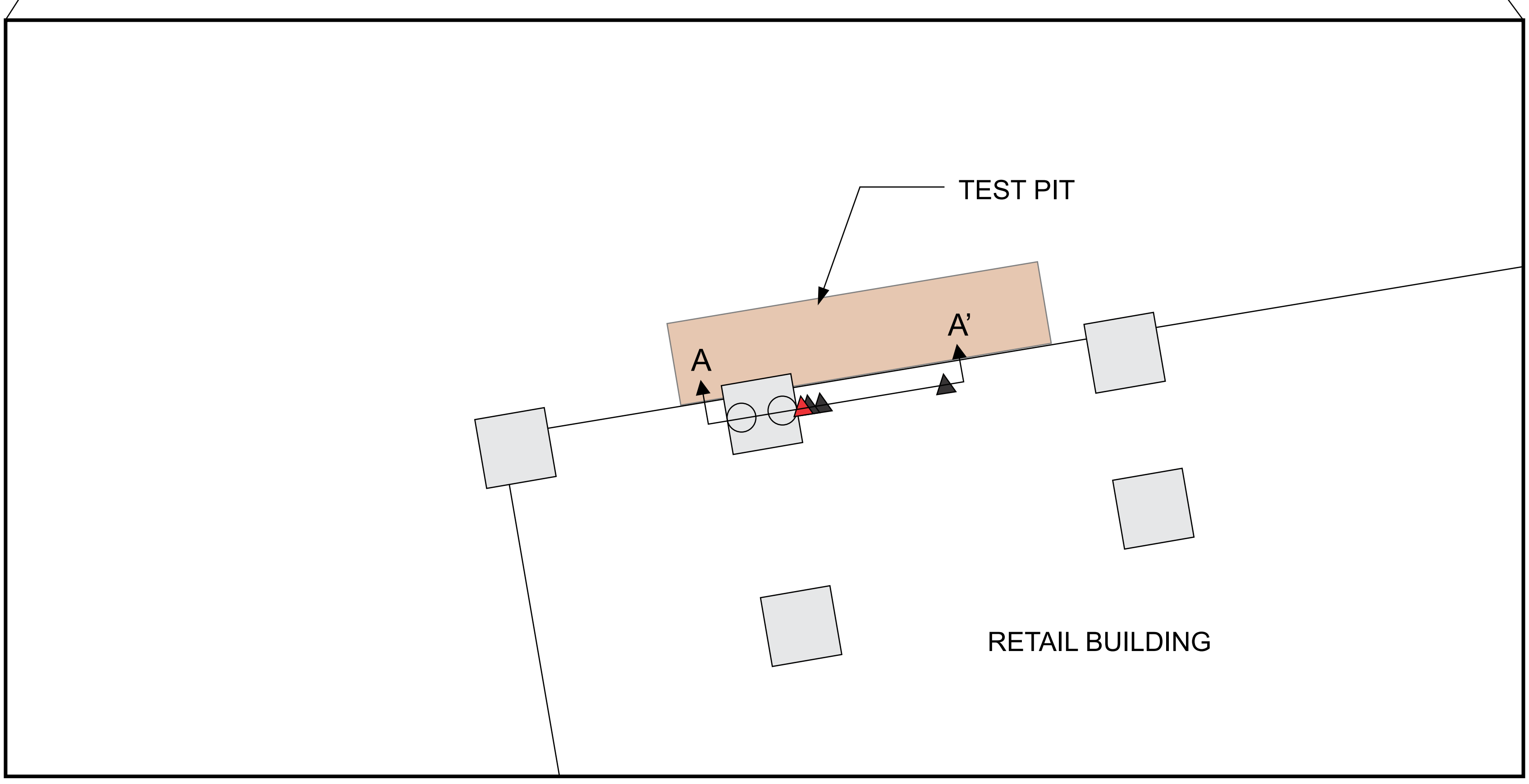
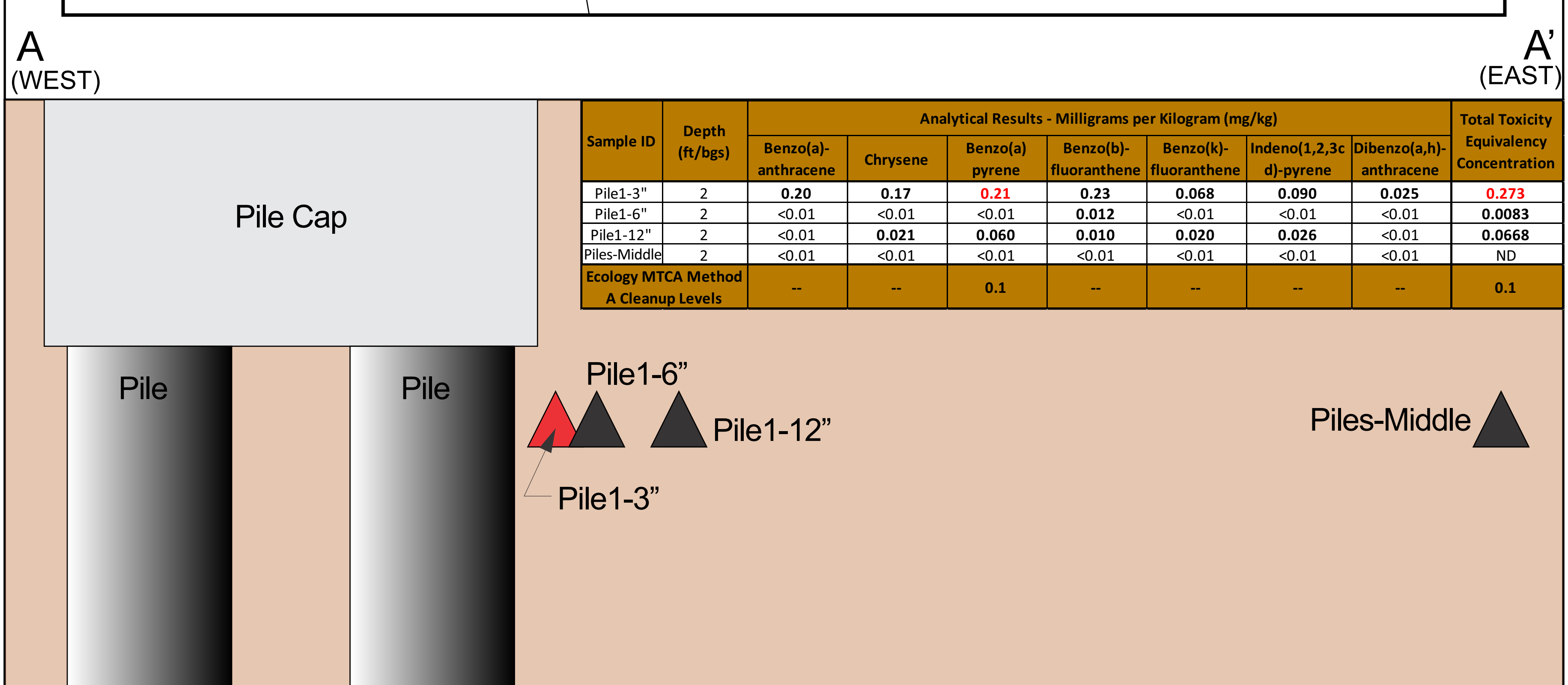
Figure 8
CVOC Concentrations in Soil Gas and Sewer Gas







Sample ID	Depth (ft/bgs)	Analytical Results - Milligrams per Kilogram (mg/kg)							Total Toxicity Equivalency Concentration
		Benzo(a)-anthracene	Chrysene	Benzo(a) pyrene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Indeno(1,2,3cd)-pyrene	Dibenzo(a,h)-anthracene	
Pile1-3"	2	**0.20**	**0.17**	**0.21**	**0.23**	**0.068**	**0.090**	**0.025**	**0.273**
Pile1-6"	2	<0.01	<0.01	<0.01	**0.012**	<0.01	<0.01	<0.01	**0.0083**
Pile1-12"	2	<0.01	**0.021**	**0.060**	**0.010**	**0.020**	**0.026**	<0.01	**0.0668**
Piles-Middle	2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	ND
Ecology MTCA Method A Cleanup Levels		--	--	0.1	--	--	--	--	0.1

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Figure 9
PAH Pile Assessment and Empirical GW Data

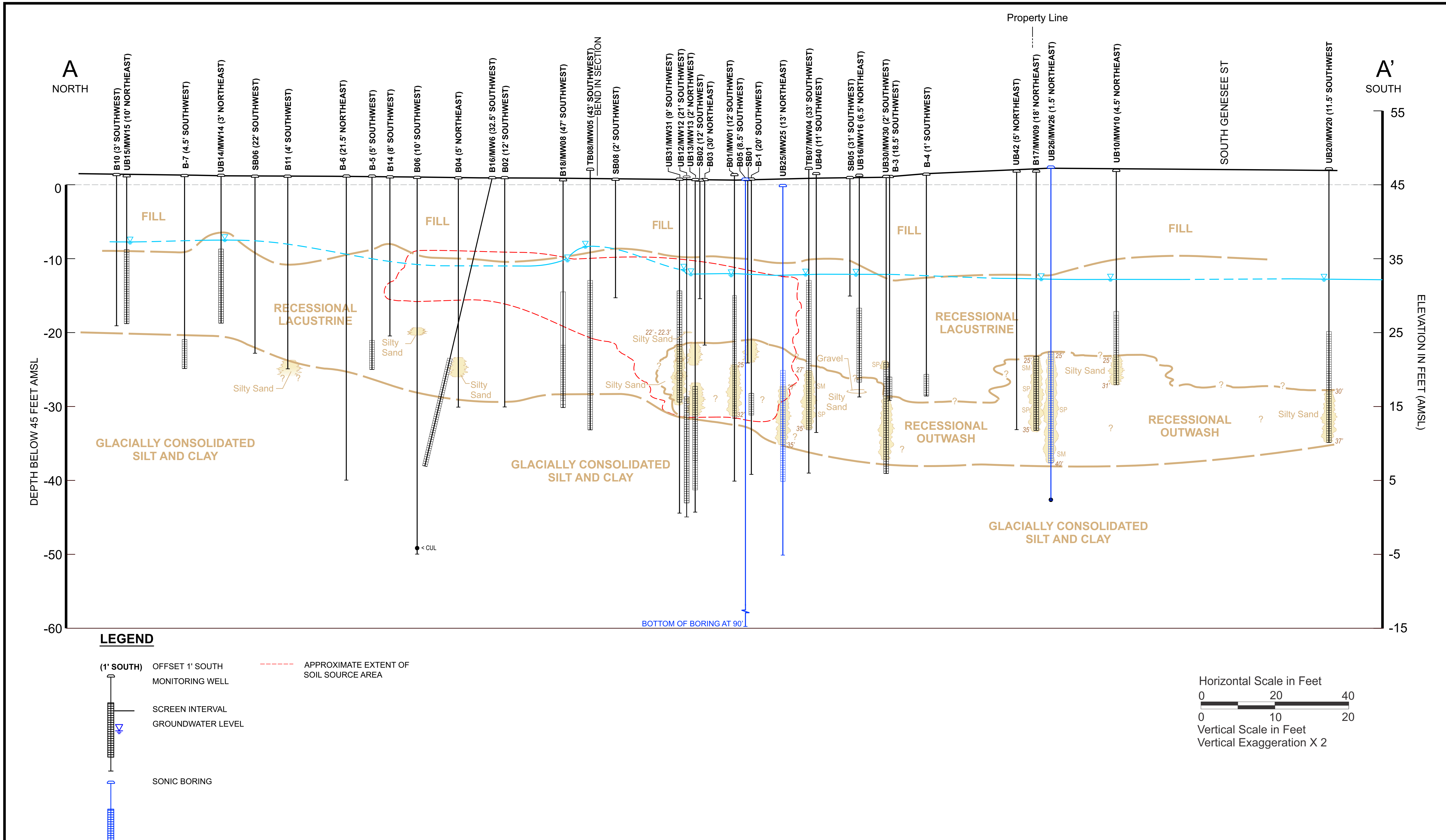

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Figure 10
Geologic Cross Section A-A'

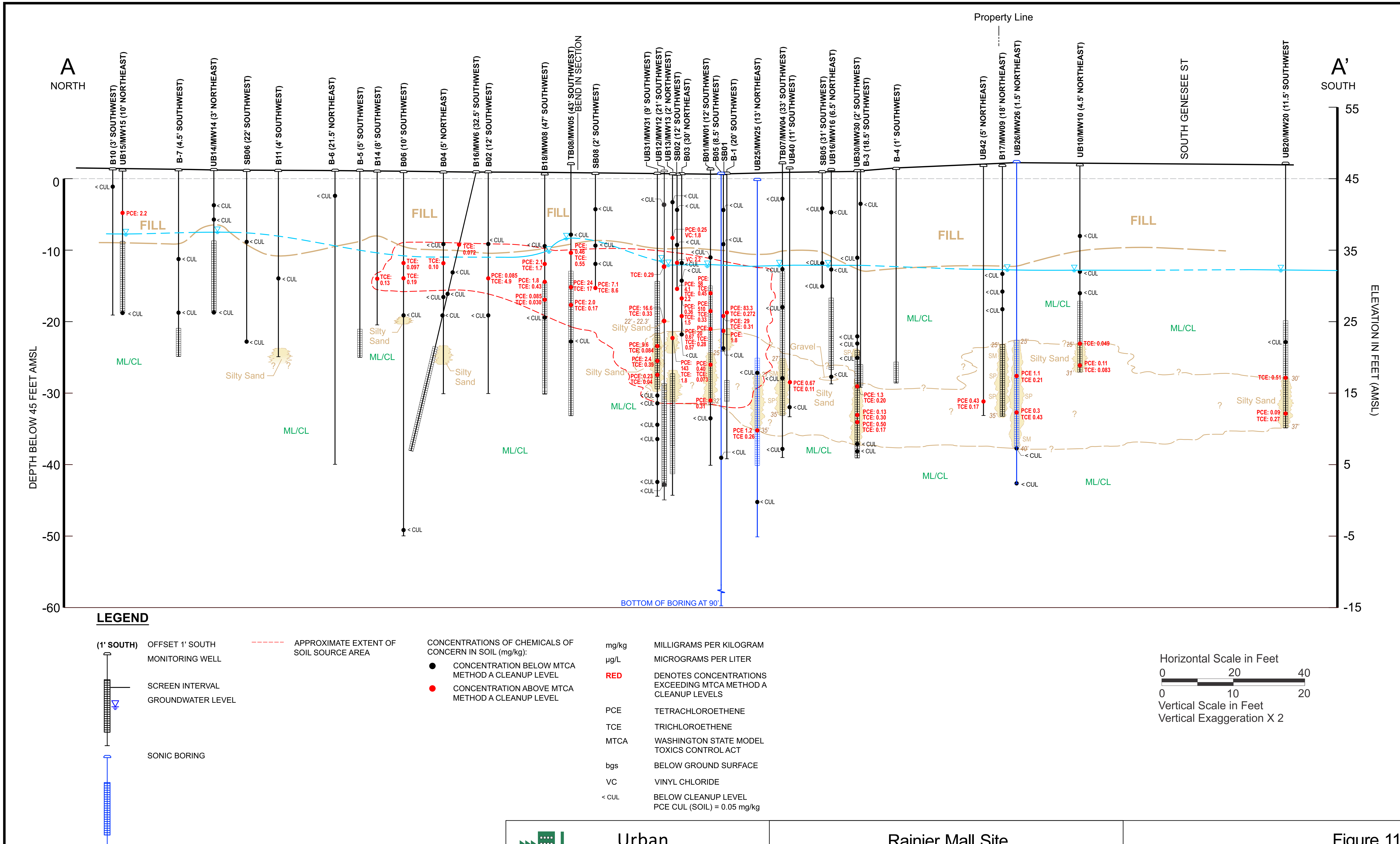

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Figure 11
Cross Section A-A' with CVOC Concentrations in Soil

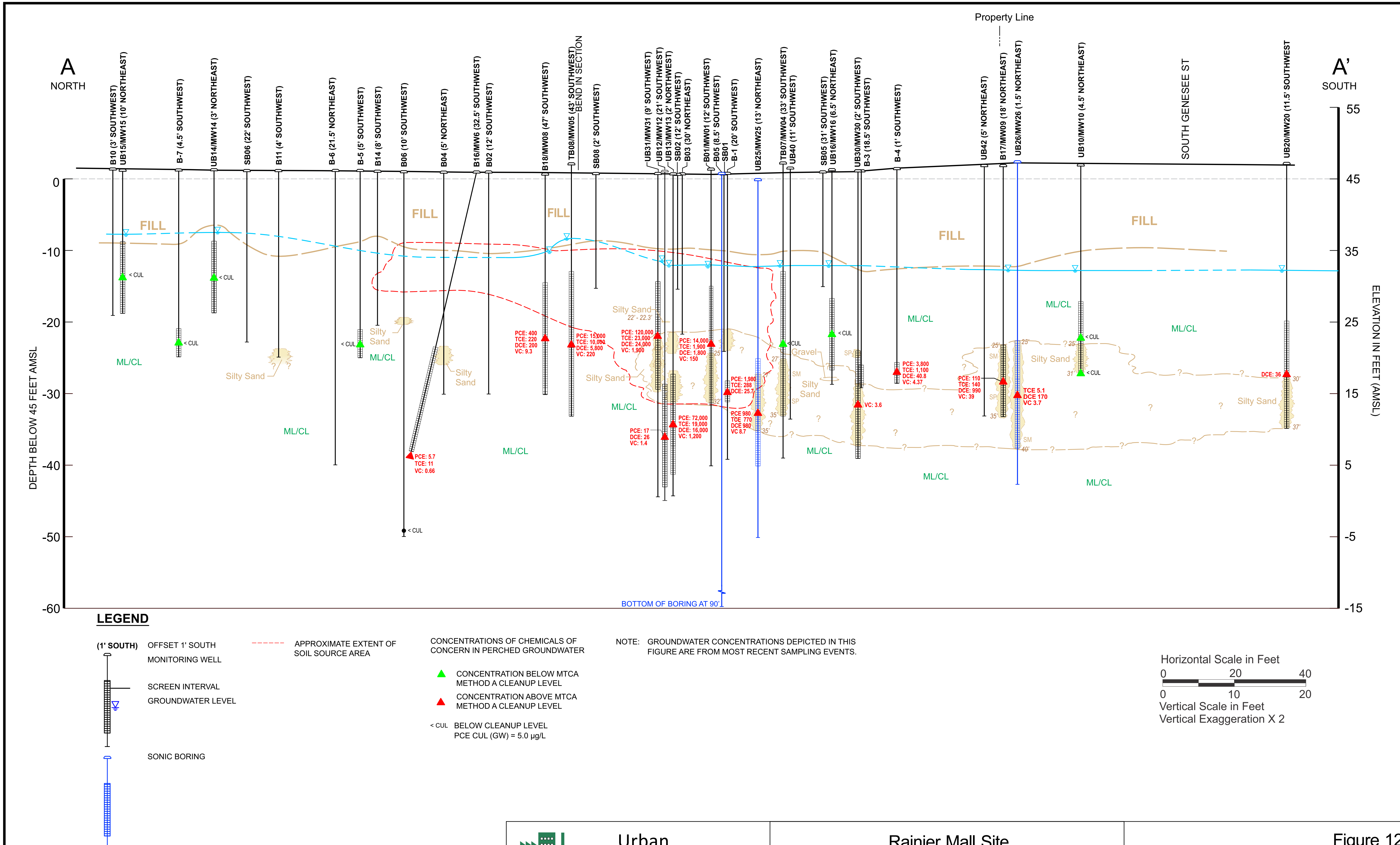

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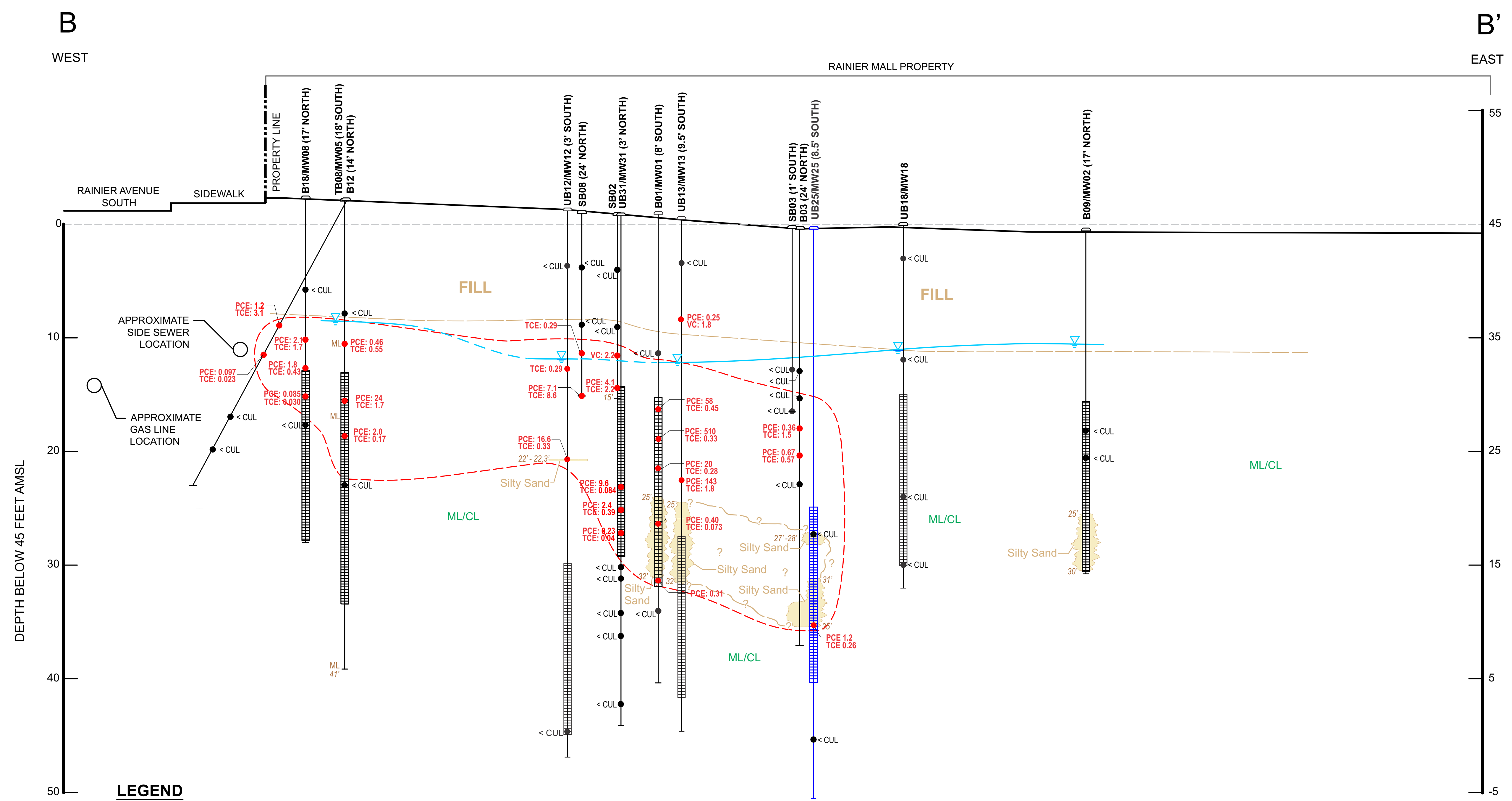
Figure 12
Cross Section A-A' with CVOC Concentrations in Groundwater



LEGEND

(1' SOUTH)	OFFSET 1' SOUTH
	MONITORING WELL
	SCREEN INTERVAL
	GROUNDWATER LEVEL
	SONIC BORING
	APPROXIMATE EXTENT OF SOIL SOURCE AREA

CONCENTRATIONS OF CHEMICALS OF CONCERN IN SOIL (mg/kg):

- ● CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL
- ● CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
RED	DENOTES CONCENTRATIONS EXCEEDING MTCA METHOD A CLEANUP LEVELS
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
bgs	BELOW GROUND SURFACE
VC	VINYL CHLORIDE
< CUL	BELOW CLEANUP LEVEL PCE CUL (SOIL) = 0.05 mg/kg

Horizontal Scale in Feet: 0 10 20

Vertical Scale in Feet: 0 5 10

Vertical Exaggeration X 2

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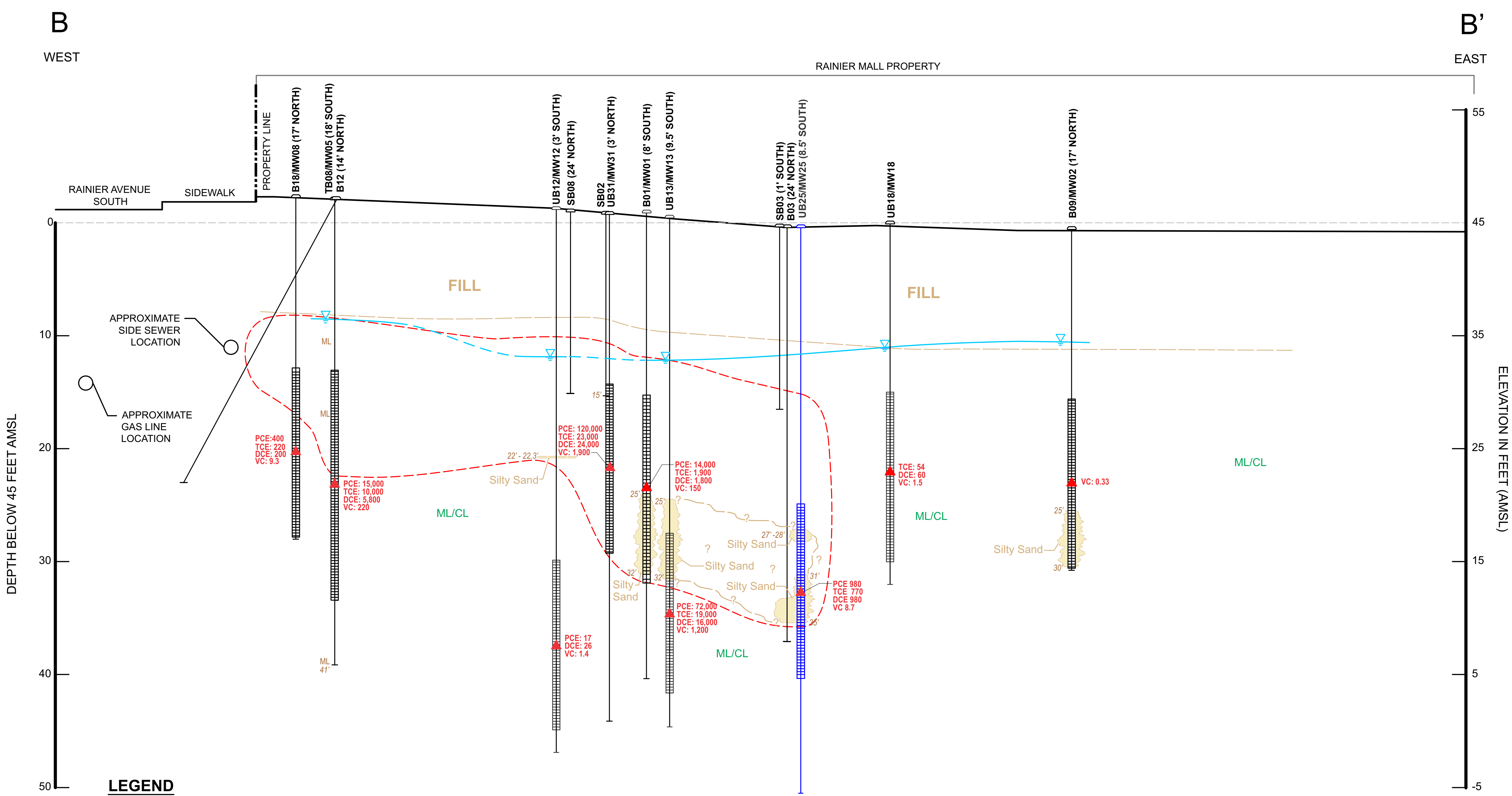
Rainier Mall Site
4208 Rainier Avenue South
Seattle, WA

Figure 13
Cross Section B-B' with CVOC Concentrations in Soil



LEGEND

(1' SOUTH) OFFSET 1' SOUTH

MONITORING WELL

SCREEN INTERVAL

GROUNDWATER LEVEL

SONIC BORING

APPROXIMATE EXTENT OF SOIL SOURCE AREA

CONCENTRATIONS OF CHEMICALS OF CONCERN IN PERCHED GROUNDWATER

CONCENTRATION BELOW MTCA METHOD A CLEANUP LEVEL

CONCENTRATION ABOVE MTCA METHOD A CLEANUP LEVEL

mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
RED	DENOTES CONCENTRATIONS EXCEEDING MTCA METHOD A CLEANUP LEVELS
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
MTCA	WASHINGTON STATE MODEL TOXICS CONTROL ACT
bgs	BELOW GROUND SURFACE
VC	VINYL CHLORIDE
< CUL	BELOW CLEANUP LEVEL PCE CUL (GW) = 5.0 µg/L

Horizontal Scale in Feet

0 10 20

0 5 10

Vertical Scale in Feet

Vertical Exaggeration X 2

NOTE: GROUNDWATER CONCENTRATIONS DEPICTED IN THIS FIGURE ARE FROM MOST RECENT SAMPLING EVENTS.

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Figure 14
Cross Section B-B' with CVOC Concentrations in Groundwater

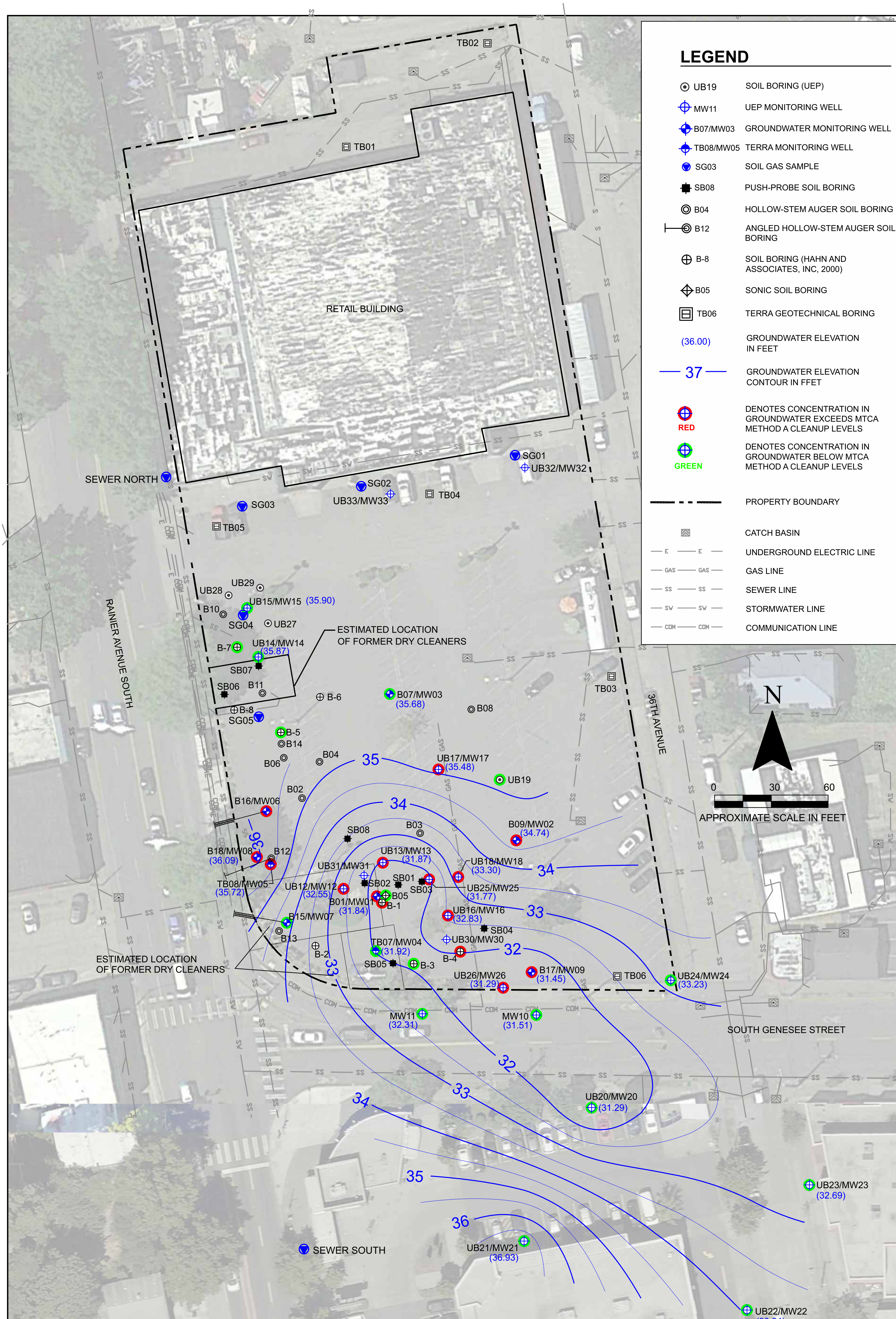

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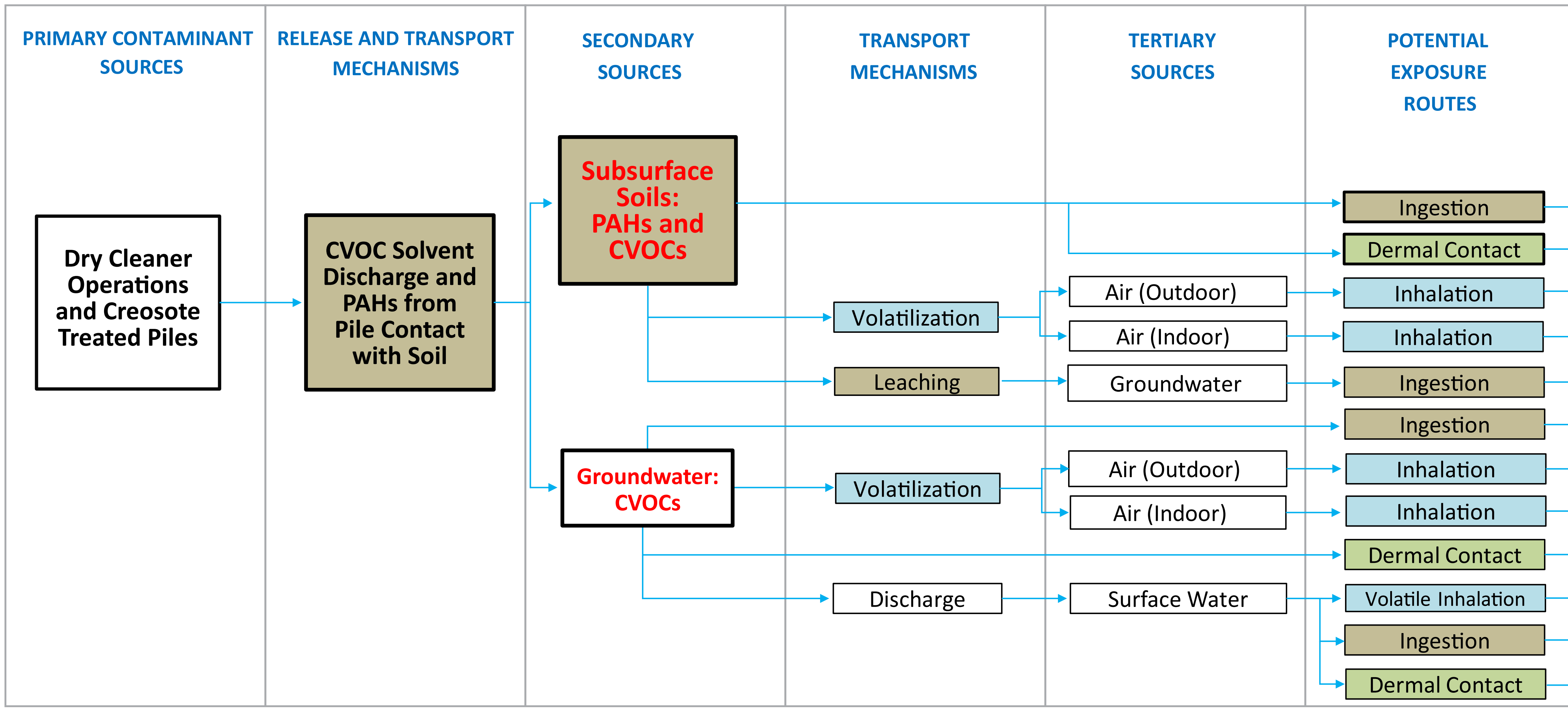
Figure 15
Groundwater Contour Map
4/14/2020



POTENTIAL EXPOSURE ROUTES	Residential Complete?	Occupational and Commercial[a] Complete?	Utility, Construction & Excavation Complete?	Terrestrial Ecological[b] Complete?
Ingestion	Y	Y	Y	X
Dermal Contact	Y	Y	Y	X
Inhalation	Y	Y	Y	X
Inhalation	Y	Y	Y	X
Ingestion	Y	Y	Y	X
Ingestion	Y	Y	Y	X
Inhalation	Y	Y	Y	X
Inhalation	Y	Y	Y	X
Dermal Contact	Y	Y	Y	X
Volatile Inhalation	X	X	X	X
Ingestion	X	X	X	X
Dermal Contact	X	X	X	X

LAND USES - POTENTIAL RECEPTORS

Notes:

Y This exposure pathway is considered complete.

X This exposure pathway is deemed incomplete (no exposure).

a The occupational receptors include site visitors and site workers.

b Ecological receptors are incomplete because the site qualifies for an exclusion under the Terrestrial Ecological Evaluation as specified in the criteria in the Washington Administrative Code 173-340-7491.

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Rainier Mall Site
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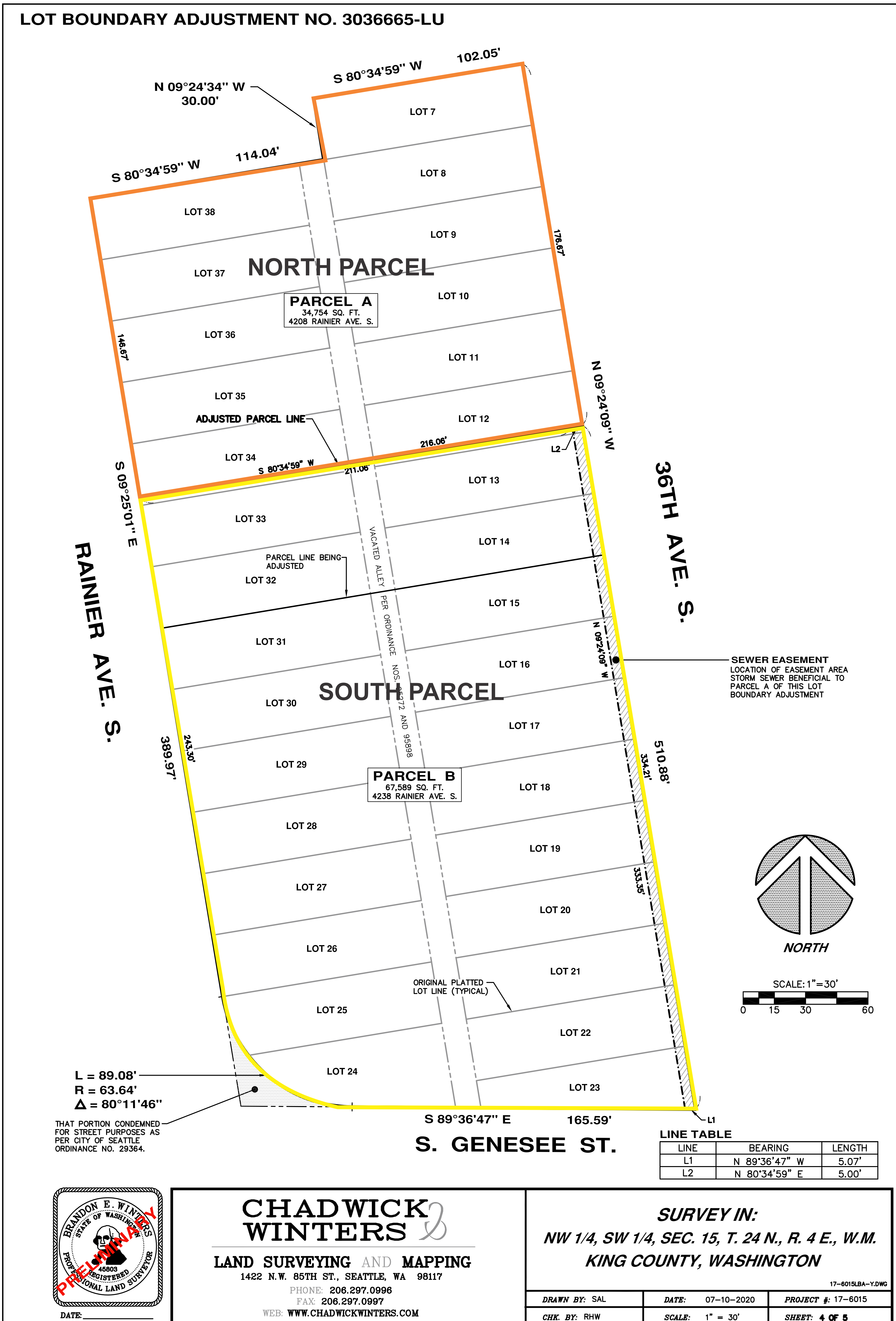
Seattle, WA

Figure 16
LUP-Rainier Mall
Conceptual Site Model



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Rainier Mall Site
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Figure 17
Approved Lot Boundary Adjustment for 2 Development Parcels

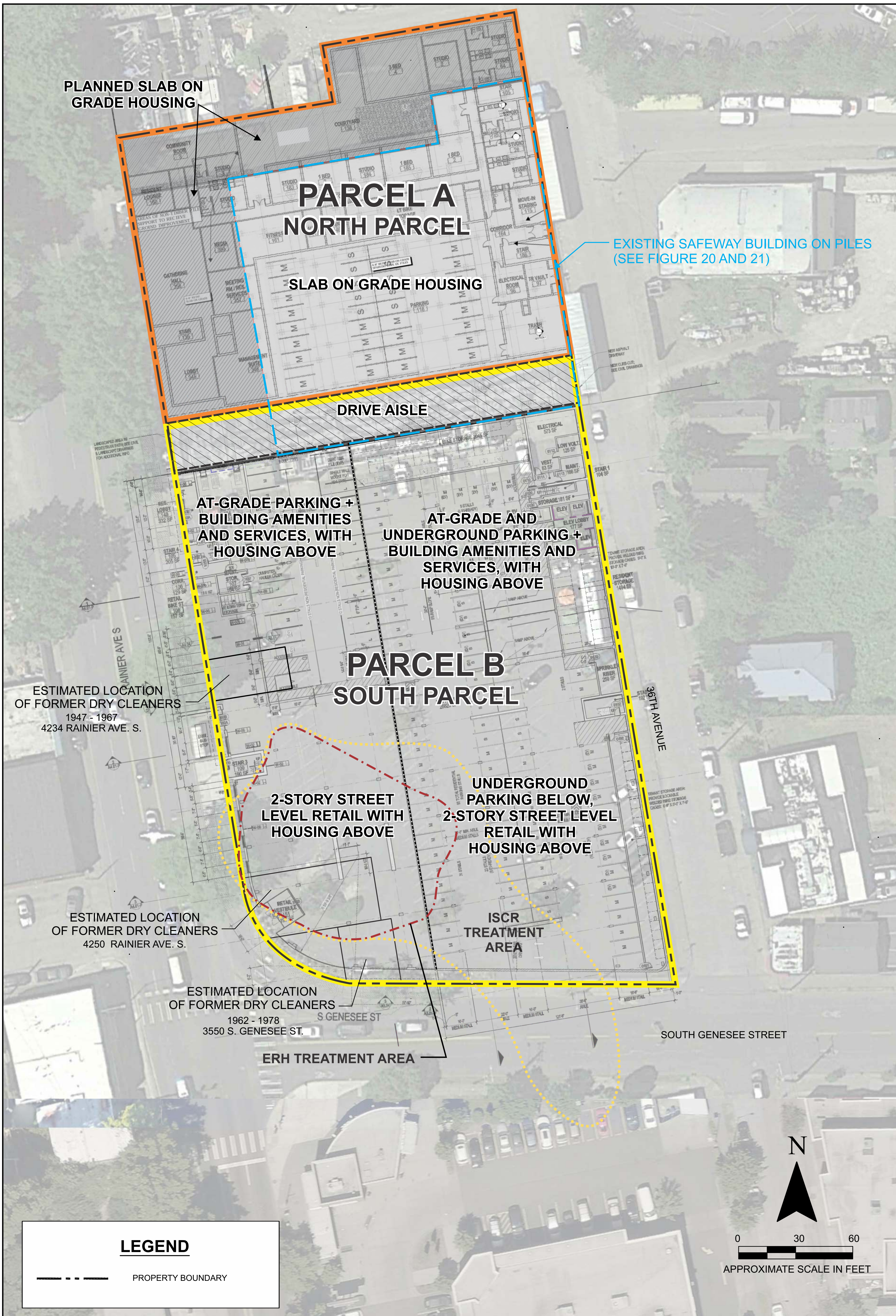

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Figure 18
Phased Development Plans and Drive Aisle Pile Removal Area

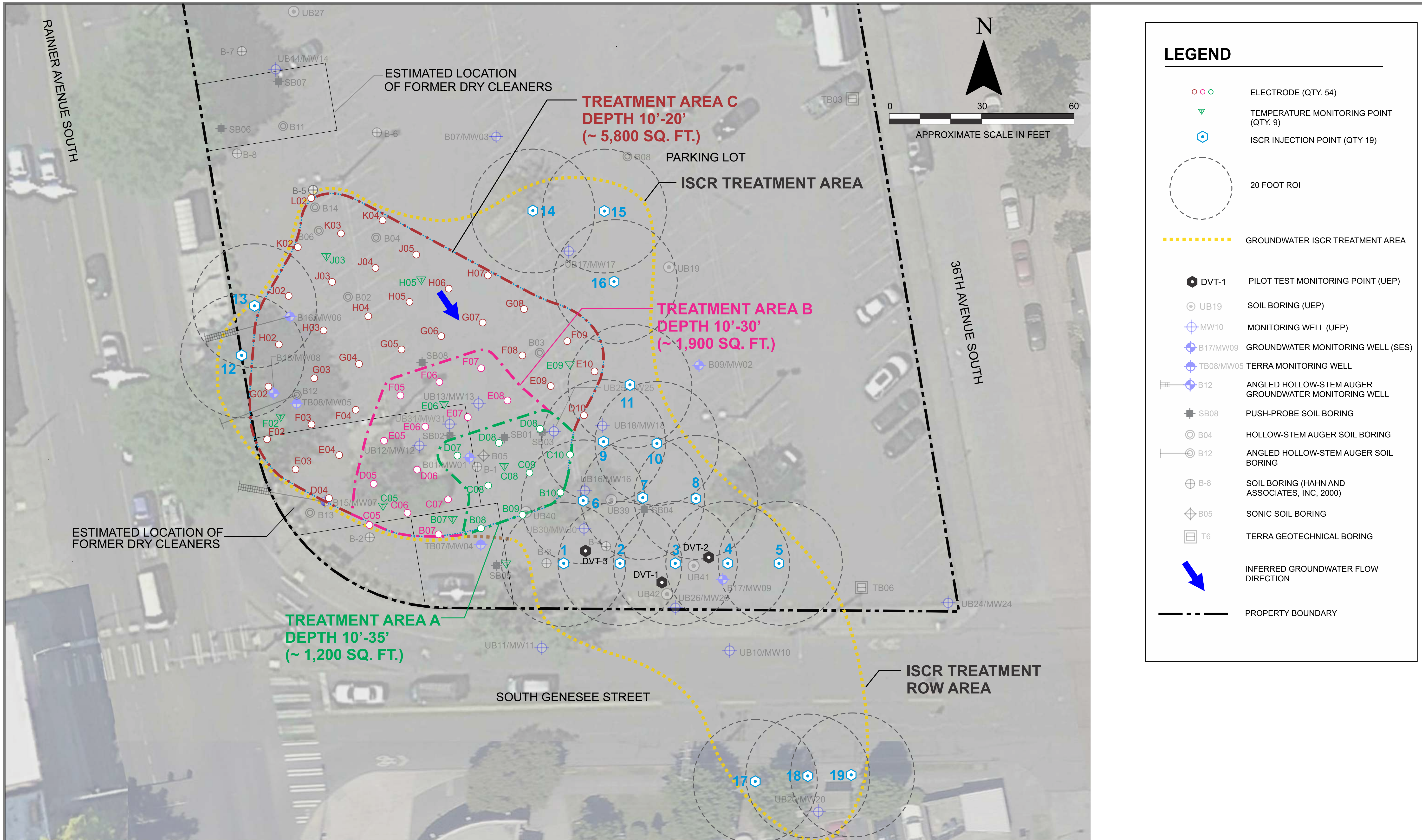

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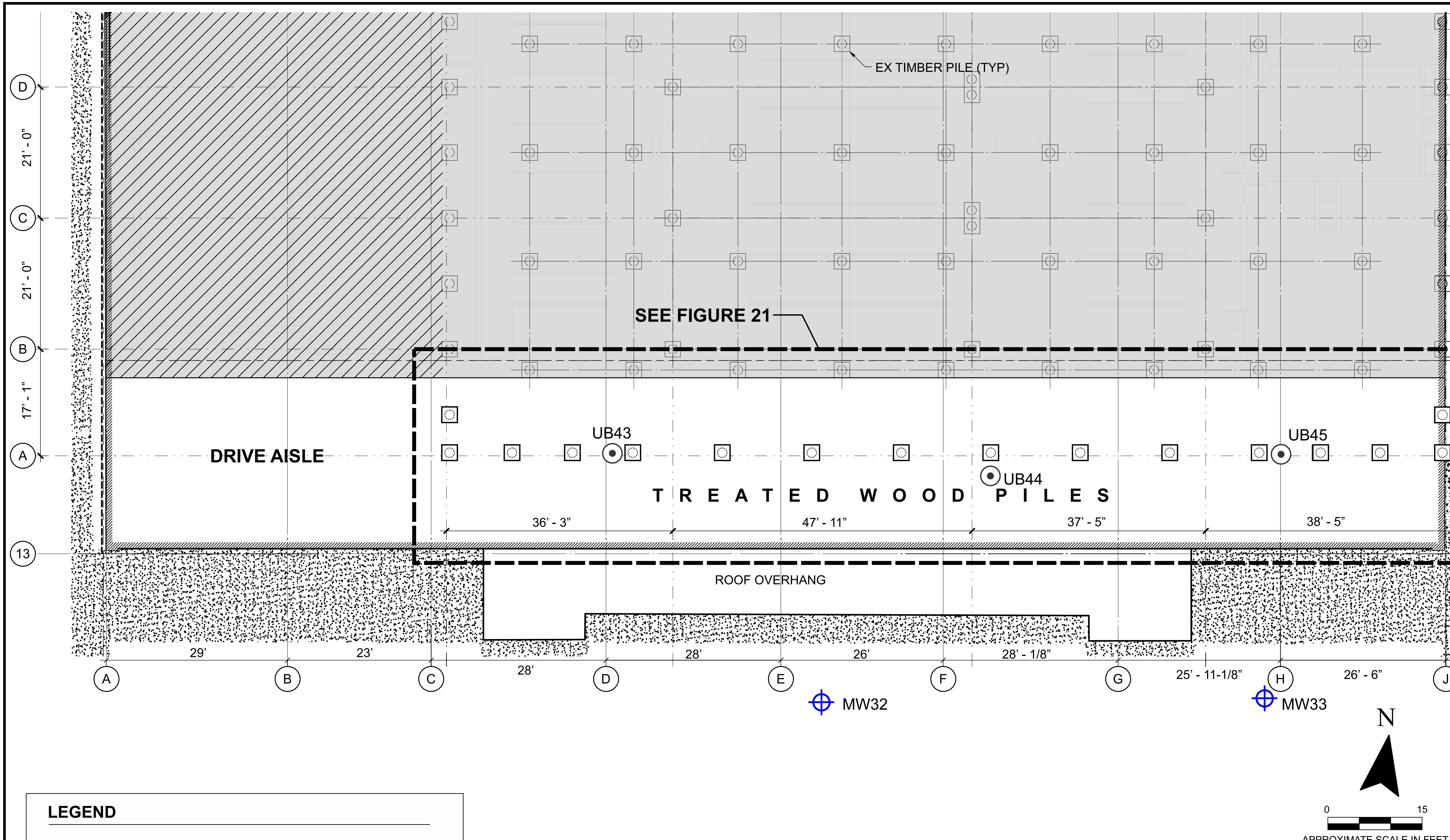
Figure 19
Preferred Remedial Alternative - ERH with ISCR



LEGEND

UB43	PROPOSED SOIL CONFIRMATION PROBE
MW32	EXISTING GW COMPLIANCE WELL

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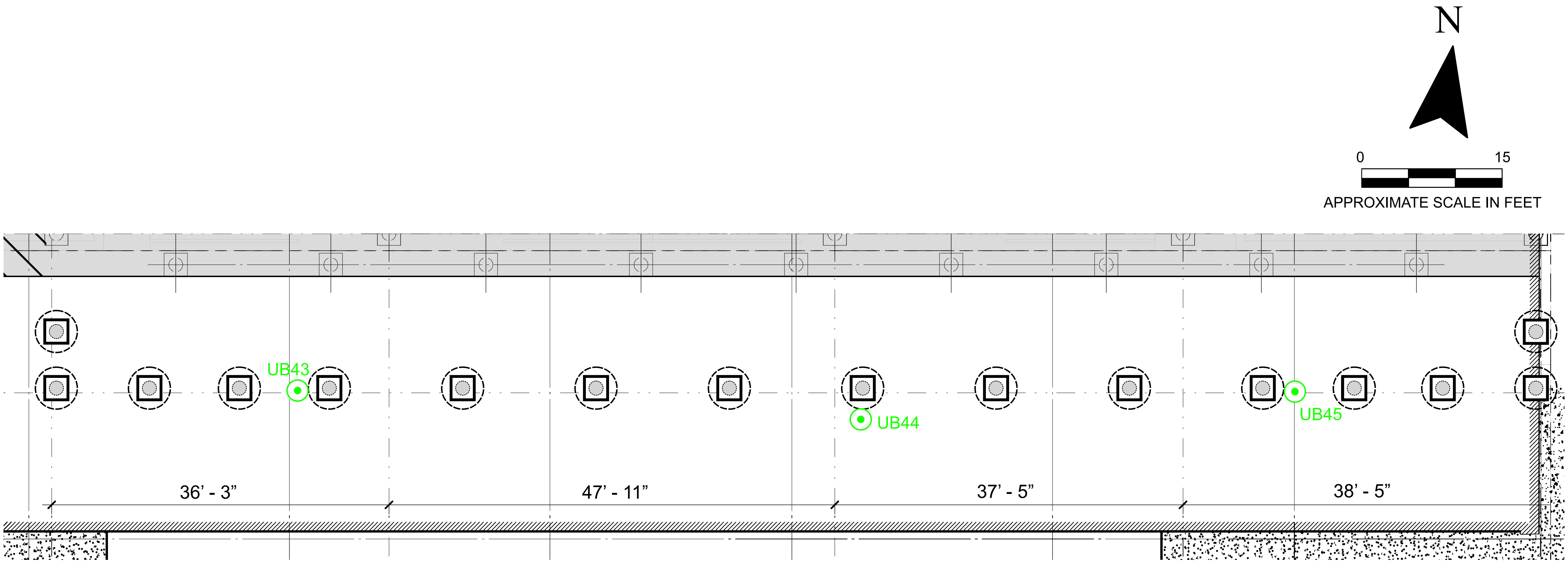
Figure 20
Drive Aisle - Planned Soil Confirmation Sampling and Pile Removal



LEGEND

PILE CAP DEMOLISHED

PILE REMOVED

PILE REMOVAL

1. REMOVE PILE CAP
2. CONFIRMATION GEO PROBE TO 5' BGS ☒ SAMPLE SOIL
3. ATTACH VIBRATORY HAMMER
4. VIBRATE AND REMOVE

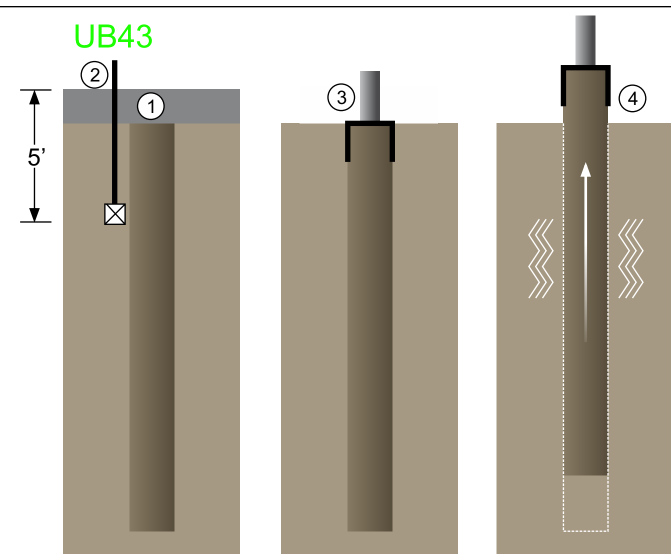
② PROBE

3' DIAMETER (ID) CAISSON

3' DIAMETER (OD) AUGER

18 - 24" DIAMETER PILE

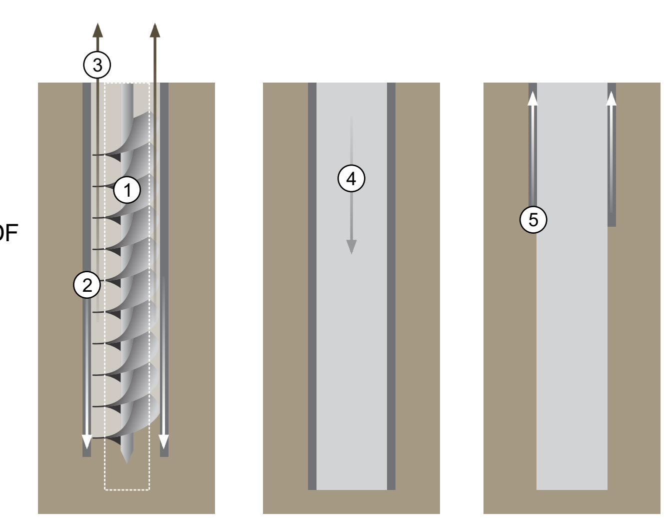
6"



NOT TO SCALE

SOIL REMOVAL

1. LARGE DIAMETER AUGER
2. CAISSON IS ADVANCED AS
3. AUGER REMOVES SOIL
4. EXCAVATION "HOLE" IS BACKFILLED WITH CDF
5. CAISSON REMOVED



NOT TO SCALE

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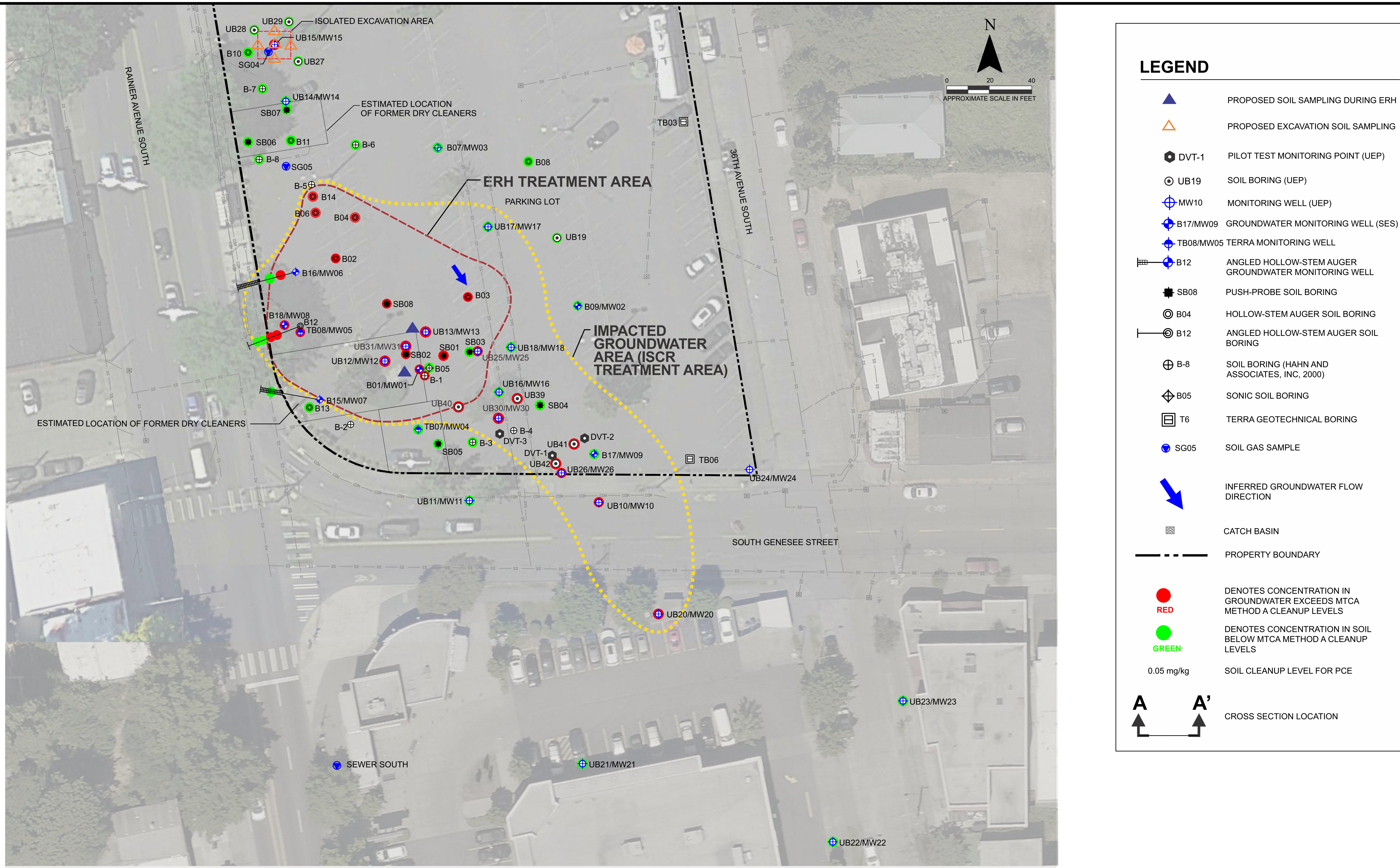
Figure 21
Treated Pile Removal - Remedial Process



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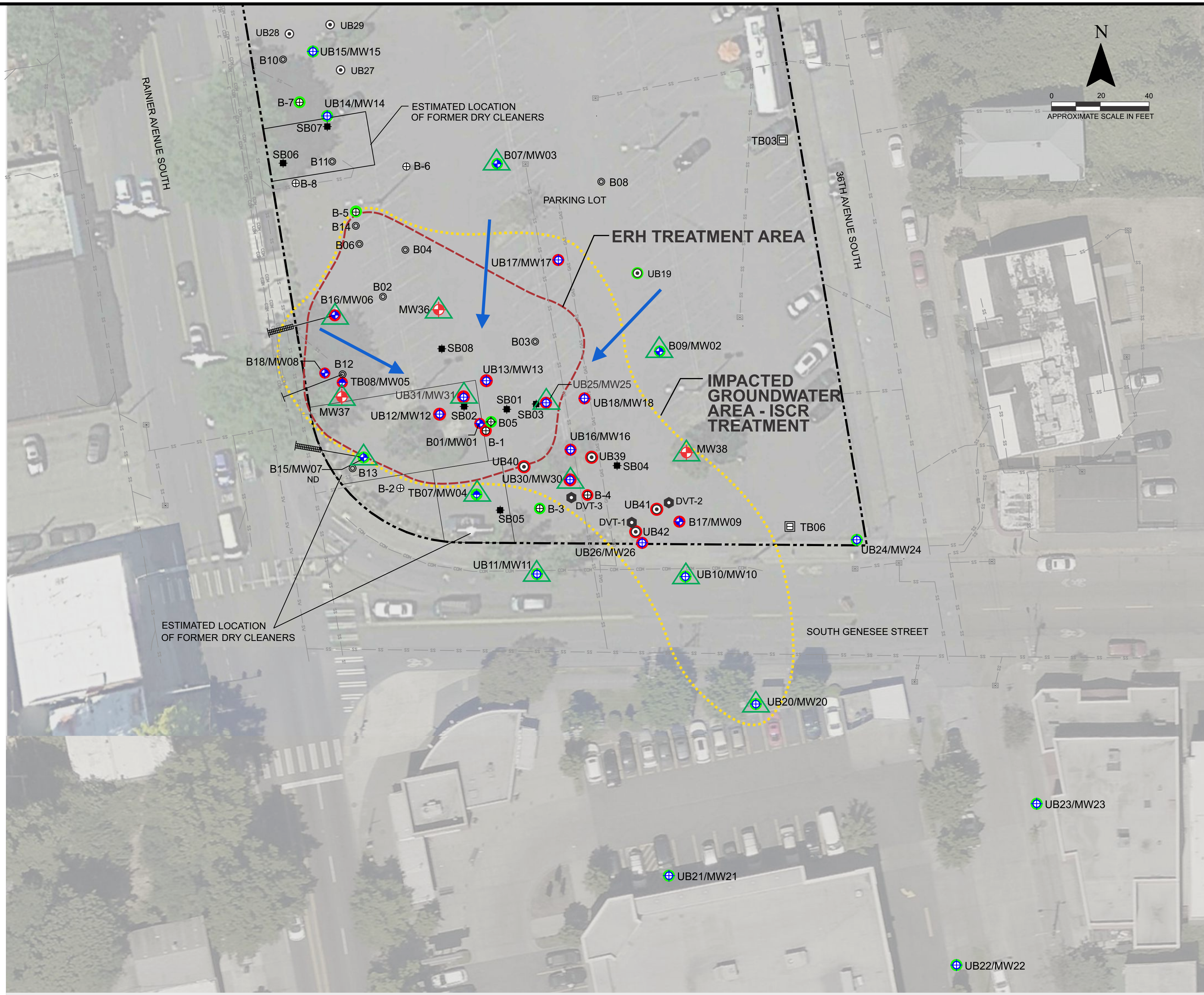
Seattle, WA

Figure 22
Soil Performance and Compliance Monitoring Plan



LEGEND

UB20/MW20	PROPOSED GROUNDWATER COMPLIANCE MONITORING LOCATION (EXISTING WELL)
MW38	PROPOSED GROUNDWATER COMPLIANCE MONITORING LOCATION (NEW WELL)
DVT-1	PILOT TEST MONITORING POINT (UEP)
UB19	SOIL BORING (UEP)
MW10	MONITORING WELL (UEP)
B17/MW09	GROUNDWATER MONITORING WELL (SES)
TB08/MW05	TERRA MONITORING WELL
B12	ANGLED HOLLOW-STEM AUGER GROUNDWATER MONITORING WELL
SB08	PUSH-PROBE SOIL BORING
B04	HOLLOW-STEM AUGER SOIL BORING
B12	ANGLED HOLLOW-STEM AUGER SOIL BORING
B-8	SOIL BORING (HAHN AND ASSOCIATES, INC, 2000)
B05	SONIC SOIL BORING
T6	TERRA GEOTECHNICAL BORING
	INFERRED GROUNDWATER FLOW DIRECTION
	CATCH BASIN
	PROPERTY BOUNDARY
RED	DENOTES CONCENTRATION IN GROUNDWATER EXCEEDS MTCA METHOD A CLEANUP LEVELS
GREEN	DENOTES CONCENTRATION IN SOIL BELOW MTCA METHOD A CLEANUP LEVELS

GROUNDWATER CLEANUP LEVELS

PCE	5 µg/L
TCE	5 µg/L
Cis DCE	16 µg/L
VC	0.2 µg/L

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Rainier Mall Site
4208 Rainier Avenue South
Seattle, WA

Figure 23
Proposed Groundwater Compliance Monitoring Plan

Exhibit B: Tables

Table 1
Soil Analytical Results for cVOCs
4208 Rainier Ave South, Seattle

Boring ID	Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results[1] - Milligrams per Kilogram (mg/kg)					
					PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC
B-1	5015-000628-005	Hahn	6/28/2000	19.5	**83.3**	**0.272**	<0.005	--	<0.005	<0.01
B-3	5015-000628-018	Hahn	6/28/2000	4.5	<0.005	<0.005	<0.005	--	<0.005	<0.01
B-6	5015-000628-018	Hahn	6/28/2000	7	<0.005	<0.005	<0.005	--	<0.005	<0.01
B-8	5015-000629-039	Hahn	6/28/2000	4.5	<0.005	<0.005	<0.005	--	<0.005	<0.01
SB01	SB01-5.0	SoundEarth	1/18/2017	5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB01-10.0			10	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB01-20.0			20	**29**	**0.31**	<0.05	<0.05	--	<0.05
	SB01-22.5			22.5	**1.8**	<0.02	<0.05	<0.05	--	<0.05
	SB01-24.5			24.5	<0.025	<0.02	<0.05	<0.05	--	<0.05
SB02	SB02-5.0	SoundEarth	1/18/2017	5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB02-10.0			10	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB02-12.5			12.5	<0.025	<0.02	**6.7**	**0.052**	--	**2.2**
	SB02-16			16	**4.1**	**2.2**	**1.1**	<0.05	--	**0.052**
SB03	SB03-12.5	SoundEarth	1/18/2017	12.5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB03-16.0			16	<0.025	<0.02	<0.05	<0.05	--	<0.05
SB04	SB04-5.0	SoundEarth	1/18/2017	5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB04-12.5			12.5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB04-16.0			16	<0.025	<0.02	<0.05	<0.05	--	<0.05
SB05	SB05-5.0	SoundEarth	1/18/2017	5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB05-12.5			12.5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB05-16.0			16	<0.025	<0.02	<0.05	<0.05	--	<0.05
SB06	SB06-10.0	SoundEarth	1/18/2017	10	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB06-24.0			24	<0.025	<0.02	<0.05	<0.05	--	<0.05
SB07	SB07-10.0	SoundEarth	1/18/2017	10	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB07-16.0			16	<0.025	<0.02	<0.05	<0.05	--	<0.05
SB08	SB08-5.0	SoundEarth	1/18/2017	5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB08-10			10	<0.025	<0.02	<0.05	<0.05	--	<0.05
	SB08-12.5			12.5	<0.025	**0.029**	**1.3**	**0.086**	--	<0.05
	SB08-16.0			16	**7.1**	**8.6**	**10**	**0.056**	--	**0.24**
B01/MW01	B01-12.5	SoundEarth	2/9/2017	12.5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	B01-17.5			17.5	**58**	**0.45**	<0.05	<0.05	--	<0.05
	B01-20			20	**510**	**0.33**	<0.05	<0.05	--	<0.05
	B01-22.5			22.5	**20**	**0.28**	<0.05	<0.05	--	<0.05
	B01-27.5			27.5	**0.40**ht	**0.073**ht	<0.05ht	<0.05ht	--	<0.05ht
	B01-32.5			32.5	**0.31**ht	<0.02ht	<0.05ht	<0.05ht	--	<0.05ht
	B01-35			35	**0.049**ht	<0.02ht	<0.05ht	<0.05ht	--	<0.05ht
B02	B02-10	SoundEarth	2/9/2017	10.0	<0.025	<0.02	**0.13**	<0.05	--	<0.05
	B02-15			15.0	**0.085**	**4.9**	**6.7**	**0.25**	--	0.097
	B02-20			20.0	<0.025	<0.02	<0.05	<0.05	--	<0.05
B03	B03-12.5	SoundEarth	2/9/2017	12.5	<0.025	<0.02	<0.05	<0.05	--	<0.05
	B03-15			15.0	<0.025	<0.02	0.082	<0.05	--	<0.05
	B03-17.5			17.5	**0.36**	**1.5**	**1.1**	<0.05	--	<0.05
	B03-20			20.0	**0.67**	**0.57**	**0.41**	<0.05	--	<0.05
	B03-22.5			22.5	<0.025	<0.02	<0.05	<0.05	--	<0.05
B04	B04-10	SoundEarth	2/9/2017	10.0	<0.025	<0.02	<0.05	<0.05	--	<0.05
	B04-12.5			12.5	<0.025	**0.10**	**0.79**	**0.12**	--	<0.05
	B04-17.5			17.5	<0.025	<0.02	**0.32**	<0.05	--	<0.05
B05	B05-40	SoundEarth	3/22/2017	40.0	<0.025	<0.02	<0.05	<0.05	--	<0.05
TB01	TB01-15	SoundEarth	1/24/2018	15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
TB02	TB02-15	SoundEarth	1/24/2018	15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
TB05	TB05-05	SoundEarth	1/25/2018	5	<0.025	<0.02	--	--	<0.05	<0.05
TB07	TB07-05	SoundEarth	1/26/2018	5	<0.025	<0.02	<0.05	--	<0.05	<0.05
	TB07-15			15.0	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	TB07-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	TB07-30			30	<0.025	<0.02	<0.05	--	<0.05	<0.05
TB08	TB08-10	SoundEarth	1/26/2018	10.0	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	TB02-12.5			12.5	**0.46**	**0.55**	**0.21**	--	<0.05	<0.05
	TB08-17.5			17.5	**24**	**1.7**	**0.45**	--	<0.05	<0.05
	TB08-20			20.0	**2.0**	**0.17**	**0.06**	--	<0.05	<0.05
	TB08-25			25	<0.025	<0.02	<0.05	--	<0.05	<0.05

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Table 1
Soil Analytical Results for cVOCs
4208 Rainier Ave South, Seattle

Boring ID	Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results[1] - Milligrams per Kilogram (mg/kg)					
					PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC
B06	B06-12.5	SoundEarth	1/26/2018	12.5	<0.025	**0.097**	**0.15**	--	<0.05	<0.05
	B06-15			15	<0.025	**0.19**	**0.47**	<0.05	<0.05	<0.05
	B06-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B06-50			50	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B07	B07-12.5	SoundEarth	1/25/2018	12.5	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B07-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B08	B08-15	SoundEarth	1/25/2018	15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B08-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B09	B09-17.5	SoundEarth	1/25/2018	17.5	<0.025	<0.02	<0.05	--	<0.05	<0.05
	B09-20			20	<0.025	<0.02	<0.05	--	<0.05	<0.05
B10	B10-2.5	SoundEarth	1/26/2018	2.5	<0.025	<0.02	--	--	<0.05	<0.05
B11	B11-15	SoundEarth	1/26/2018	15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B12	B12-10.5	SoundEarth	2/7/2018	10.5–11.5	**1.2**	**3.1**	**0.88**	<0.05	<0.05	<0.05
	B12-14			14–15	**0.097**	**0.023**	<0.05	<0.05	<0.05	<0.05
	B12-17			17–18	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B12-20			20–21	<0.025	<0.02	<0.05	--	<0.05	<0.05
B13	B13-15	SoundEarth	2/7/2018	15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B14	B14-15	SoundEarth	2/7/2018	15	<0.025	**0.13**	**0.40**	<0.05	<0.05	<0.05
B15	B15-11	SoundEarth	10/1/2018	10.5–11.5	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B15-14			14–15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B15-17			17–18	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B15-20			20–21	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B16	B16-11	SoundEarth	10/1/2018	10.5–11.5	<0.025	**0.072**	<0.05	<0.05	<0.05	<0.05
	B16-14			14–15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B16-17			17–18	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B16-20			20–21	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B17	B17-15	SoundEarth	10/2/2018	15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B17-17.5			17.5	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	B17-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
B18	B18-10	SoundEarth	10/2/2018	10	<0.025	<0.02	**0.51**	<0.05	<0.05	<0.05
	B18-12.5			12.5	**2.1**	**1.7**	**0.93**	<0.05	<0.05	<0.05
	B18-15			15	**1.8**	**0.43**	**0.38**	<0.05	<0.05	<0.05
	B18-17.5			17.5	**0.085**	**0.030**	<0.05	<0.05	<0.05	<0.05
	B18-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB10	UB10-10	UEP	4/20/2019	10	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB10-15			15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB10-18			18	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB10-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB10-25			25	<0.025	**0.049**	<0.05	<0.05	<0.05	<0.05
	UB10-28			28	**0.11**	**0.083**	<0.05	<0.05	<0.05	<0.05
UB11	UB11-13	UEP	4/20/2019	13	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB11-15			15	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB11-20			20	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB11-25			25	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB11-28			28	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB12 (CD02A)	UB12-5	UEP	3/4/2020	5	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB12-14			14	<0.02	**0.29**	**2.06**	<0.02	<0.05	**0.34**
	UB12-22			22	**16.6**	**0.33**	**0.17**	<0.02	<0.05	<0.02
	UB12-37			37	~~**0.16**~~	<0.02	<0.02	<0.02	<0.05	<0.02
	UB12-46			46	~~**0.028**~~	<0.02	<0.02	<0.02	<0.05	<0.02
UB13 (CD08)	UB13-4	UEP	3/5/2020	4	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB13-9			9	**0.25**	<0.02	**33**	**0.21**	<0.05	**1.8**
	UB13-23			23	**143**	**1.8**	**0.16**	<0.02	<0.05	**0.033**
	UB13-43			43	~~**0.39**~~	<0.02	<0.02	<0.02	<0.05	<0.02
UB14 (CD06)	UB14-5	UEP	3/5/2020	5	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB14-7			7	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB14-20			20	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02

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Table 1
Soil Analytical Results for cVOCs
4208 Rainier Ave South, Seattle

Boring ID	Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results[1] - Milligrams per Kilogram (mg/kg)					
					PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC
UB15 (CD10A)	UB15-6	UEP	3/5/2020	6	**2.2**	<0.02	<0.02	<0.02	<0.05	<0.02
	UB15-20			20	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
UB16 (CD02B)	UB16-6	UEP	3/4/2020	6	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB16-14			14	**0.028**	<0.02	<0.02	<0.02	<0.05	<0.02
	UB16-29			29	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
UB17 (CD05B)	UB17-3	UEP	3/5/2020	3	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB17-11			11	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB17-24			24	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
UB18 (CD03)	UB18-3	UEP	3/5/2020	3	<0.02	<0.02	**0.022**	<0.02	<0.05	<0.02
	UB18-12			12	**0.027**	<0.02	<0.02	<0.02	<0.05	<0.02
	UB18-24			24	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB18-30			30	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
UB19	UB19-24	UEP	3/5/2020	24	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
UB20	UB20-25	UEP	3/12/2020	25	<0.02	<0.02	<0.02	<0.02	<0.05	<0.02
	UB20-30			30	**0.047**	**0.51**	**0.36**	<0.02	<0.05	<0.02
	UB20-35			35	**0.09**	**0.27**	**0.083**	<0.02	<0.05	<0.02
UB21	UB21-25	UEP	4/7/2020	25	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB21-30			30	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB21-34			34	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB22	UB22-25	UEP	4/7/2020	25	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB23	UB23-25	UEP	4/7/2020	25	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB23-30			30	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB23-33			33	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB25	UB25-27	UEP	4/10/2020	27	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB25-35			35	**1.2**	**0.26**	<0.05	<0.05	<0.05	<0.05
	UB25-45			45	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB26	UB26-30	UEP	4/10/2020	30	**1.1**	**0.21**	<0.05	<0.05	<0.05	<0.05
	UB26-35			35	**0.31**	**0.43**	**0.14**	<0.05	<0.05	<0.05
	UB26-40			40	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB26-45			45	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB27	UB27-6	UEP	4/10/2020	6	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB27-12			12	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB28	UB28-6	UEP	4/10/2020	6	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB28-11			11	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB29	UB29-6	UEP	4/10/2020	6	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB29-11			11	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB30	UB30-12	UEP	5/15/2020	12	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB30-23			23	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB30-24			24	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB30-26			26	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB30-30			30	**1.3**	**0.20**	<0.05	<0.05	<0.05	<0.05
	UB30-31			31	**0.13**	**0.030**	<0.05	<0.05	<0.05	<0.05
	UB30-34			34	**0.56**	**0.10**	<0.05	<0.05	<0.05	<0.05
	UB30-35			35	**0.50**	**0.17**	<0.05	<0.05	<0.05	<0.05
	UB30-38			38	**0.035**	**0.024**	<0.05	<0.05	<0.05	<0.05
	UB30-39			39	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB31	UB31-24	UEP	5/15/2020	24	**9.6**	**0.084**	<0.05	<0.05	<0.05	<0.05
	UB31-26			26	**2.4**	**0.39**	**0.073**	<0.05	<0.05	<0.05
	UB31-28			28	**0.23**	**0.04**	<0.05	<0.05	<0.05	<0.05
	UB31-31			31	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB31-32			32	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB31-35			35	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB31-37			37	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
	UB31-43			43	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05

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Table 1
Soil Analytical Results for cVOCs
4208 Rainier Ave South, Seattle

Boring ID	Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results[1] - Milligrams per Kilogram (mg/kg)					
					PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC
UB39	UB39-33	UEP	10/28/2020	33	**0.14**	**0.076**	<0.05	<0.05	<0.05	<0.05
UB40	UB40-30	UEP	10/28/2020	30	**0.67**	**0.11**	<0.05	<0.05	<0.05	<0.05
	UB40-33.5			33.5	<0.025	<0.02	<0.05	<0.05	<0.05	<0.05
UB41	UB41-33	UEP	10/29/2020	33	**0.32**	**0.28**	**0.085**	<0.05	<0.05	<0.05
UB42	UB42-33	UEP	10/29/2020	33	**0.43**	**0.17**	<0.05	<0.05	<0.05	<0.05
Ecology MTCA Method A Cleanup Levels[2] Unless Otherwise Specified					0.05	0.03	160[3]	1,600[3]	4,000[3]	0.67[4]

Notes:

Red denotes concentration exceeding MTCA cleanup level.
~~0.39~~ = Sample results was determined to be anomalous.
< = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).(1) Analyzed by EPA Method 8260C or 8260D.
(2) MTCA Cleanup Regulation, Chapter 173-340 of WAC, Table 740-1 Method A Cleanup Levels for Soil, revised 2013.
(3) MTCA Cleanup Regulation, Chapter 173-340 of WAC, CLARC Soil, Method B Noncancer, Direct Contact, CLARC Website: <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>
(4) MTCA Cleanup Regulation, Chapter 173-340 of WAC, CLARC Soil, Method B Cancer, Direct Contact, CLARC Website: < https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>

-- = not analyzed/not applicable
bgs = below grade surface
UEP = Urban Environmental Partners llc
WAC = Washington Administrative Code
EPA = U.S. Environmental Protection Agency
cVOCs: Chlorinated Volatile Organic Compounds
PCE = tetrachloroethylene
TCE = trichloroethylene
DCE = dichloroethylene
VC = Vinyl Chloride
MTCA = Washington Model Toxics Control Act.

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Table 2
Soil Analytical Results for
Petroleum Hydrocarbons and Select VOCs
4208 Rainier Ave South, Seattle

Boring ID	Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results - Milligrams per Kilogram (mg/kg)						
					GRPH	DRPH	ORPH	Benzene	Toluene	Ethylbenzene	Total Xylenes
TB01	TB01-15	SoundEarth	1/24/2018	15	**15**	**110**x	<250	--	--	--	--
TB02	TB02-15	SoundEarth	1/24/2018	15	<5	<50	<250	--	--	--	--
TB05	TB05-05	SoundEarth	1/24/2018	5	<5	**190**x	**5,100**	--	--	--	--
UB12 (CD02A)	UB12-5	UEP	3/4/2020	5	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB12-14			14	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB12-22			22	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB12-37			37	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB12-46			46	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
UB13 (CD08)	UB13-4	UEP	3/5/2020	4	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB13-9			9	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB13-23			23	**160***	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB13-43			43	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
UB14 (CD06)	UB14-5	UEP	3/5/2020	5	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB14-7			7	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB14-20			20	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
UB15 (CD10A)	UB15-6	UEP	3/5/2020	6	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB15-20			20	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
UB16 (CD02B)	UB16-6	UEP	3/4/2020	6	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB16-14			14	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB16-29			29	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
UB17 (CD05B)	UB17-3	UEP	3/5/2020	3	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB17-11			11	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB17-24			24	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
UB18 (CD03)	UB18-3	UEP	3/5/2020	3	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB18-12			12	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB18-24			24	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
	UB18-30			30	<10	<50	<250	<0.02	<0.10	<0.03	<0.15
UB34	UB43-3	UEP	6/3/2020	3	--	<50	<250	--	--	--	--
	UB34-7			7	--	<50	<250	--	--	--	--
	UB34-13			13	--	<50	<250	--	--	--	--
UB35	UB35-4	UEP	6/3/2020	4	--	<50	<250	--	--	--	--
	UB35-10			10	--	<50	<250	--	--	--	--
	UB35-14			14	--	<50	<250	--	--	--	--
Ecology MTCA Method A Cleanup Levels[1] Unless Otherwise Specified					**100/30[2,3]**	**2,000[4]**	**2,000[4]**	**0.03[5]**	**7[5]**	**6[5]**	**9[5]**

Notes:

Red denotes concentration exceeding MTCA cleanup level.
< = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).
(1) MTCA Cleanup Regulation, Chapter 173-340 of WAC, Table 740-1 Method A Cleanup Levels for Soil, revised 2013.
(2) Analyzed by Method NWTPH-Gx or NWTPH-HCID.
(3) The GRPH CUL is 30 mg/kg when benzene is present, or 100 mg/kg without benzene
(4) Analyzed by Method NWTPH-Dx or NWTPH-HCID
(5) Analyzed by EPA Method 8021B, 8260C, or 8260D.

Laboratory Notes:
x = The sample chromatographic pattern does not resemble the fuel standard used for quantitation.
* = The gasoline range value consists of a chlorinated compound with elevated concentrations.

-- = not analyzed/not applicable
bgs = below grade surface
NWTPH = Northwest Total Petroleum Hydrocarbon
WAC = Washington Administrative Code
EPA = U.S. Environmental Protection Agency
GRPH = Gasoline-Range Petroleum Hydrocarbons
DRPH = Diesel-Range Petroleum Hydrocarbons
ORPH = Oil-Range Petroleum

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Table 3
Soil Analytical Results for Total Metals
4208 Rainier Ave South, Seattle

Boring ID	Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results[1] - Milligrams per Kilogram (mg/kg)							
					Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
TB01	TB01-05	SoundEarth	1/24/2018	5	2.54	--	<1	18.8	4.82	<1	--	--
TB03	TB03-05	SoundEarth	1/24/2018	5	2.39	--	<1	28.2	4.26	<1	--	--
TB04	TB04-05	SoundEarth	1/24/2018	5	1.79	--	<1	12.1	8.10	<1	--	--
B06	B06-05	SoundEarth	1/24/2018	5	6.73	--	<1	18.0	8.81	<1	--	--
B09	B09-05	SoundEarth	1/24/2018	5	3.17	--	<1	26.8	4.06	<1	--	--
Ecology MTCA Method A Cleanup Levels[2] Unless Otherwise Specified					**20**	**16,000[3]**	**2**	**2,000**	**250**	**2**	**400[3]**	**400[3]**

Notes:

Red denotes concentration exceeding MTCA cleanup level.
< = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).
(1) Samples analyzed by EPA Method 6020A.
(2) MTCA Cleanup Regulation, Chapter 173-340 of WAC, Table 740-1 Method A Cleanup Levels for Soil, revised 2013.
(3) MTCA Cleanup Regulation, Chapter 173-340 of WAC, CLARC, Soil, Method B, Noncancer, Direct Contact, CLARC Website <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>.

-- = not analyzed/not applicable
bgs = below grade surface
WAC = Washington Administrative Code
EPA = U.S. Environmental Protection Agency
MTCA = Washington Model Toxics Control Act.
SoundEarth = SoundEarth Strategies, Inc.

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Table 4
Soil Analytical Results for PAHs
4208 Rainier Ave South, Seattle

Boring ID	Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results[1] - Milligrams per Kilogram (mg/kg)							Total Toxicity Equivalency Concentration[2]
					Benzo(a)-anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Indeno(1,2,3cd)-pyrene	Dibenzo(a,h)-anthracene	
TB01	TB01-05	SoundEarth	1/24/2018	5	<0.02	<0.02	<0.1	<0.2	<0.2	<0.2	<0.2	ND
TB03	TB03-05	SoundEarth	1/24/2018	5	<0.02	<0.02	<0.1	<0.2	<0.2	<0.2	<0.2	ND
B09	B09-05	SoundEarth	1/24/2018	5	**0.015**	**0.028**	**0.022**	**0.031**	**0.012**	<0.010	<0.010	**0.029**
NA	Pile1-3"	UEP	4/27/2020	2	**0.20**	**0.17**	**0.21**	**0.23**	**0.068**	**0.090**	**0.025**	**0.273**
NA	Pile1-6"	UEP	4/27/2020	2	<0.01	<0.01	<0.01	**0.012**	<0.01	<0.01	<0.01	**0.0083**
NA	Pile1-12"	UEP	4/27/2020	2	<0.01	**0.021**	**0.060**	**0.010**	**0.020**	**0.026**	<0.01	**0.0668**
NA	Piles-Middle	UEP	4/27/2020	2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	ND
UB32	UB32-13	UEP	6/3/2020	13	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**ND**
UB33	UB32-12	UEP	3/3/2020	12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	ND
Ecology MTCA Method A Cleanup Levels[3] Unless Otherwise Specified					--	--	**0.1**	--	--	--	--	**0.1**

Notes:

Red denotes concentration exceeding MTCA cleanup level.
< or ND = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).
(1) Samples analyzed by GC/MS-SIM or EPA Method 8270D.
(2) Calculated Using Toxicity Equivalency Methodology in WAC 173-340-708(e)
(3) MTCA Cleanup Regulation, Chapter 173-340 of WAC, Table 740-1 Method A Cleanup Levels for Soil, revised 2013.

-- = not analyzed/not applicable
bgs = below grade surface
WAC = Washington Administrative Code
EPA = U.S. Environmental Protection Agency
MTCA = Washington Model Toxics Control Act.
SoundEarth = SoundEarth Strategies, Inc.
UEP = Urban Environmental Partners

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Table 5
Groundwater Analytical Results for cVOCs
4208 Rainier Ave South, Seattle

Boring/Well ID	Sample ID	Sampled By	Date Sampled	Analytical Results - Micrograms per Liter (µg/L)					
				PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC
B-1	B-1 (29-32)	Hahn	6/28/2000	1,980	288	25.7	--	<1.0	<1.2
B-3	B-3 (27-30)	Hahn	6/28/2000	<1.0	<1.0	1.8	--	<1.0	<1.2
B-4	B-4 (27-30)	Hahn	6/28/2000	3,800	1,100	40.8	--	2.94	4.37
B-5	B-5 (23-36)	Hahn	6/29/2000	<1.0	<1.0	<1.0	--	<1.0	<1.2
B-7	B-7 (23-26)	Hahn	6/29/2000	1.25	<1.0	<1.0	--	<1.0	<1.2
MW01	MW01-20180102	SoundEarth	1/2/2018	8,700	<500	<500	<500	<500	<100
	MW1-20200313	UEP	3/13/2020	16,400	3,820	3,460	37	2.4	499
	MW01-20200827	UEP	8/27/2020	14,000	1,900	1,800	28	2.0	150
MW02	MW02-20180129	SoundEarth	1/29/2018	<1	<1	7.1	<1	<1	0.33
	MW2-20200312	UEP	3/12/2020	<1	0.94	11	<1	<0.5	<0.2
	MW02-20200826	UEP	8/26/2020	<1	<1	9.8	<1	<1	0.33
	MW02-PDB20200826	UEP	8/26/2020	<1	<1	8.9	<1	<1	0.47
MW03	MW03-20180129	SoundEarth	1/29/2018	<1	<1	<1	<1	<1	<0.2
	MW3-20200312	UEP	3/12/2020	<1	<0.4	<1	<1	<0.5	<0.2
	MW03-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
	MW03-PDB20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
MW04	MW04-20180129	SoundEarth	1/29/2018	<1	<1	<1	<1	<1	<0.2
	MW4-20200312	UEP	3/12/2020	<1	<0.4	<1	<1	<0.5	<0.2
	MW04-20200827	UEP	8/27/2020	<1	<1	<1	<1	<1	<0.2
	MW04-PDB20200827	UEP	8/27/2020	<1	<1	<1	<1	<1	<0.2
MW05	MW05-20180129	SoundEarth	1/29/2018	35,000	6,600	2,600	27	2.9	240
	MW5-20200312	UEP	3/12/2020	38,900	19,800	12,200	122	8.0	138
	MW05-20200828	UEP	8/28/2020	15,000	10,000	5,800	140	<100	220
MW06	MW06-20181005	SoundEarth	10/5/2018	<1	2.4	3.5	<1	<1	<0.2
	MW6-20200312	UEP	3/12/2020	5.7	11	13	<1	<0.5	0.66
	MW06-20200827	UEP	8/27/2020	3.5	5.7	8.9	<1	<1	0.34
MW07	MW07-20181005	SoundEarth	10/5/2018	<1	<1	<1	<1	<1	<0.2
	MW7-20200312	UEP	3/12/2020	<1	<0.4	<1	<1	<0.5	<0.2
	MW07-20200827	UEP	8/27/2020	<1	<1	<1	<1	<1	<0.2
MW08	MW08-20181005	SoundEarth	10/5/2018	560	320	390	2.0	<1	16
	MW8-20200312	UEP	3/12/2020	1,200	510	420	3.1	<0.5	13
	MW08-20200828	UEP	8/28/2020	400	220	200	<5	<5	9.3
MW09	MW09-20181005	SoundEarth	10/5/2018	20	59	36	<1	<1	1.7
	MW9	UEP	4/21/2019	38	110	93	1.2	<1	7.4
	MW9-20200312	UEP	3/12/2020	300	740	1,030	11	<0.5	12
	MW9-04142020	UEP	4/14/2020	350	460	370	2.8	<0.5	5
	MW09-20200515	UEP	5/15/2020	99	87	48	<1	<0.5	0.47
	MW09-20200826	UEP	8/26/2020	530	300	590	<10	<10	9.9
	MW09-20201207	UEP	12/7/2020	110	140	990	<10	<10	39
MW10	MW10	UEP	4/21/2019	41	54	22	<1	<1	0.24
	MW10-20200312	UEP	3/12/2020	<1	<0.4	<1	<1	<0.5	<0.2
	MW10-04142020	UEP	4/14/2020	<1	<1	<1	<1	<0.5	<0.2
	MW10-04142020b	UEP	4/14/2020	<1	<1	<1	<1	<0.5	<0.2
	MW10-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
	MW10-DB-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
MW11	MW11	UEP	4/21/2019	<1	<1	<1	<1	<1	<0.2
	MW11-04142020	UEP	4/14/2020	<1	<1	<1	<1	<1	<0.2
	MW11-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
	MW11-DB-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
UB12 (CD02A) / MW12	MW12-20200313	UEP	3/13/2020	1,030	45	13	<1	<0.5	4.1
	MW12-20200827	UEP	8/27/2020	17	1.7	26	<1	<1	1.4
UB13 (CD08) / MW13	UB13W-23	UEP	3/5/2020	25,300	3,180	1,353	<1	<0.5	<0.2
	MW13-20200313	UEP	3/13/2020	2,190	5,580	1,160	3.3	22	76
	MW13-20200827	UEP	8/27/2020	72,000	19,000	16,000	140	12	1,200

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Table 5
Groundwater Analytical Results for cVOCs
4208 Rainier Ave South, Seattle

Boring/Well ID	Sample ID	Sampled By	Date Sampled	Analytical Results - Micrograms per Liter (µg/L)					
				PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC
UB14 (CD06) / MW14	MW14-20200305	UEP	3/5/2020	<1	<0.4	<1	<1	<0.5	<0.2
	MW14-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
UB15 (CD10A) / MW15	MW15-20200312	UEP	3/12/2020	<1	<0.4	<1	<1	<0.5	<0.2
	MW15-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
UB16 (CD02B) / MW16	MW16-20200304	UEP	3/4/2020	4,590	744	536	<1	<0.5	58.6
	MW16-20200312	UEP	3/12/2020	12	2.2	1.0	<1	<0.5	<0.2
	MW16-20200827	UEP	8/27/2020	<1	<1	<1	<1	<1	<0.2
UB17 (CD05B) / MW17	MW17-20200305	UEP	3/5/2020	<1	<0.4	166	<1	<0.5	<0.2
	MW17-20200312	UEP	3/12/2020	1.4	0.47	95	<1	<0.5	1.0
	MW17-20200826	UEP	8/26/2020	<1	<1	190	<1	<1	0.83
UB18 (CD03) / MW18	UB18W-24	UEP	3/5/2020	11.2	17.2	33.4	<1	<0.5	<0.2
	MW18-20200312	UEP	3/12/2020	2.8	68	97	3.5	1.3	2.8
	MW18-20200826	UEP	8/26/2020	1.8	54	60	2.1	<1	1.5
UB19	UB19W-25	UEP	3/5/2020	<1	<0.4	3.0	<1	<0.5	<0.2
UB20/MW20	MW20-20200312*	UEP	3/13/2020	2.0	38	55	<1	<0.5	0.20
	MW20-04102020	UEP	4/10/2020	<1	<1	3.8	<1	<1	<0.2
	MW20-20200828	UEP	8/28/2020	<1	2.7	36	<1	<1	<0.2
	MW20-DB-20200828	UEP	8/28/2020	<1	<1	<1	<1	<1	<0.2
UB21/MW21	MW21-04102020	UEP	4/10/2020	<1	<1	<1	<1	<1	<0.2
	MW21-20200828	UEP	8/28/2020	<1	<1	<1	<1	<1	<0.2
UB22/MW22	MW22-04102020	UEP	4/10/2020	<1	<1	<1	<1	<1	<0.2
	MW22-20200828	UEP	8/28/2020	<1	<1	<1	<1	<1	<0.2
UB23/MW23	MW23-04102020	UEP	4/10/2020	<1	<1	<1	<1	<1	<0.2
	MW23-20200828	UEP	8/28/2020	<1	<1	<1	<1	<1	<0.2
UB24/MW24	MW24-04102020	UEP	4/10/2020	<1	<1	<1	<1	<1	<0.2
	MW24-20200826	UEP	8/26/2020	<1	<1	<1	<1	<1	<0.2
UB25/MW25	MW25-04142020	UEP	4/14/2020	5,200	1,900	1,500	17	2.7	140
	MW25-20200827	UEP	8/27/2020	980	770	980	3.5	<1	8.7
	MW25-PDB20200827	UEP	8/27/2020	830	750	810	2.6	1.2	1.7
	MW25-PDB2-20200827	UEP	8/27/2020	680	670	1,100	<10	<10	2.2
UB26/MW26	MW26-04142020	UEP	4/14/2020	52	68	8.1	<1	<1	0.27
	MW26-20200826	UEP	8/26/2020	720	490	130	1.1	<1	7.80
	MW26-20201207	UEP	12/7/2020	<1	5.1	170	<1	<1	3.7
UB30/MW30	MW-30	UEP	5/23/2020	1,500	410	250	<100	<100	30
	MW30-20200827	UEP	8/27/2020	4,400	850	540	<10	<10	53
	MW30-PDB20200827	UEP	8/27/2020	6,400	1,200	740	10	1.1	69
	MW30-20201207	UEP	12/7/2020	1.1	<1	4.8	<1	<1	3.6
UB31/MW31	MW-31	UEP	5/23/2020	120,000	22,000	15,000	120	11	1,300
	MW31-20200827	UEP	8/27/2020	120,000	23,000	24,000	<1,000	<1,000	1,900
	MW31-PDB20200827	UEP	8/27/2020	120,000	25,000	20,000	190ve	12	1,900
Ecology MTCA Method A Cleanup Levels[2] Unless Otherwise Specified				5	5	16[3]	160[3]	400[3]	0.2

Notes:

Red denotes concentration exceeding MTCA cleanup level.
< = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).
(1) Analyzed by EPA Method 8260C or 8260D.
(2) MTCA Cleanup Regulation, Chapter 173-340-900 of WAC, Table 720-1 Method A Cleanup Levels for Groundwater, revised November 2007.
(3) MTCA Cleanup Regulation, Chapter 173-340 of WAC, CLARC, Groundwater, Method B, Non cancer, CLARC Website <https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx>

-- = not analyzed/not applicable
bgs = below grade surface
UEP = Urban Environmental Partners llc
WAC = Washington

DCE = dichloroethylene
VC = Vinyl Chloride
MTCA = Washington Model Toxics Control Act.
Hahn = Hahn and Associates, Inc.
SoundEarth = SoundEarth Strategies, Inc.
* Labeling Error - This sample was

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Table 6
Groundwater Analytical Results for Petroleum Hydrocarbons and Select VOCs
4208 Rainier Ave South, Seattle

Boring/Well ID	Sample ID	Sampled By	Date Sampled	Analytical Results - Micrograms per Liter (µg/L)						
				GRPH[1]	DRPH[2]	ORPH[2]	Benzene[3]	Toluene[3]	Ethylbenzene[3]	Total Xylenes[3]
B-1	B-1 (29-32)	Hahn	6/28/2000	--	--	--	<1	<1	<1	<3
B-3	B-3 (27-30)	Hahn	6/28/2000	--	--	--	<1	<1	<1	<3
B-4	B-4 (27-30)	Hahn	6/28/2000	--	--	--	<1	<1	<1	<3
B-5	B-5 (23-36)	Hahn	6/29/2000	--	--	--	<1	<1	<1	<3
B-7	B-7 (23-26)	Hahn	6/29/2000	--	--	--	<1	<1	<1	<3
UB12 (CD02A) / MW12	MW12-20200313	UEP	3/13/2020	**720***	<200	<400	<1	<1	<1	<2
UB13 (CD08) / MW13	UB13W-23	UEP	3/5/2020	**25,200***	<200	<400	<10	<10	<10	<20
	MW13-20200313	UEP	3/13/2020	**8,200***	<200	<400	<1	<1	<1	<2
UB14 (CD06) / MW14	MW14-20200305	UEP	3/5/2020	<100	<200	<400	<1	<1	<1	<2
UB15 (CD10A) / MW15	MW15-20200312	UEP	3/12/2020	<100	<200	<400	<1	<1	<1	<2
UB16 (CD02B) / MW16	MW16-20200304	UEP	3/4/2020	**3,800***	<200	<400	<10	<10	<10	<20
	MW16-20200312	UEP	3/4/2020	<100	<200	<400	<1	<1	<1	<2
UB17 (CD05B) / MW17	MW17-20200305	UEP	3/5/2020	<100	<200	<400	<1	<1	<1	<2
	MW17-20200312	UEP	3/12/2020	<100	<200	<400	<1	<1	<1	<2
UB18 (CD03) / MW18	UB18W-24	UEP	3/5/2020	<100	<200	<400	<1	<1	<1	<2
	MW18-20200312	UEP	3/12/2020	**115***	<200	<400	<1	<1	<1	<2
UB34	UB34-W	UEP	6/3/2020	--	**160x**	<250	--	--	--	--
UB35	UB35-W	UEP	6/3/2020	--	<65	<320	--	--	--	--
Ecology MTCA Method A Cleanup Levels[4] Unless Otherwise Specified				**1,000/800[5]**	**500**	**500**	**5**	**1,000**	**700**	**1,000**

Notes:

Red denotes concentration exceeding MTCA cleanup level.
< = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).
(1) Analyzed by Northwest Method NWTPH-Gx or NEPTH-HCID
(2) Analyzed by Northwest Method NWTPH-Dx or NEPTH-HCID
(3) Analyzed by EPA Method 8260C or 8260D.
(4) MTCA Cleanup Regulation, Chapter 173-340-900 of WAC, Table 720-1 Method A Cleanup Levels for Groundwater, revised November 2007.
(5) For gasoline mixtures without benzene the cleanup level is 1,000 ug/l, for gasoline mixtures with benzene the cleanup level is 800 ug/l.
* = The gasoline range value consist of chlorinated compound(s) with elevated concentrations.

-- = not analyzed/not applicable
bgs = below grade surface
UEP = Urban Environmental Partners llc
WAC = Washington Administrative Code
EPA = U.S. Environmental Protection Agency
GRPH = Gasoline-Range Petroleum Hydrocarbons

DRPH = Diesel-Range Petroleum Hydrocarbons
ORPH = Oil-Range Petroleum Hydrocarbons
MTCA = Washington Model Toxics Control Act.
Hahn = Hahn and Associates, Inc.

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Table 7
Soil Gas and Sewer Gas Results for cVOCs
4208 Rainier Ave South, Seattle

Sample ID	Sampled By	Date Sampled	Depth (ft/bgs)	Analytical Results[1] - Micrograms per Cubic Meter (µg/m³)										
				PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	VC	Chloroethane	1,1-Dichloroethane	1,2-Dichloroethane	1,1,1-Trichloroethane	1,1,2-Trichloroethane
SG01	SoundEarth	1/2/2018	8	**48**	<5.4	<4	<4	<4	<2.6	<2.6	<4	<4	<5.5	<5.5
SG02	SoundEarth	1/2/2018	8	**38**	<5.4	<4	<4	<4	<2.6	<2.6	<4	<4	<5.5	<5.5
SG03	SoundEarth	1/2/2018	8	**25**	<5.4	<4	<4	<4	<2.6	<2.6	<4	<4	<5.5	<5.5
SG04	UEP	4/10/2020	1.5	<110	<4.3	<6.3	<6.3	<6.3	<4.1	<42	<6.5	<0.65	<8.7	<1.7
SG05	UEP	4/10/2020	1.5	<110	<4.3	<6.3	<6.3	<6.3	<4.1	<42	<6.5	<0.65	<8.7	<1.7
Sewer South	UEP	5/15/2020	10	**270**	**69**	**340**	**3.7**	<3	**22**	<20	<3.1	<0.31	<4.1	<0.83
Sewer North	UEP	5/15/2020	10	<54	<2.1	<3.2	<3.2	<3.2	<2	<21	<3.2	<0.32	<4.4	<0.87
Ecology MTCA Method B Screening Levels for Sub-Slab Soil Gas[2]				**320**	**11**	**NE**	**NE**	**3,000**	**9.50**	**NE**	**52**	**3.2**	**76,000**	**5.20**
Ecology MTCA Method B Screening Levels for Deep Soil Gas[3]				**960**	**33**	**NE**	**NE**	**9,100**	**28**	**NE**	**160**	**9.6**	**230,000**	**16.00**

Notes:

Red denotes concentration exceeding MTCA screening level.
< or ND = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).
(1) Samples analyzed by U.S. EPA Method TO-15
(2) Most Conservative MTCA Method B Sub-Slab Soil Gas Screening Level, CLARC Master Spreadsheet January 2020.
(3) Most Conservative MTCA Method B Deep Soil Gas Screening Level, CLARC Master CLARC Master Spreadsheet January 2020..

-- = not analyzed/not applicable
NE = Not Established
bgs = below grade surface
cVOCs: Chlorinated Volatile Organic Compounds
PCE = tetrachloroethylene
TCE = trichloroethylene
DCE = dichloroethylene
VC = Vinyl Chloride
WAC = Washington Administrative Code
EPA = U.S. Environmental Protection Agency
MTCA = Washington Model Toxics

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Table 8
Groundwater Analytical Results for PAHs
4208 Rainier Ave South, Seattle

Boring/Well ID	Sample ID	Sampled By	Date Sampled	Analytical Results[1] - Micrograms per Liter (µg/L)							Total Toxicity Equivalency Concentration[2]
				Benzo(a)-anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Indeno(1,2,3cd)-pyrene	Dibenzo(a,h)-anthracene	
UB32/MW32	MW32-20200608	UEP	6/8/2020	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	ND
	MW32-20200826	UEP	8/26/2020	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	ND
	MW32-20201207	UEP	12/7/2020	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	ND
	MW32-20210311	UEP	3/11/2021	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	ND
UB33/MW33	MW33-20200608	UEP	6/8/2020	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	ND
	MW33-20200826	UEP	8/26/2020	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	ND
	MW33-20201207	UEP	12/7/2020	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	ND
	MW33-20200311	UEP	3/11/2021	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	ND
Ecology MTCA Method A Cleanup Levels[3] Unless Otherwise Specified				**--**	**--**	**0.1**	**--**	**--**	**--**	**--**	**0.1**

Notes:

Red denotes concentration exceeding MTCA cleanup level.
< or ND = Not Detected at a concentration exceeding the specified laboratory reporting limit (RL).
(1) Samples analyzed by EPA Method 8270E SIM.
(2) Calculated Using Toxicity Equivalency Methodology in WAC 173-340-708(e)
(3) MTCA Cleanup Regulation, Chapter 173-340 of WAC, Table 720-1 Method A Cleanup Levels for Groundwater, revised 2013.

-- = not analyzed/not applicable
bgs = below grade surface
WAC = Washington Administrative Code
EPA = U.S. Environmental Protection Agency
MTCA = Washington Model Toxics Control Act.
UEP = Urban Environmental Partners

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Table 9
Field Parameters for Source Area Monitoring Wells (8/20)
4208 Rainier Ave South, Seattle

Well ID	Date Sampled	Groundwater Sampling Field Parameters											
		Total Manganese	Dissolved Manganese	Alkalinity	Nitrate	Total Iron	Ferrous Iron	Dissolved Iron	Temp	Dissolved Oxygen	ORP	pH	Specific Conductivity
		µg/L							°C	mg/L	mV	--	µS/cm
MW01	8/27/2020	<1	3.45	83,400	3,460	71.1	<50	74.0	17.0	0.37	29.60	6.64	1.465
MW04	8/27/2020	--	--	--	--	--	--	--	17.0	0.67	54.9	6.69	1.035
MW05	8/28/2020	--	--	--	--	--	--	--	16.8	1.53	43.4	6.38	1.767
MW06	8/27/2020	--	--	--	--	--	--	--	15.9	0.46	33.9	7.11	1.107
MW07	8/27/2020	<1	<1	81,500	3,200	88.6	<50	67.5	17.0	0.40	7.3	7.04	1.096
MW08	8/28/2020	1	<1	66,000	3,140	73.7	<50	57.3	15.4	0.70	45.5	6.44	1.063
MW09	8/26/2020	--	--	--	--	--	--	--	17.2	0.74	12.3	6.08	1.155
MW10	8/26/2020	--	--	--	--	--	--	--	17.0	0.22	20.9	6.37	1.073
MW12	8/27/2020	--	--	--	--	--	--	--	15.9	0.35	-17.8	7.85	0.425
MW13	8/27/2020	<1	<1	81,500	3,200	88.6	<50	67.5	16.9	0.61	-58.0	6.71	1.868
MW16	8/27/2020	--	--	--	--	--	--	--	16.1	0.51	14.4	6.73	1.252
MW17	8/26/2020	--	--	--	--	--	--	--	18.1	0.70	-15.0	6.57	1.497
MW18	8/26/2020	206	198	56,300	233	2,570	227	<50	18.2	0.46	22.1	6.59	1.312
MW20	8/28/2020	153	57.4	69,800	914	5,630	<50	57.8	15.7	0.77	-1.5	6.61	1.005
MW25	8/27/2020	--	--	--	--	--	--	--	18.6	0.45	-122.1	7.37	1.834
MW26	8/26/2020	--	--	--	--	--	--	--	17.4	0.55	23.4	6..82	1.204
MW30	8/27/2020	206	198	56,300	233	2,570	227	<50	16.5	0.52	-86.9	6.86	1.302
MW31	8/27/2020	--	--	--	--	--	--	--	16.3	0.36	35.5	6.57	2.070
MW32	8/26/2020	206	198	56,300	233	2,570	227	<50	19.6	0.55	-105.0	6.60	0.997
MW33	8/26/2020	153	57.4	69,800	914	5,630	<50	57.8	20.8	0.47	-101.4	6.55	0.691
Average		103	79.3	68,989	1,725	2,144	92	50.8	17.2	0.57	-8.2	6.7	1.3

Notes:

µg/L = micrograms per liter
mg/L = miligrams per liter
°C = Degrees Celsius
mV= milivolt
mV= milivolts
µS/cm = microsiemens per centimeter

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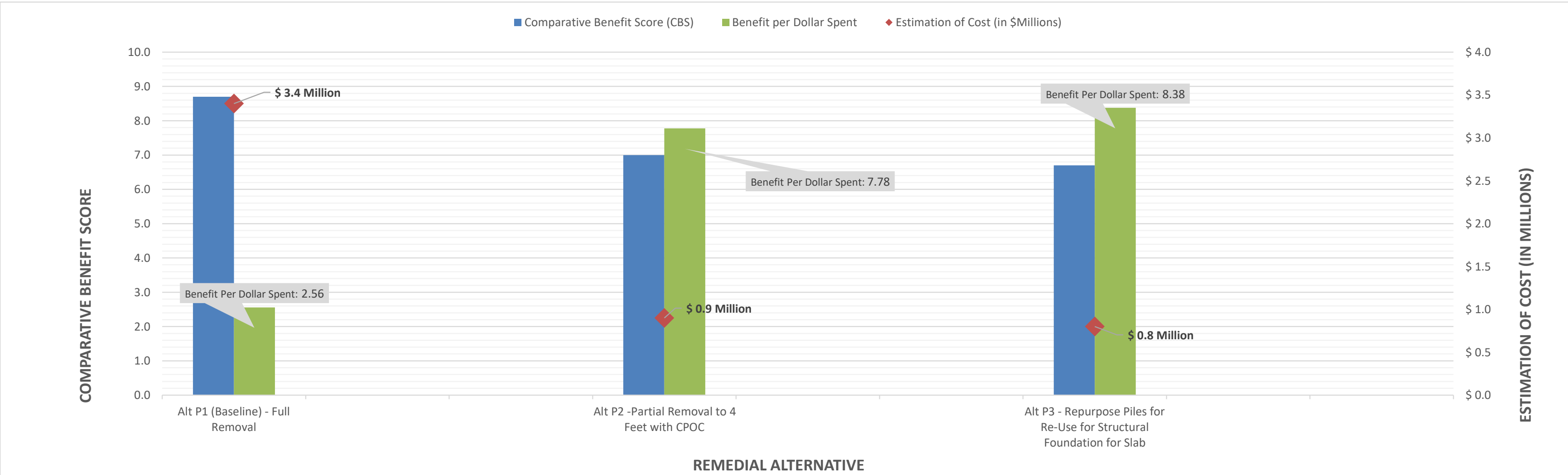
Table 10
Focused Feasibility Evaluation for Treated Piles
Summary of Evaluation Criteria and Costs
4208 Rainier Ave South, Seattle

Alternative Name/Description	**Alt P1 (Baseline) - Full Removal**			**Alt P2 -Partial Removal to 4 Feet with CPOC**			**Alt P3 - Repurpose Piles for Re-Use for Structural Foundation for Slab**		
MTCA Evaluation Criteria									
	Score	Weighting Factor	Weighted Score	Score	Weighting Factor	Weighted Score	Score	Weighting Factor	Weighted Score
Protectiveness	10	0.3	3.0	8	0.3	2.4	7	0.3	2.1
Permanence	10	0.2	2.0	6	0.2	1.2	4	0.2	0.8
Long Term Effectiveness	9	0.2	1.8	7	0.2	1.4	7	0.2	1.4
Manageability of Short Term Risk	5	0.1	0.5	7	0.1	0.7	9	0.1	0.9
Implementability	6	0.1	0.6	7	0.1	0.7	9	0.1	0.9
Consideration of Public Concerns	8	0.1	0.8	6	0.1	0.6	6	0.1	0.6
Comparative Benefit Score (CBS)	**8.7**			**7.0**			**6.7**		
Estimation of Cost (in $Millions)	$ 3.4			$ 0.9			$ 0.8		
Benefit per Dollar Spent	**2.56**			**7.78**			**8.38**		

Notes:
Benefit to Cost Ratio equals the Comparative Benefit Score Divided by Cost: Higher Value Equals Greater Benefit Per Dollar Spent



Urban Environmental Partners llc
Diligent, responsive, and practical consulting!

Table 11
Summary of Evaluation Criteria and Costs
4208 Rainier Ave South, Seattle

Alternative Name/Description	Alt 1 - Excavation and ISCR			Alt 2 - Excavation and MNA			Alt 3 - Dual-Phase Extraction (DPE) with Air Sparging			Alt 4 - Electrical Resistance Heating (ERH)			Alt 5 - ERH and In-Situ Chemical Reduction		
MTCA Evaluation Criteria															
	Score	Weighting Factor	Weighted Score	Score	Weighting Factor	Weighted Score	Score	Weighting Factor	Weighted Score	Score	Weighting Factor	Weighted Score	Score	Weighting Factor	Weighted Score
Protectiveness	9	0.3	2.7	6	0.3	1.8	3	0.3	0.9	8	0.3	2.4	9	0.3	2.7
Permanence	10	0.2	2.0	6	0.2	1.2	5	0.2	1.0	8	0.2	1.6	9	0.2	1.8
Long Term Effectiveness	9	0.2	1.8	6	0.2	1.2	4	0.2	0.8	8	0.2	1.6	8	0.2	1.6
Manageability of Short Term Risk	7	0.1	0.7	7	0.1	0.7	5	0.1	0.5	3	0.1	0.3	2	0.1	0.2
Implementability	7	0.1	0.7	9	0.1	0.9	5	0.1	0.5	4	0.1	0.4	6	0.1	0.6
Consideration of Public Concerns	5	0.1	0.5	5	0.1	0.5	5	0.1	0.5	5	0.1	0.5	5	0.1	0.5
Comparative Benefit Score (CBS)	**8.4**			**6.3**			**4.2**			**6.8**			**7.4**		
Estimation of Cost (in millions)	$ 6.7			$ 6.9			$ 4.4			$ 5.0			$ 3.2		
Benefit per Dollar Spent	**1.25**			**0.91**			**0.95**			**1.36**			**2.31**		

Notes:
Benefit to Cost Ratio equals the Comparative Benefit Score Divided by Cost: Higher Value Equals Greater Benefit Per Dollar Spent
Alternative 2 has a relatively moderate score for protective and permanence as it relies on MNA to manage residuals

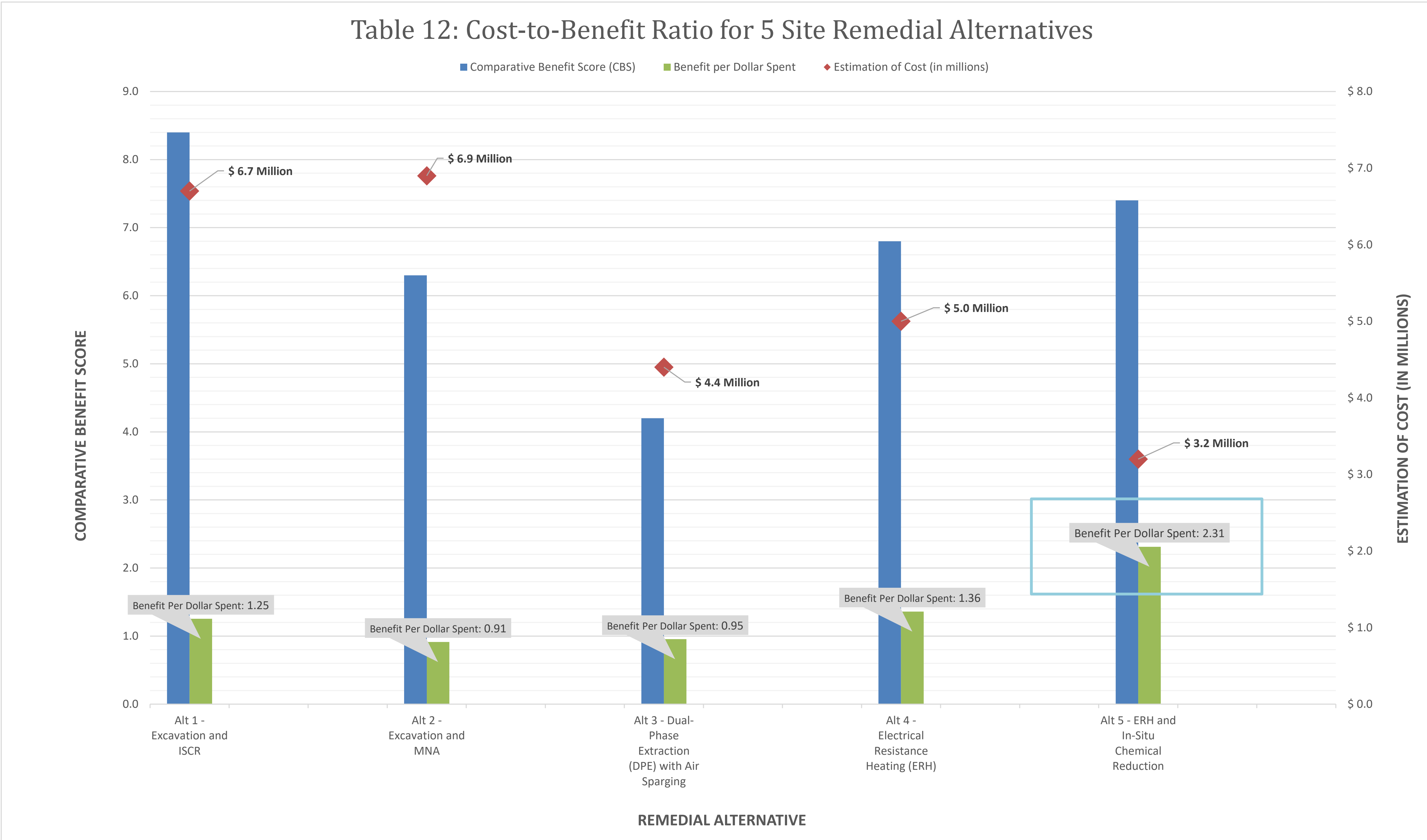


Table 12: Cost-to-Benefit Ratio for 5 Site Remedial Alternatives
Comparative Benefit Score (CBS)
Benefit per Dollar Spent
Estimation of Cost (in millions)
COMPARATIVE BENEFIT SCORE
ESTIMATION OF COST (IN MILLIONS)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
$ 8.0
$ 7.0
$ 6.0
$ 5.0
$ 4.0
$ 3.0
$ 2.0
$ 1.0
$ 0.0
$ 6.7 Million
$ 6.9 Million
$ 4.4 Million
$ 5.0 Million
$ 3.2 Million
Benefit Per Dollar Spent: 1.25
Benefit Per Dollar Spent: 0.91
Benefit Per Dollar Spent: 0.95
Benefit Per Dollar Spent: 1.36
Benefit Per Dollar Spent: 2.31
Alt 1 - Excavation and ISCR
Alt 2 - Excavation and MNA
Alt 3 - Dual-Phase Extraction (DPE) with Air Sparging
Alt 4 - Electrical Resistance Heating (ERH)
Alt 5 - ERH and In-Situ Chemical Reduction
REMEDIAL ALTERNATIVE

Appendix A: TRS Design Plans for ERH

ELECTRICAL RESISTANCE HEATING DESIGN PACKAGE

PRELIMINARY

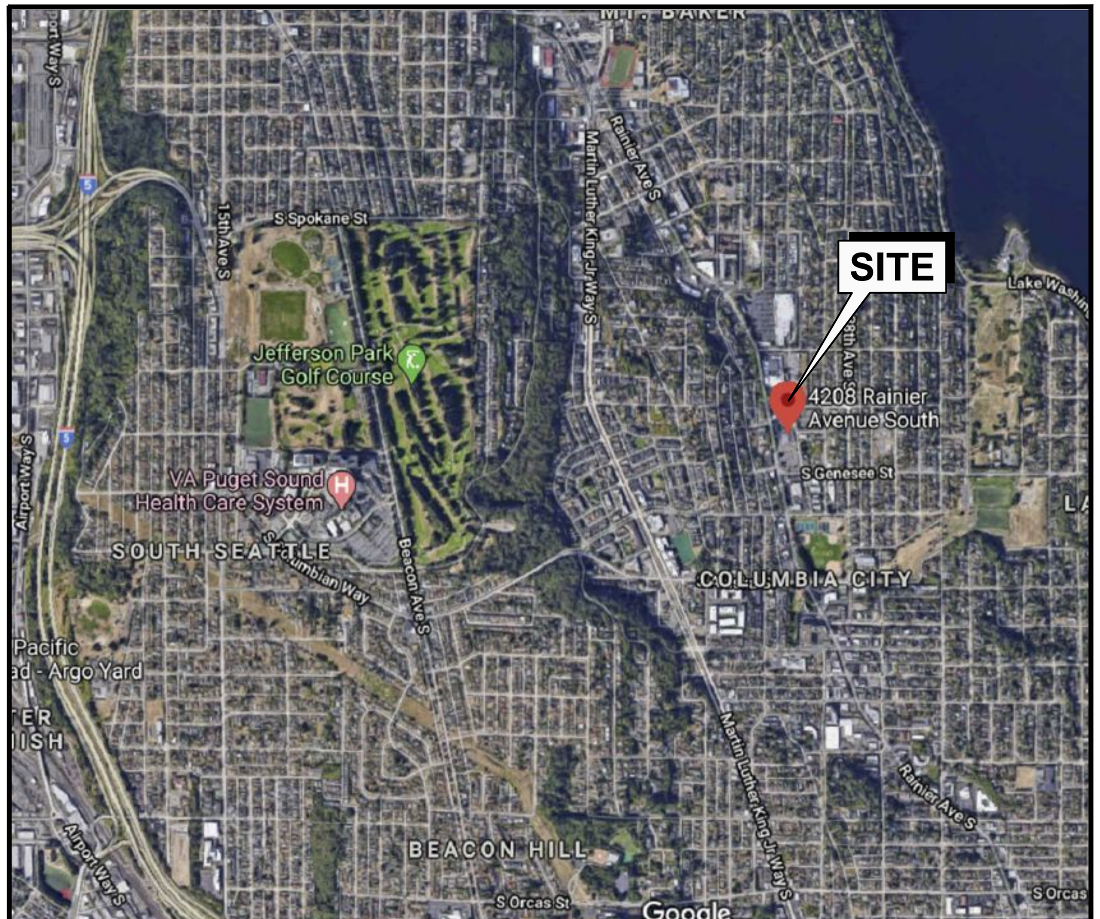
Not Approved for Construction

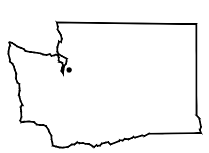
RAINER MALL PROPERTY
4208 RANIER AVE. SOUTH
SEATTLE, WASHINGTON 98118

Prepared by:

TRS Accelerating Value

MARCH 2021



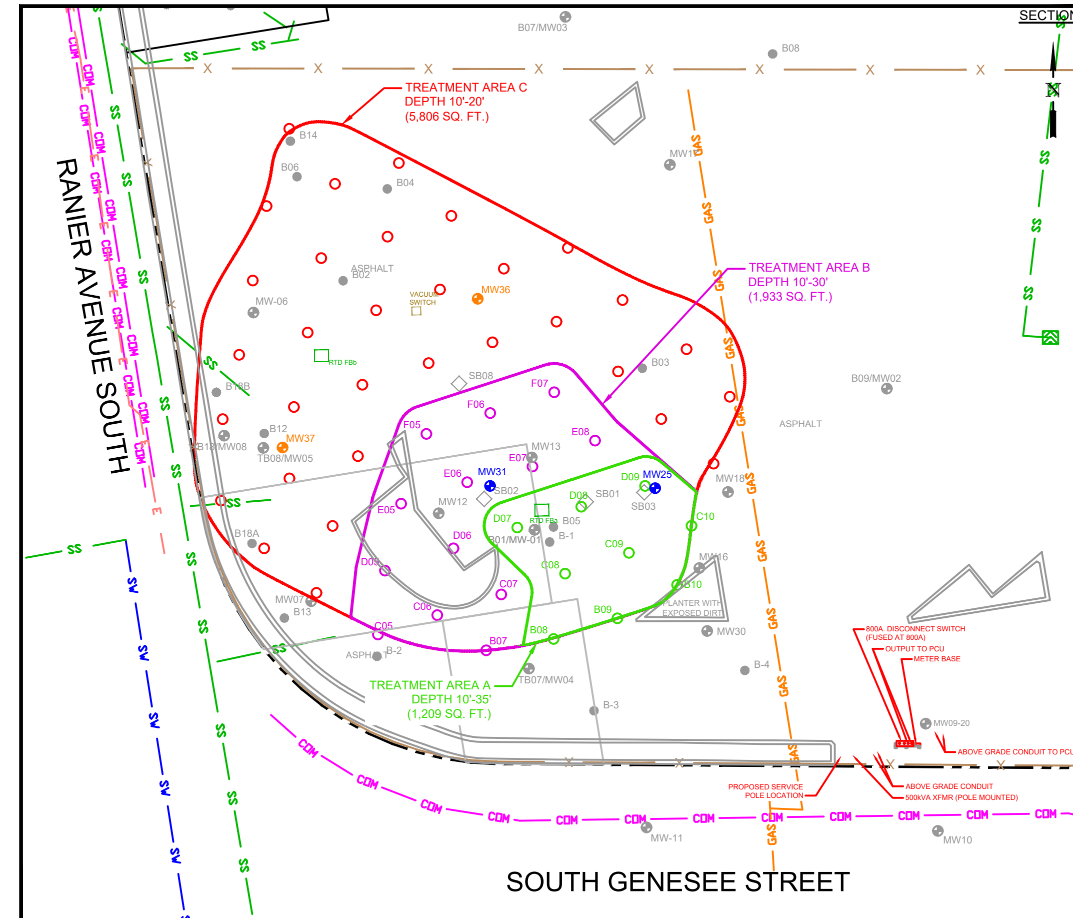


WASHINGTON

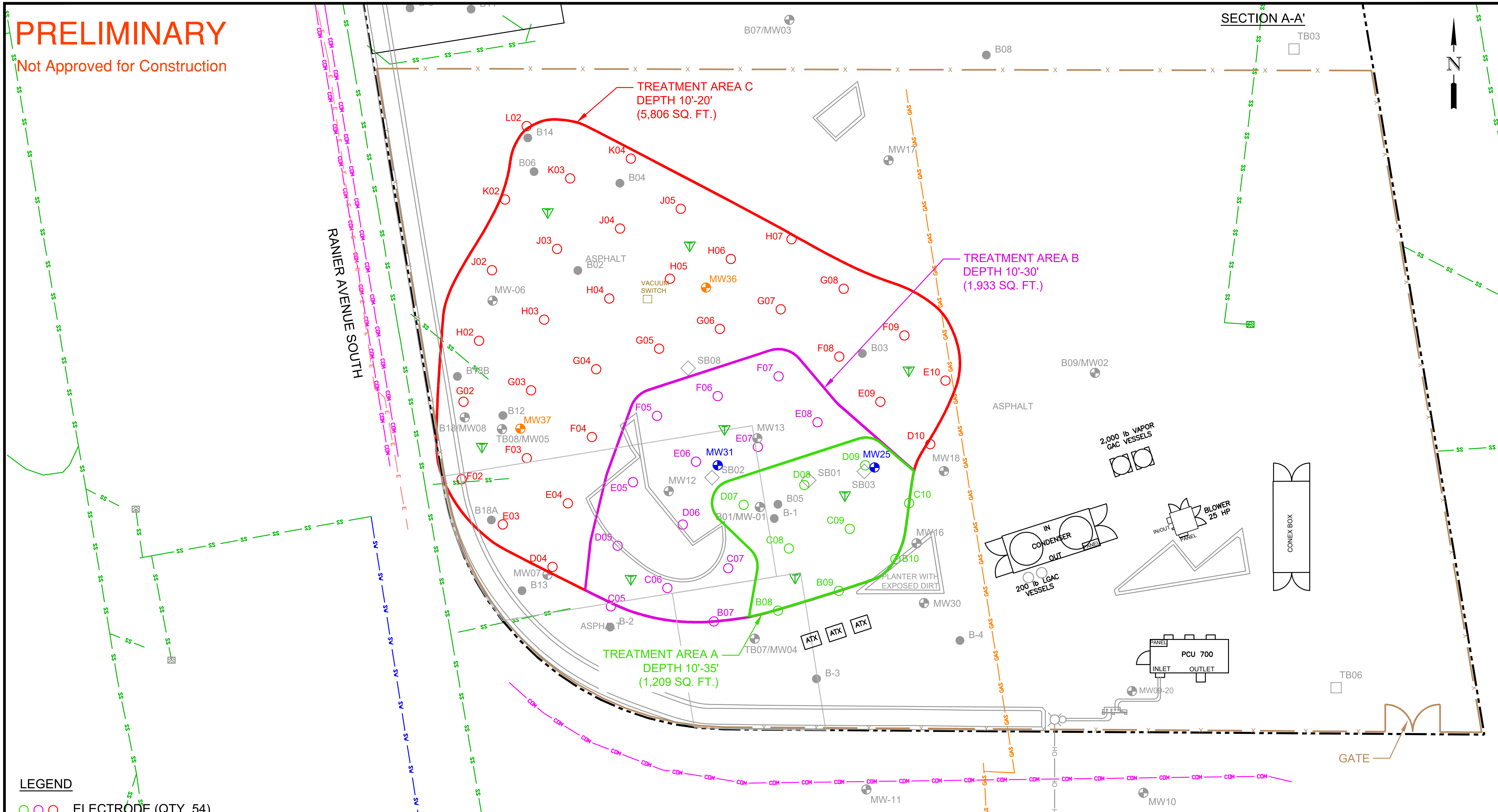
SITE LOCATION MAP

SHEET INDEX

DRAWING NUMBER	TITLE AND DESCRIPTION
Y-1	SITE PLAN WITH ELECTRODE LAYOUT
Y-1B	SITE PLAN ELECTRICAL UTILITY DETAIL
Y-2	SITE PLAN WITH HISTORIC SOIL CONTAMINATION LEVELS
Y-3	VAPOR RECOVERY PIPING PLAN
Y-4	FIELD BOX PLACEMENT AND WIRING PLAN
Y-5	CABLE AND PHASING PLAN
Y-6	DRIP PIPING PLAN AND SOLENOID WIRING PLAN
Y-7	RTD WIRING PLAN
Y-8	EQUIPMENT PIPING PLAN
Y-9	SECURITY PLAN
M-1	ELECTRODE DETAIL TYPE A
M-2	ELECTRODE DETAIL TYPE B
M-3	ELECTRODE DETAIL TYPE C
M-4	TEMPERATURE MONITORING POINT DETAIL TYPE A
M-5	TEMPERATURE MONITORING POINT DETAIL TYPE B
M-6	TEMPERATURE MONITORING POINT DETAIL TYPE C
P-1	LEGEND-PROCESS AND INSTRUMENTATION DIAGRAM
P-2	PROCESS FLOW DIAGRAM
P-3	PROCESS FLOW MASS BALANCE
P-4	FIELD PROCESS AND INSTRUMENTATION DIAGRAM
P-5	CONDENSER PROCESS AND INSTRUMENTATION DIAGRAM
P-6	COOLING TOWER PROCESS AND INSTRUMENTATION DIAGRAM
P-7	VAPOR TREATMENT PROCESS AND INSTRUMENTATION DIAGRAM
P-8	WATER TREATMENT PROCESS AND INSTRUMENTATION DIAGRAM
E-1	ELECTRICAL ONE-LINE DIAGRAM LEGEND
E-2	ELECTRICAL ONE-LINE DIAGRAM REQUIREMENTS
E-3	ELECTRICAL ONE-LINE DIAGRAM
E-4	ELECTRICAL ONE-LINE DIAGRAM



SITE PLAN



LEGEND

- ELECTRODE (QTY. 54)
- TEMPERATURE MONITORING POINT (QTY. 8)
- EXISTING MONITORING WELL
- EXISTING S.S. MONITORING WELL
- EXISTING BORING LOCATION
- S.S. MONITORING WELL TO BE INSTALLED PRIOR TO ERH
- PERIMETER FENCE

0 10 20 40

SCALE IN FEET

TRS *Accelerating Value*

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

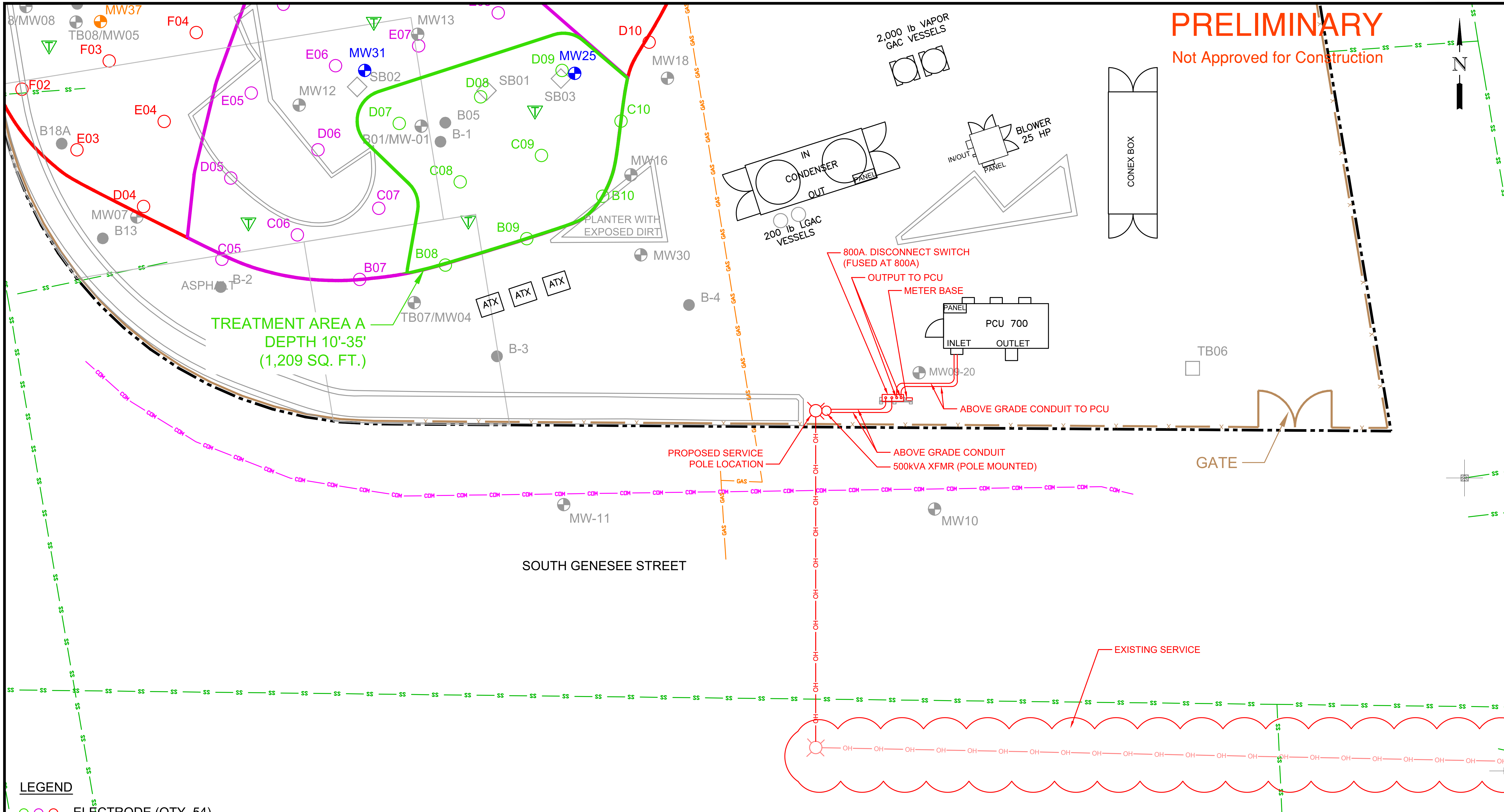
SITE PLAN WITH ELECTRODE LAYOUT

APPROVED FOR CONSTRUCTION

BY ____________

DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	Y-1



LEGEND

- ELECTRODE (QTY. 54)
- TEMPERATURE MONITORING POINT (QTY. 8)
- EXISTING MONITORING WELL
- EXISTING S.S. MONITORING WELL
- EXISTING BORING LOCATION
- S.S. MONITORING WELL TO BE INSTALLED PRIOR TO ERH
- PERIMETER FENCE

0 7.5 15 30

SCALE IN FEET

TRS *Accelerating Value*

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

SITE PLAN
ELECTRICAL UTILITY DETAIL

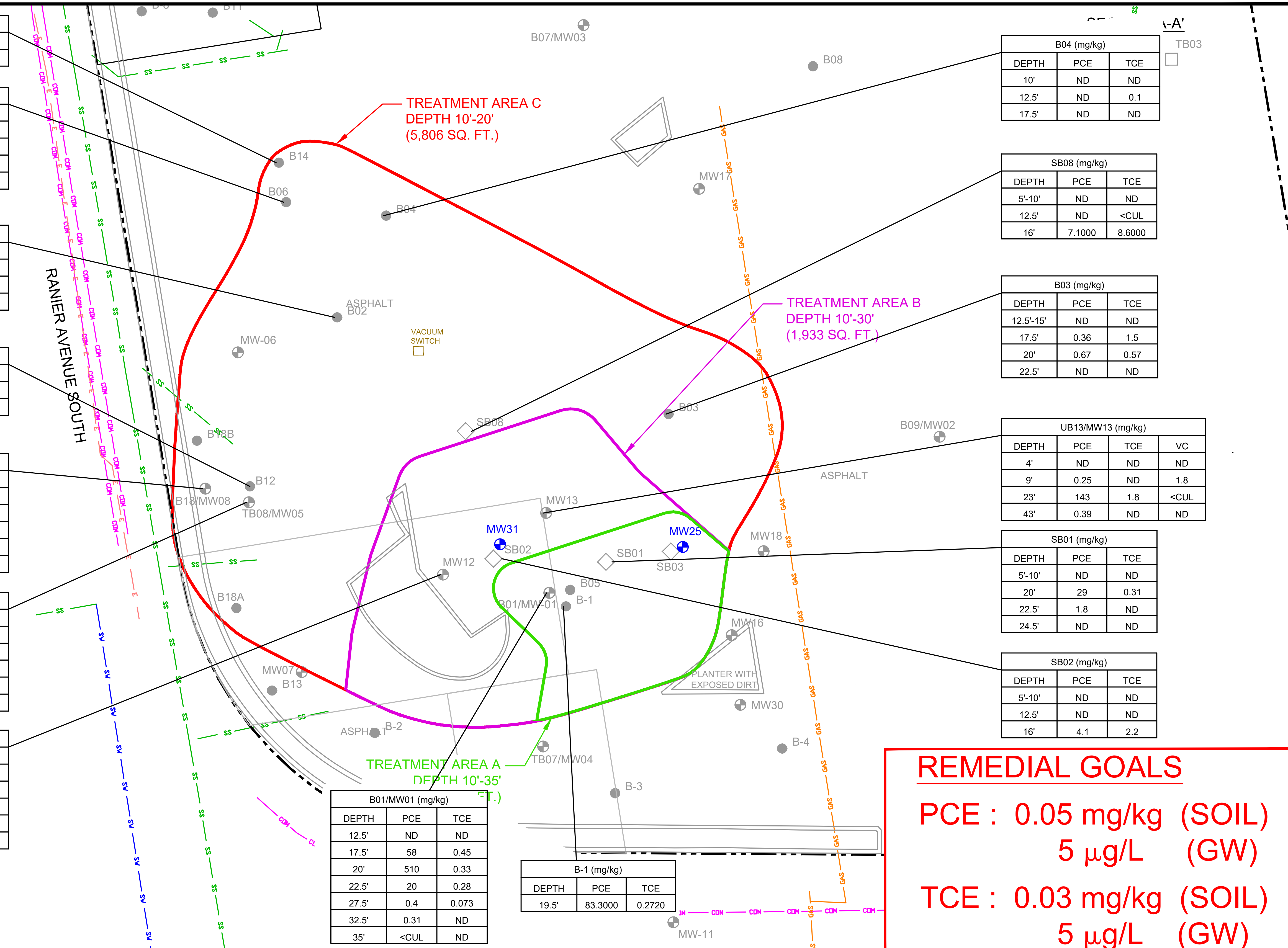
APPROVED FOR CONSTRUCTION

BY ____________

DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	Y-1B

PRELIMINARY
Not Approved for Construction



B14 (mg/kg)		
DEPTH	PCE	TCE
15'	ND	0.13

B06 (mg/kg)		
DEPTH	PCE	TCE
12.5'	ND	0.097
15'	ND	0.19
20'	ND	ND
50'	ND	ND

B02 (mg/kg)		
DEPTH	PCE	TCE
10'	ND	ND
15'	0.085	4.9
20'	ND	ND

B-12 (mg/kg)		
DEPTH	PCE	TCE
10.5'-11.5'	1.2000	3.1000
14'-15'	0.0970	0.0230

B18/MW08 (mg/kg)		
DEPTH	PCE	TCE
10'	ND	ND
12.5'	2.1	1.7
15'	1.8	0.43
17.5'	0.085	0.03
20'	ND	ND

TB08/MW05 (mg/kg)		
DEPTH	PCE	TCE
10'	ND	ND
12.5'	0.46	0.55
17.5'	24	1.7
20'	2	0.17
25'	ND	ND

UB12/MW12 (mg/kg)		
DEPTH	PCE	TCE
5'	ND	ND
14'	0.29	<CUL
22'	16.6	0.33
37'	0.16	ND
46'	<CUL	ND

B01/MW01 (mg/kg)		
DEPTH	PCE	TCE
12.5'	ND	ND
17.5'	58	0.45
20'	510	0.33
22.5'	20	0.28
27.5'	0.4	0.073
32.5'	0.31	ND
35'	<CUL	ND

B-1 (mg/kg)		
DEPTH	PCE	TCE
19.5'	83.3000	0.2720

B04 (mg/kg)		
DEPTH	PCE	TCE
10'	ND	ND
12.5'	ND	0.1
17.5'	ND	ND

SB08 (mg/kg)		
DEPTH	PCE	TCE
5'-10'	ND	ND
12.5'	ND	<CUL
16'	7.1000	8.6000

B03 (mg/kg)		
DEPTH	PCE	TCE
12.5'-15'	ND	ND
17.5'	0.36	1.5
20'	0.67	0.57
22.5'	ND	ND

UB13/MW13 (mg/kg)			
DEPTH	PCE	TCE	VC
4'	ND	ND	ND
9'	0.25	ND	1.8
23'	143	1.8	<CUL
43'	0.39	ND	ND

SB01 (mg/kg)		
DEPTH	PCE	TCE
5'-10'	ND	ND
20'	29	0.31
22.5'	1.8	ND
24.5'	ND	ND

SB02 (mg/kg)		
DEPTH	PCE	TCE
5'-10'	ND	ND
12.5'	ND	ND
16'	4.1	2.2

REMEDIAL GOALS

PCE : 0.05 mg/kg (SOIL)
5 µg/L (GW)

TCE : 0.03 mg/kg (SOIL)
5 µg/L (GW)

NOTES

HISTORIC SOIL CONCENTRATION DATA PROVIDED BY URBAN ENVIRONMENTAL PARTNERS, LLC

LEGEND

- EXISTING MONITORING WELL
- EXISTING S.S. MONITORING WELL
- EXISTING BORING LOCATION

0 10 20 40
SCALE IN FEET

TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

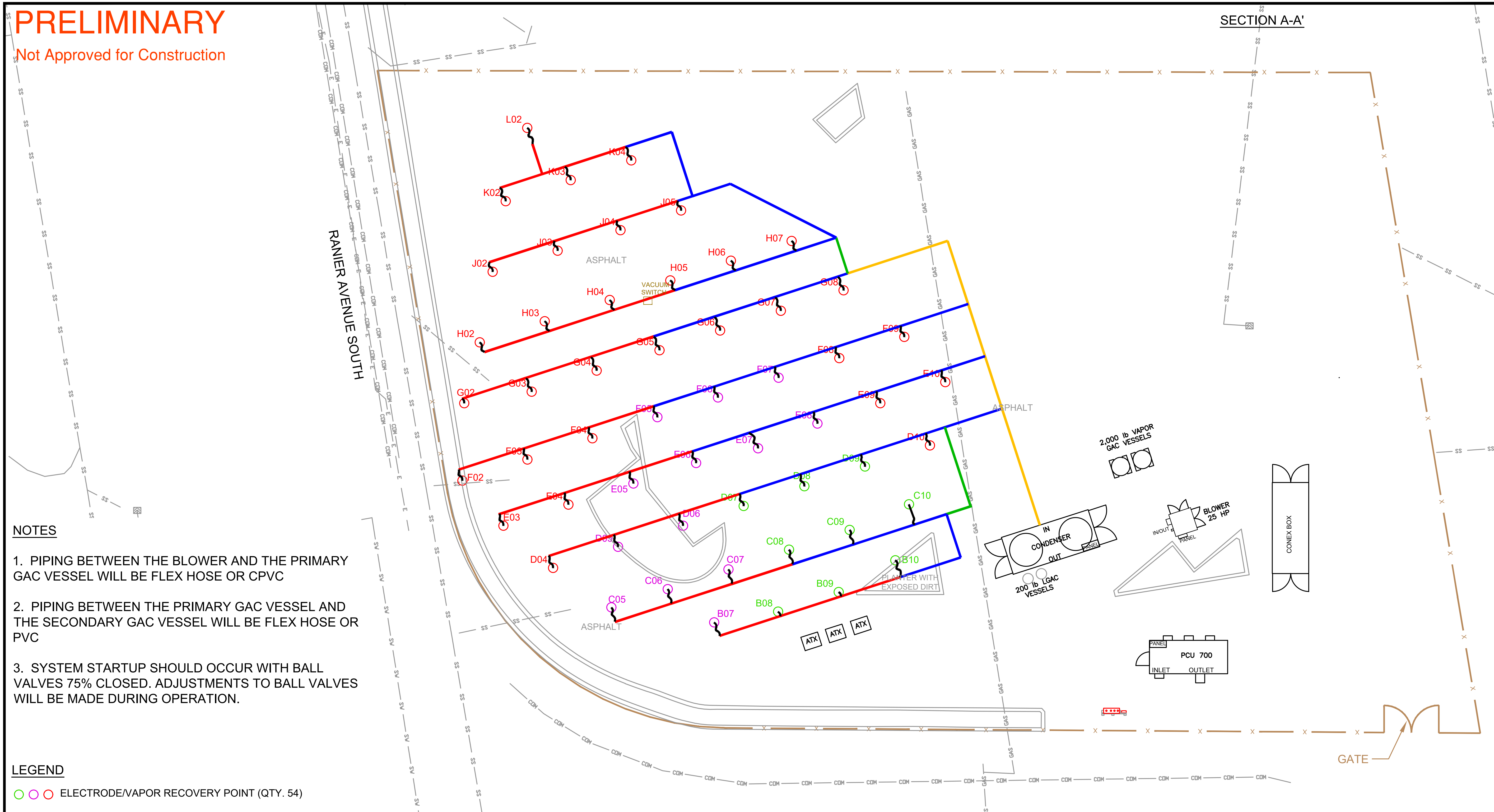
HISTORIC SOIL CONTAMINATION CONCENTRATIONS

APPROVED FOR CONSTRUCTION
BY ____
DATE ____

DATE 2021.MAR.25 | PROJECT WA.RAI.2136 | SHEET Y-2

PRELIMINARY

Not Approved for Construction



NOTES

1. PIPING BETWEEN THE BLOWER AND THE PRIMARY GAC VESSEL WILL BE FLEX HOSE OR CPVC
2. PIPING BETWEEN THE PRIMARY GAC VESSEL AND THE SECONDARY GAC VESSEL WILL BE FLEX HOSE OR PVC
3. SYSTEM STARTUP SHOULD OCCUR WITH BALL VALVES 75% CLOSED. ADJUSTMENTS TO BALL VALVES WILL BE MADE DURING OPERATION.

LEGEND

- ELECTRODE/VAPOR RECOVERY POINT (QTY. 54)
- 1-1/2" SCH 40 CPVC (1 TO 3 WELLS)
- 2" SCH 40 CPVC (4 TO 8 WELLS)
- 3" SCH 40 CPVC (9 TO 20 WELLS)
- 4" SCH 40 CPVC (20+ WELLS)
- 1" NOVAFLEX
- VACUUM SWITCH

0 10 20 40

SCALE IN FEET

TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

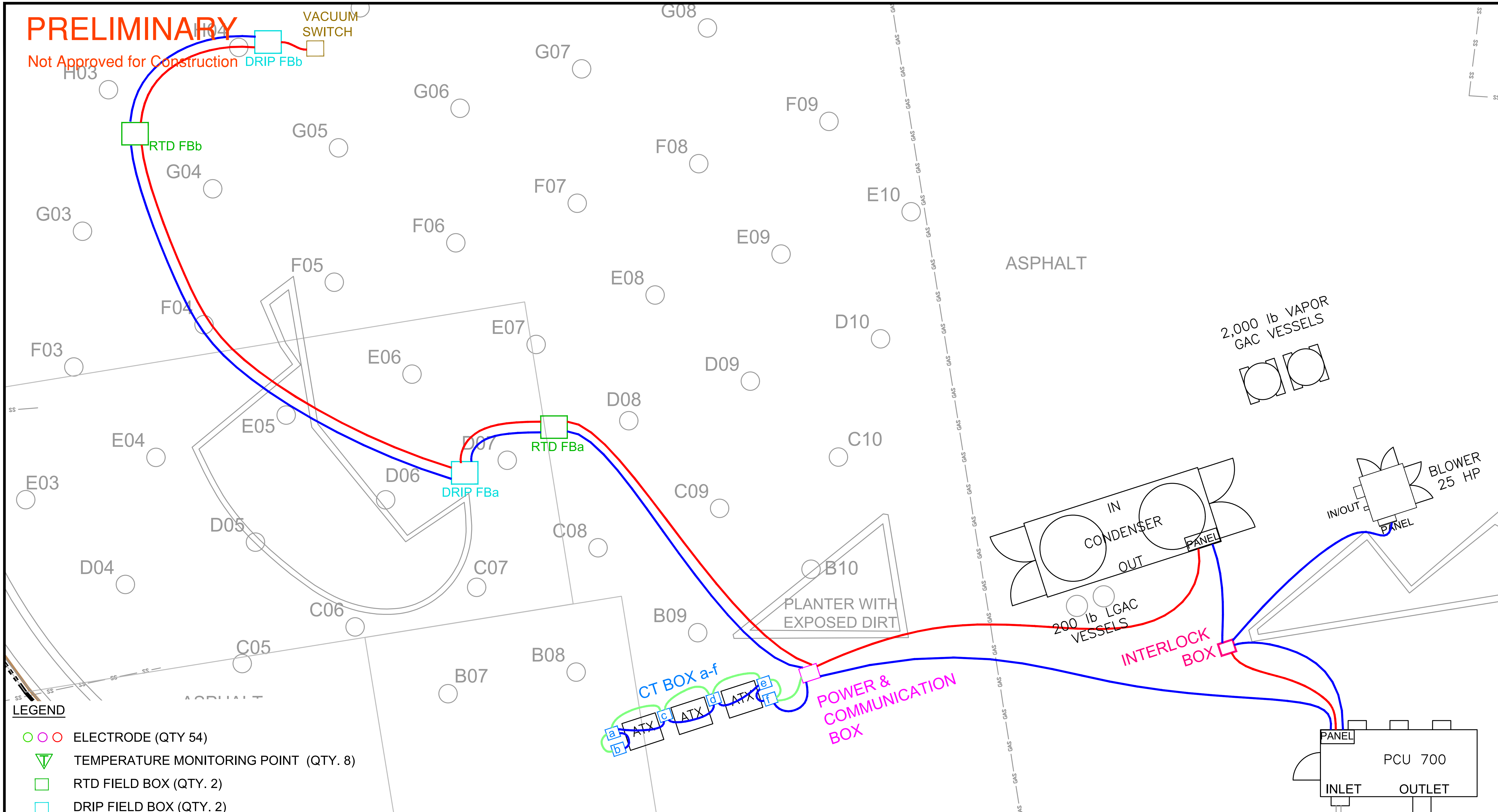
VAPOR RECOVERY PIPING PLAN

APPROVED FOR CONSTRUCTION

BY ____________

DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	Y-3



LEGEND

- ELECTRODE (QTY 54)
- TEMPERATURE MONITORING POINT (QTY. 8)
- RTD FIELD BOX (QTY. 2)
- DRIP FIELD BOX (QTY. 2)
- INTERLOCK BOX (QTY. 1)
- POWER & COMMUNICATION BOX (QTY. 1)
- CT BOX (QTY. 6)
- ETHERNET CABLE
- 12/3 SOOW CABLE
- 24 VDC CABLE

0 5 10 20

SCALE IN FEET

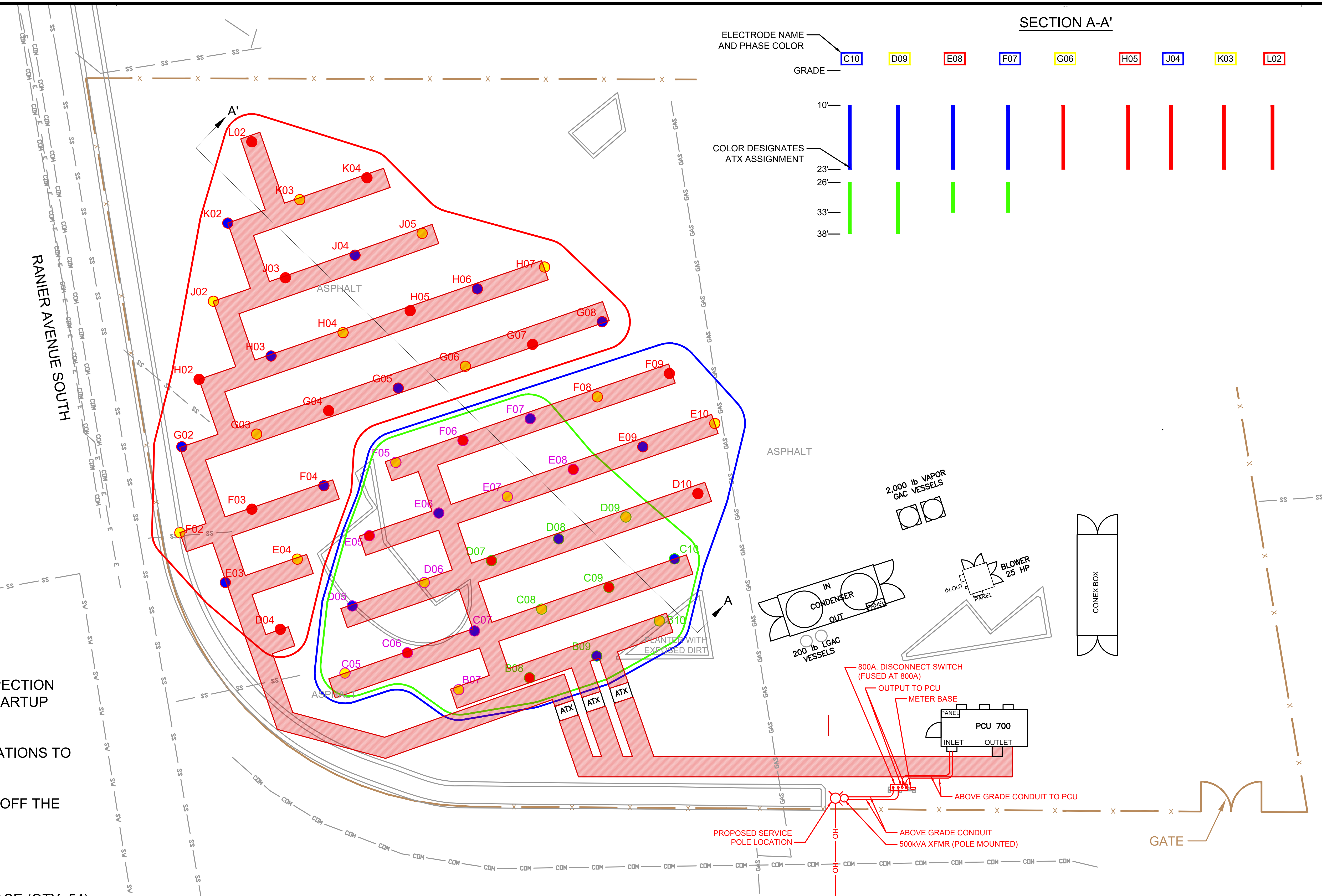
TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY D. SEILER	SITE	RANIER MALL PROPERTY	
	LOCATION	SEATTLE, WASHINGTON	
	CLIENT	RANIER AND GENESEE, LLC	
DRAWN BY A. PEABODY	FIELD BOX PLACEMENT AND WIRING PLAN		
CHECKED BY PENDING APPROVAL			
PROJECT MANAGER TRS PERSONNEL	APPROVED FOR CONSTRUCTION	DATE 2021.MAR.25	PROJECT WA.RAI.2136
QSAT REVIEW G. KNIGHT	BY ____ DATE ____	SHEET	Y-4

PRELIMINARY

Not Approved for Construction



NOTES

1. IR GUN SHOULD BE USED FOR VISUAL INSPECTION OF ALL CONNECTIONS AND CABLES UPON STARTUP AND WEEKLY DURING OPS.

2. PHASING MAY BE UPDATED DURING OPERATIONS TO OPTIMIZE PERFORMANCE.

3. ALL CONNECTIONS SHOULD BE ELEVATED OFF THE GROUND.

LEGEND

ELECTRODE - COLOR INDICATES PHASE (QTY. 54)

CABLE ROUTING

ELECTRODE PHASING

Blue	Yellow	Red	
(8)	(10)	(9)	ATX-1
(9)	(9)	(9)	ATX-2
(7)	(8)	(7)	ATX-3

0 10 20 40
SCALE IN FEET

TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

PHASING AND CABLE ROUTING PLAN

APPROVED FOR CONSTRUCTION

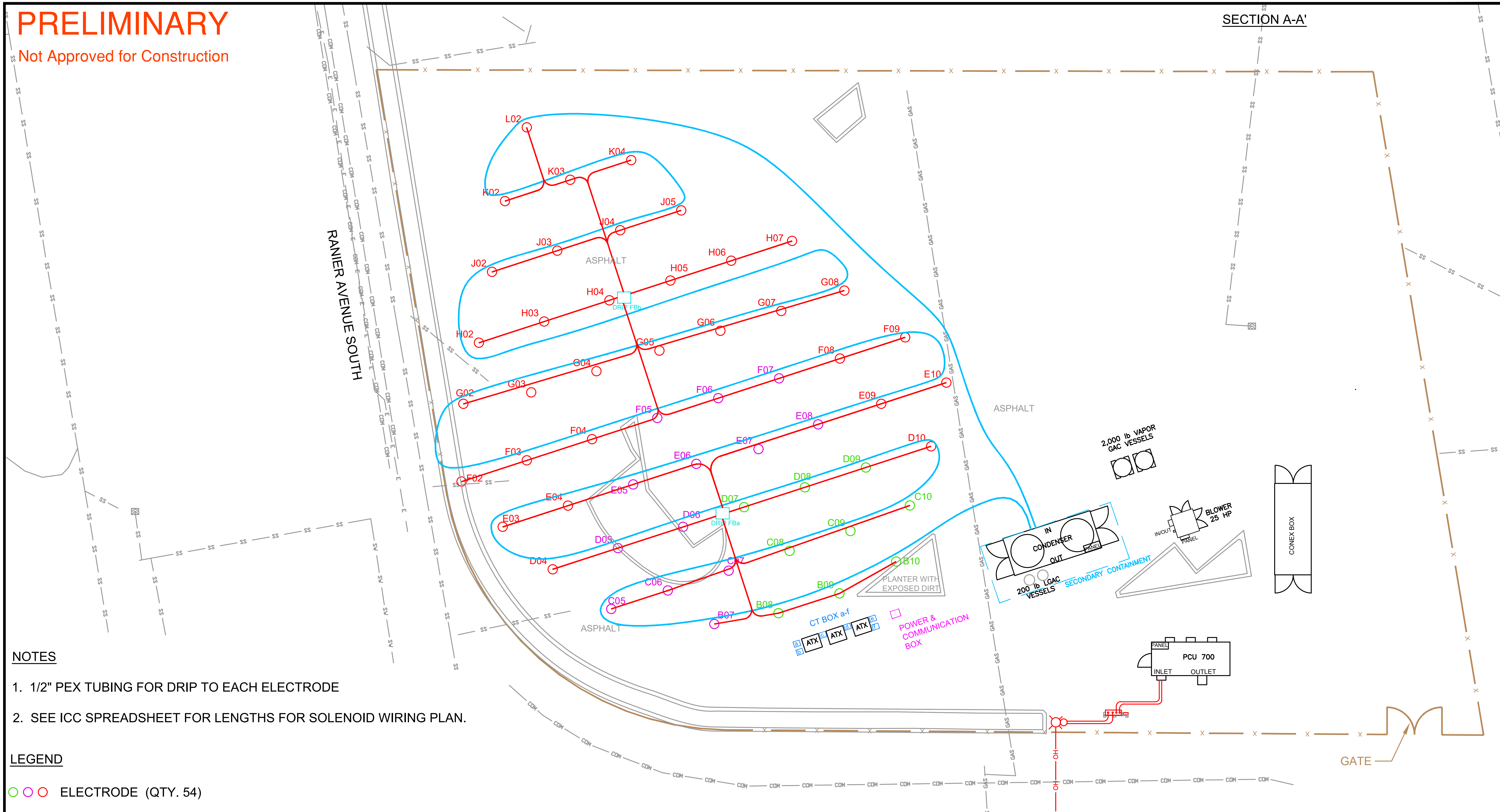
BY ____________

DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	Y-5

PRELIMINARY

Not Approved for Construction



NOTES

1. 1/2" PEX TUBING FOR DRIP TO EACH ELECTRODE
2. SEE ICC SPREADSHEET FOR LENGTHS FOR SOLENOID WIRING PLAN.

LEGEND

- ELECTRODE (QTY. 54)
- DRIP FBx — DRIP FIELD BOX (QTY. 2)
- 3/4" PEX PIPING (1,020 FT)
- 18/2 SOOW CABLE

  STANDARD LENGTHS ARE:
  - 25' -ORANGE BAND
  - 50'-GREEN BAND
  - 100'-NO BAND

0 10 20 40

SCALE IN FEET

TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT

SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

DRIP PIPING AND SOLENOID WIRING PLAN

APPROVED FOR CONSTRUCTION

BY ____________________

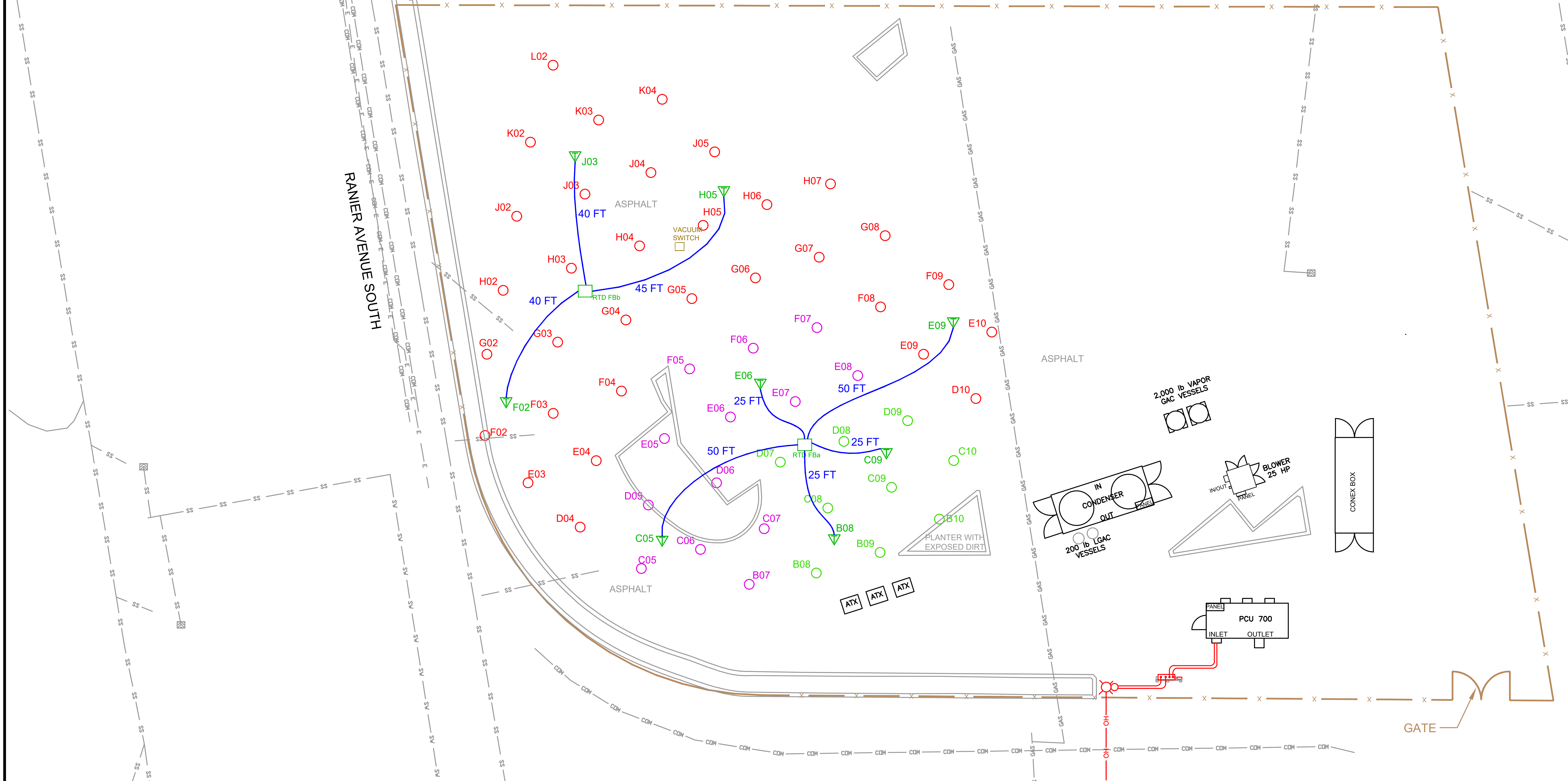
DATE ____________________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	Y-6

PRELIMINARY

Not Approved for Construction

SECTION A-A'



LEGEND

- ELECTRODES (QTY. 54)
- TEMPERATURE MONITORING POINT (QTY.8)
- RTD FBx RTD FIELD BOX (QTY. 2)
- RTD WIRING

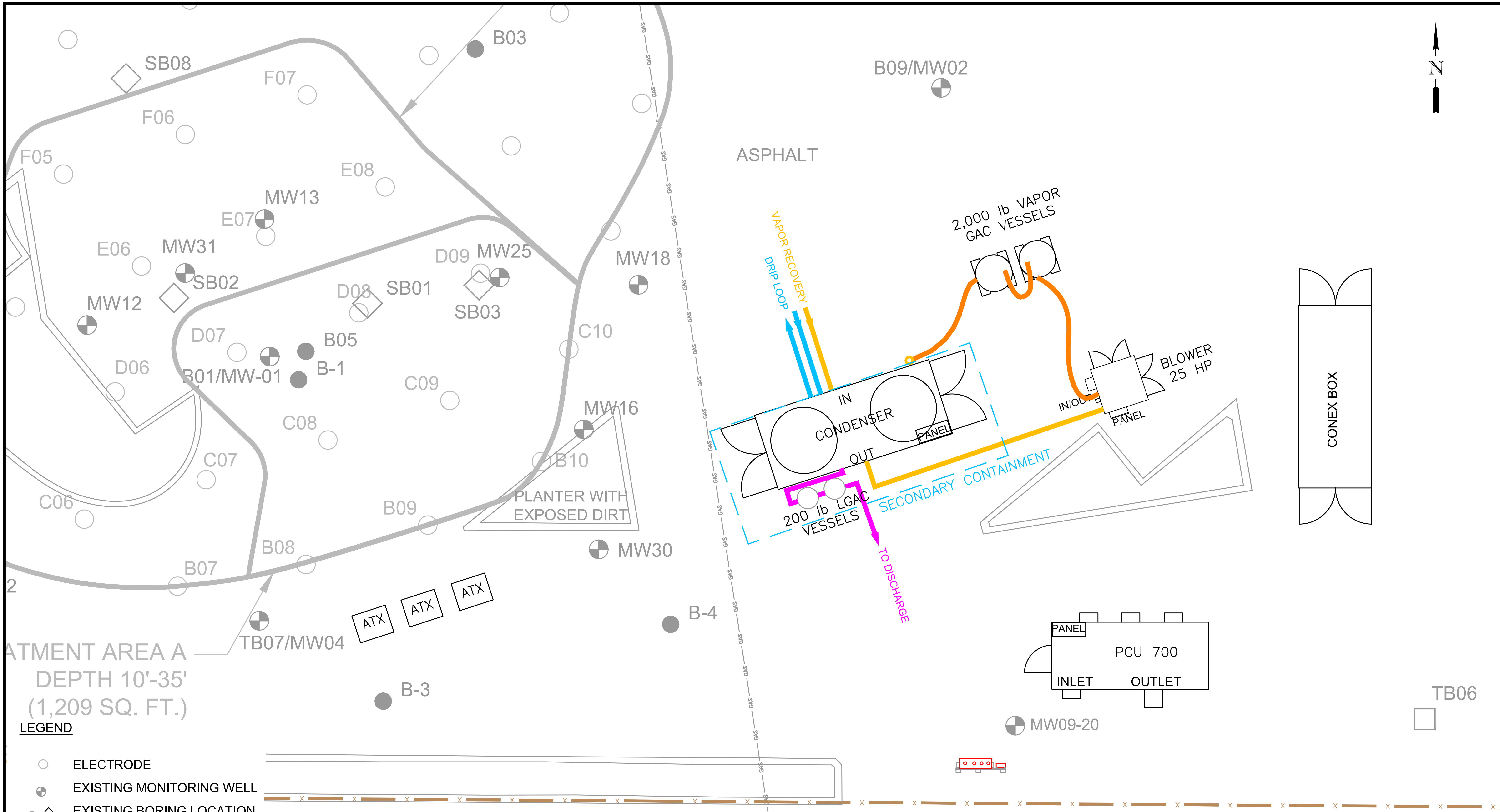
0 10 20 40

SCALE IN FEET

TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY D. SEILER	SITE	RANIER MALL PROPERTY	
	LOCATION	SEATTLE, WASHINGTON	
DRAWN BY A. PEABODY	CLIENT	RANIER AND GENESEE, LLC	
CHECKED BY PENDING APPROVAL	RTD WIRING PLAN		
PROJECT MANAGER TRS PERSONNEL	APPROVED FOR CONSTRUCTION	DATE 2021.MAR.25	PROJECT WA.RAI.2136
QSAT REVIEW G. KNIGHT	BY ______ DATE ______	SHEET	Y-7



LEGEND

○	ELECTRODE
◐	EXISTING MONITORING WELL
● ◇	EXISTING BORING LOCATION
○	ELECTRODES
- - -	SECONDARY CONTAINMENT
—	3/4" PEX
—	1" CPVC
—	4" CPVC
—	4" FLEXIBLE HOSE

PRELIMINARY

Not Approved for Construction

0 5 10 20

SCALE IN FEET

TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

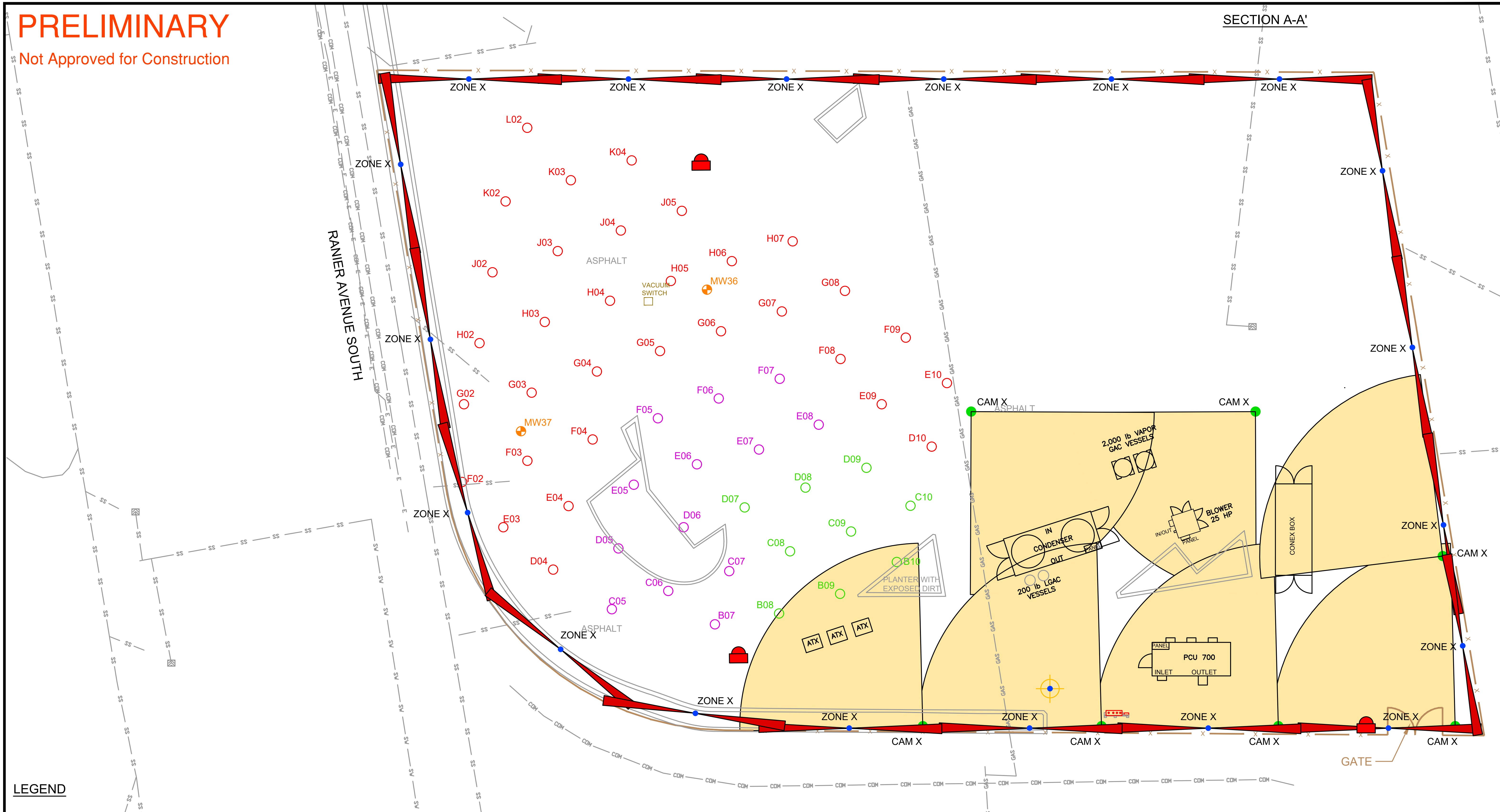
DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

EQUIPMENT PIPING PLAN

APPROVED FOR CONSTRUCTION		DATE 2021.MAR.25	PROJECT WA.RAI.2136
BY		SHEET	Y-8
DATE			

PRELIMINARY

Not Approved for Construction



LEGEND

○ ○ ○ ELECTRODE (QTY. 54)

HONEYWELL MOTION SENSOR (QTY. 19)

PROCESS STOP (QTY. 3)

VIDEOFIED SECURITY CAMERA (QTY. 6)

360° PTZ CAMERA (QTY. 1)

0 10 20 40

SCALE IN FEET

TRS Accelerating Value

TRS GROUP, INC. 338 COMMERCE AVE., SUITE 304, LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT

SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

SECURITY SENSORS PLAN

APPROVED FOR CONSTRUCTION

BY ______

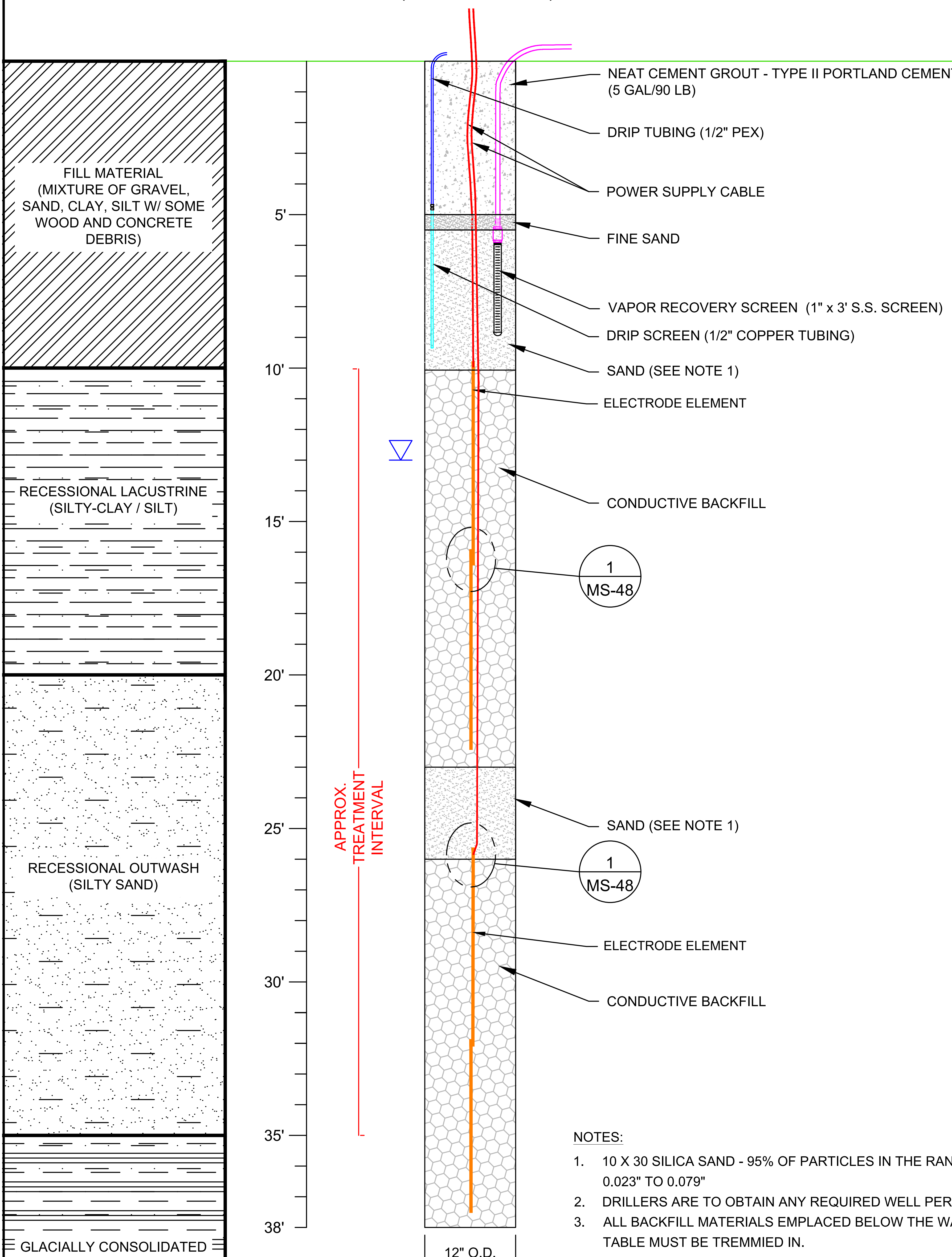
DATE ______

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	Y-9

PRELIMINARY

Not Approved for Construction

ABOVE GRADE BORED ELECTRODE TYPE A (TYPICAL OF 9)



NOTES:

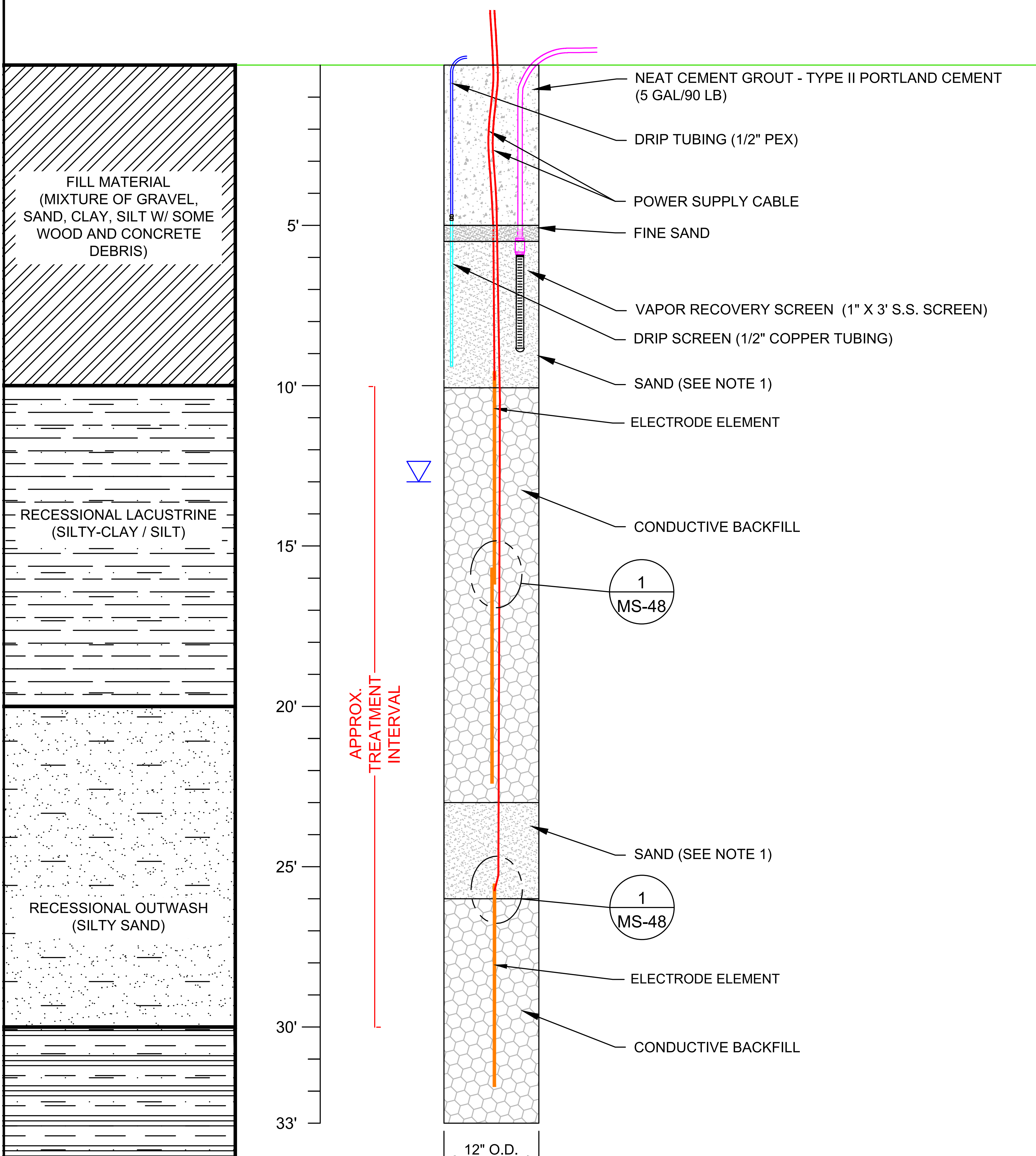
1. 10 X 30 SILICA SAND - 95% OF PARTICLES IN THE RANGE OF 0.023" TO 0.079"
2. DRILLERS ARE TO OBTAIN ANY REQUIRED WELL PERMITS.
3. ALL BACKFILL MATERIALS EMPLACED BELOW THE WATER TABLE MUST BE TREMMIED IN.
4. A SMALLER AUGER WITH AN OVER-SIZED CUTTING HEAD IS NOT ACCEPTABLE. AUGERS WITH FLIGHTS MUST PROVIDE THE OD AS SHOWN IN THIS DETAIL
5. BACKFILL IS TO BE PRE-MIXED BEFORE EMPLACEMENT.
6. LITHOLOGY SUMMARY PROVEDED BY URBAN ENVIRONMENTAL PARTERNERS, LLC.

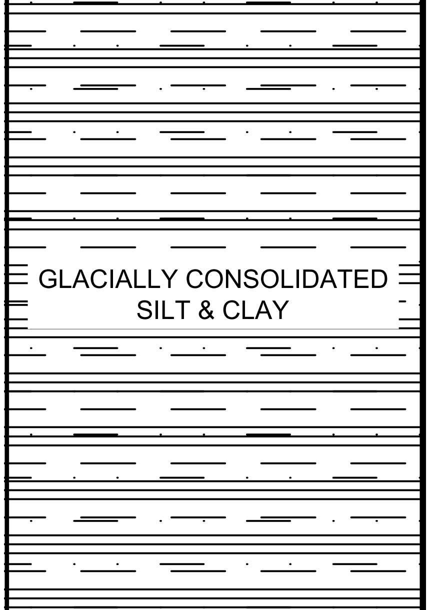
TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC
TITLE	ELECTRODE DETAIL TYPE A
APPROVED FOR CONSTRUCTION	BY ____ DATE ____
DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	M-1

ABOVE GRADE BORED ELECTRODE
TYPE B
(TYPICAL OF 13)





NOTES:

1. 10 X 30 SILICA SAND - 95% OF PARTICLES IN THE RANGE OF 0.023" TO 0.079"
2. DRILLERS ARE TO OBTAIN ANY REQUIRED WELL PERMITS.
3. ALL BACKFILL MATERIALS EMPLACED BELOW THE WATER TABLE MUST BE TREMMIED IN.
4. A SMALLER AUGER WITH AN OVER-SIZED CUTTING HEAD IS NOT ACCEPTABLE. AUGERS WITH FLIGHTS MUST PROVIDE THE OD AS SHOWN IN THIS DETAIL
5. BACKFILL IS TO BE PRE-MIXED BEFORE EMPLACEMENT.
6. LITHOLOGY SUMMARY PROVEDED BY URBAN ENVIRONMENTAL PARTERNERS, LLC.

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

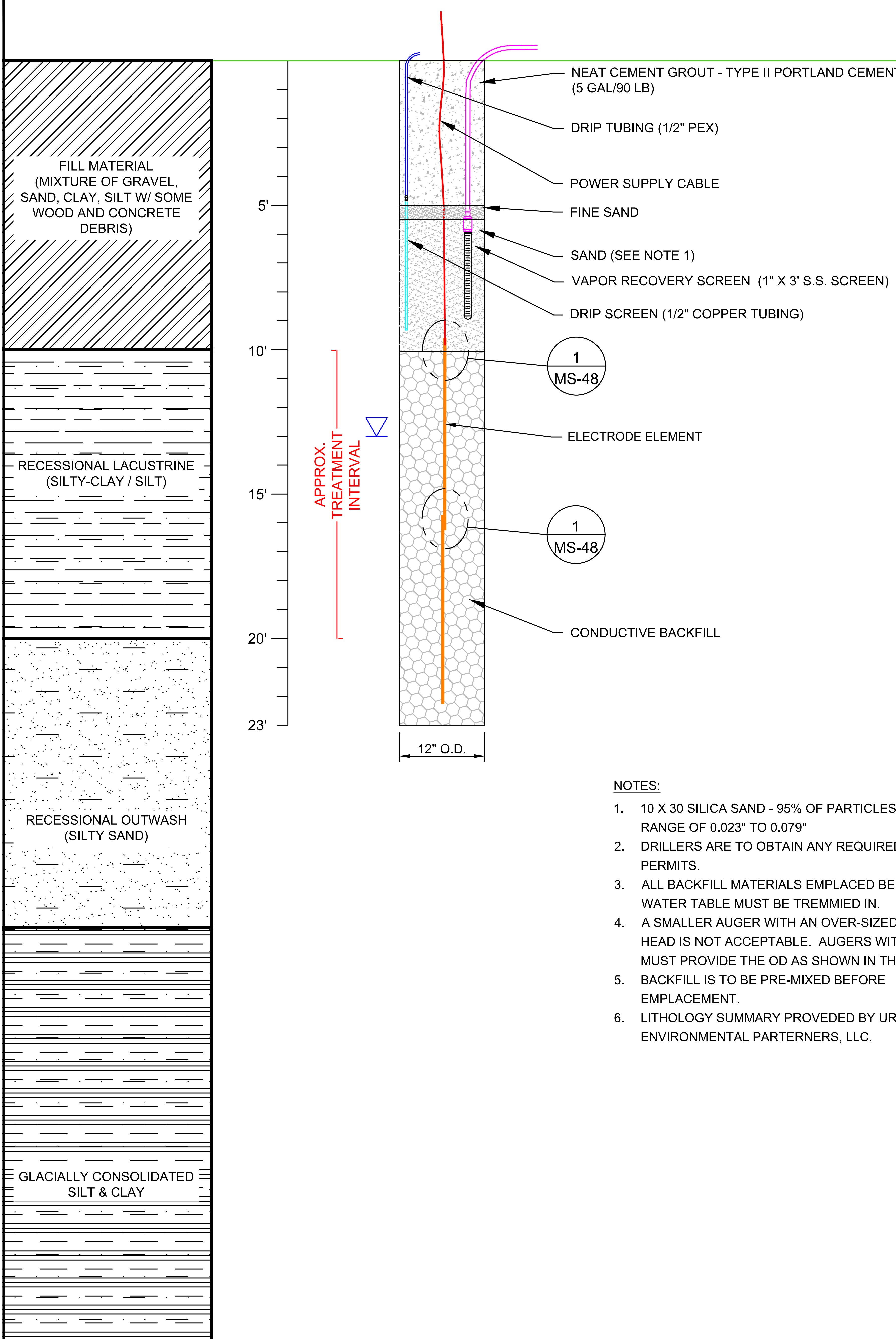
ELECTRODE DETAIL
TYPE B

APPROVED FOR CONSTRUCTION
BY ____________
DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	M-2

PRELIMINARY
Not Approved for Construction

ABOVE GRADE BORED ELECTRODE
TYPE C
(TYPCAL OF 32)



NOTES:

1. 10 X 30 SILICA SAND - 95% OF PARTICLES IN THE RANGE OF 0.023" TO 0.079"
2. DRILLERS ARE TO OBTAIN ANY REQUIRED WELL PERMITS.
3. ALL BACKFILL MATERIALS EMPLACED BELOW THE WATER TABLE MUST BE TREMMIED IN.
4. A SMALLER AUGER WITH AN OVER-SIZED CUTTING HEAD IS NOT ACCEPTABLE. AUGERS WITH FLIGHTS MUST PROVIDE THE OD AS SHOWN IN THIS DETAIL
5. BACKFILL IS TO BE PRE-MIXED BEFORE EMPLACEMENT.
6. LITHOLOGY SUMMARY PROVEDED BY URBAN ENVIRONMENTAL PARTERNERS, LLC.

TRS Accelerating Value
TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

ELECTRODE DETAIL
TYPE C

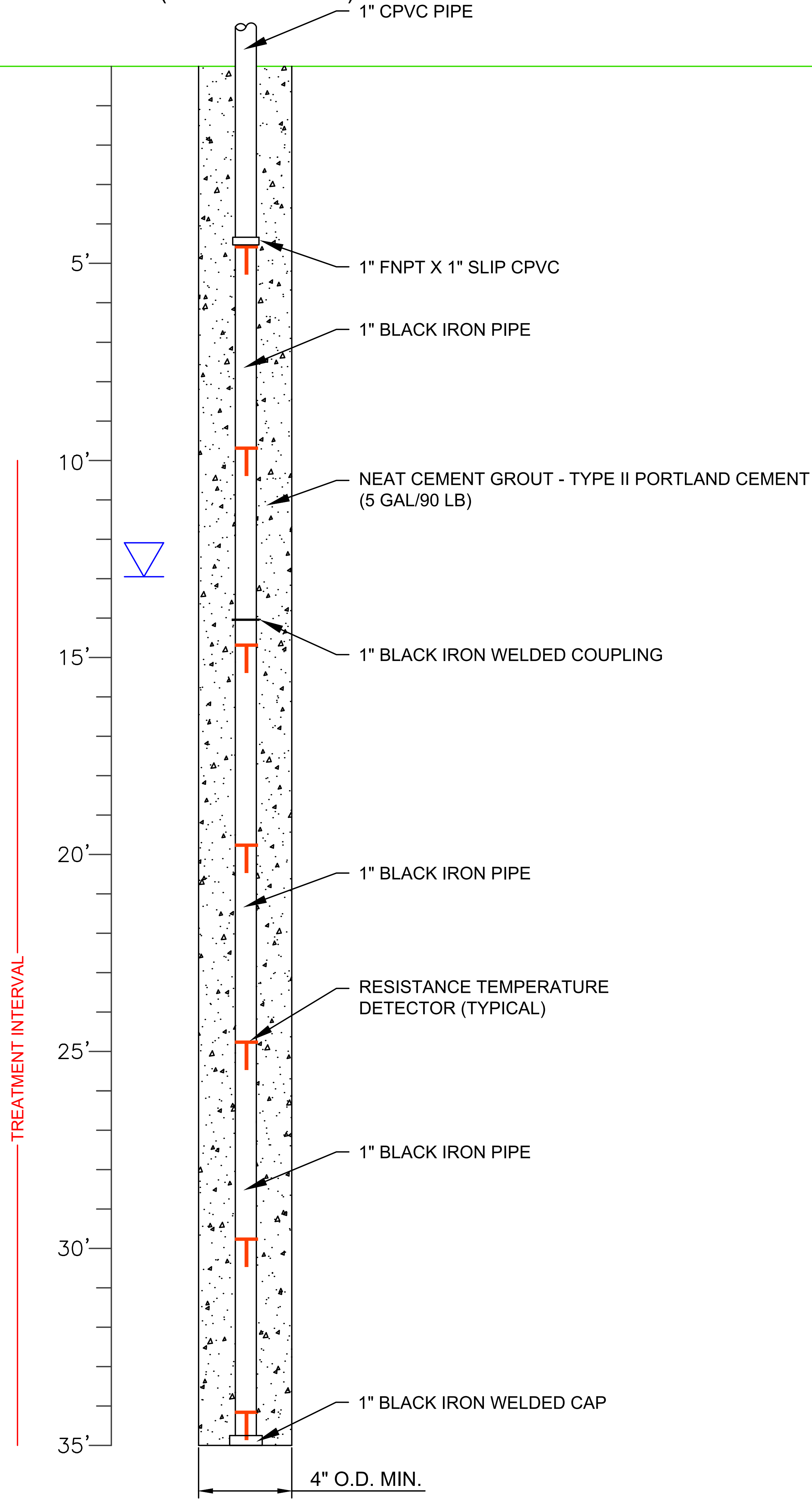
APPROVED FOR CONSTRUCTION
BY ____________
DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	M-3

PRELIMINARY

Not Approved for Construction

ABOVE GRADE TEMPERATURE MONITORING POINT TYPE A (TYPICAL OF 2)



NOTE:
USE A WATER PUMP TO EVACUATE WATER FROM THE TMP CASING, IF WATER IS OBSERVED.

TRS Accelerating Value

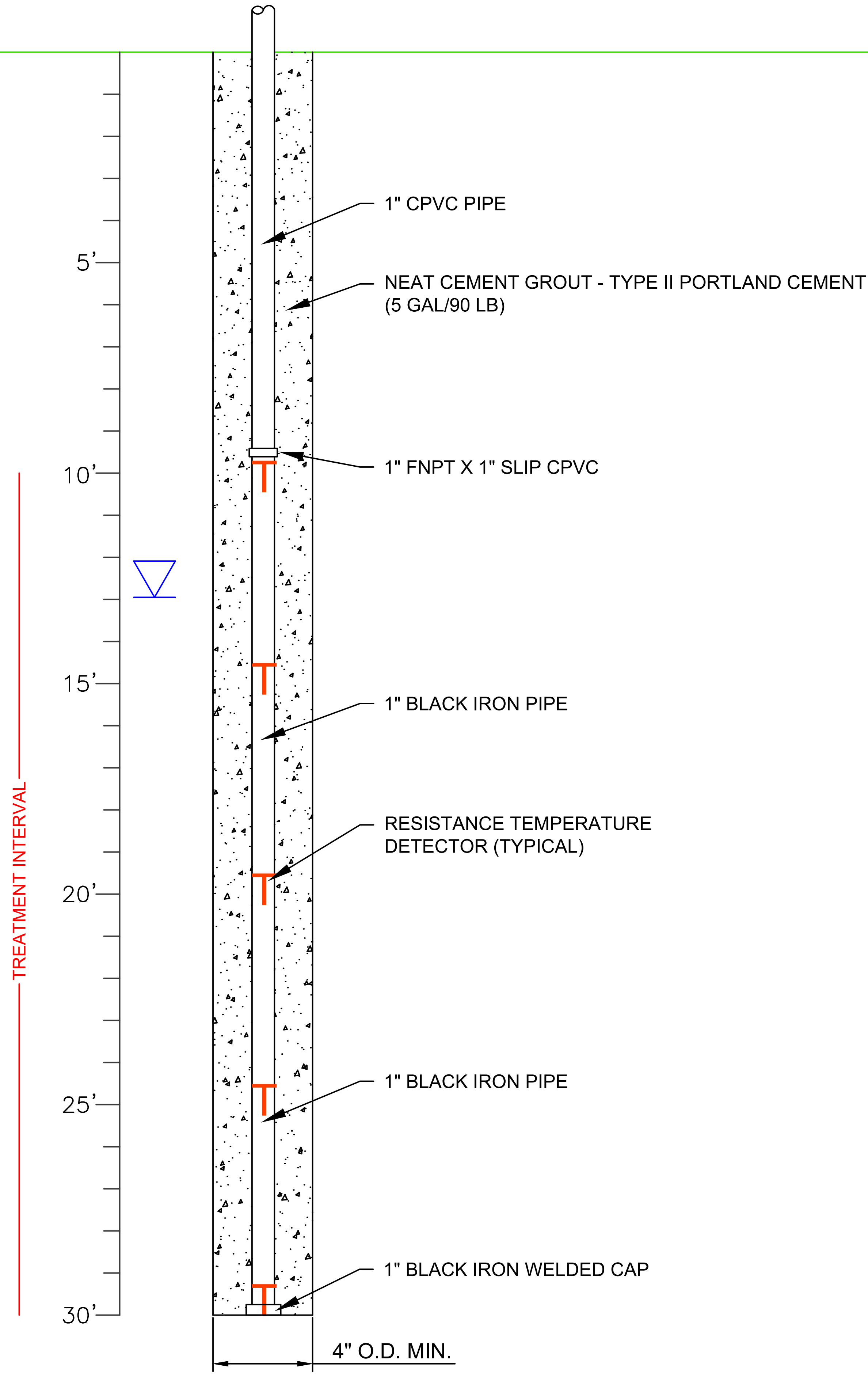
TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY: D. SEILER	SITE: RANIER MALL PROPERTY		
DRAWN BY: A. PEABODY	LOCATION: SEATTLE, WASHINGTON		
CHECKED BY: PENDING APPROVAL	CLIENT: RANIER AND GENESEE, LLC		
PROJECT MANAGER: TRS PERSONNEL	TEMPERATURE MONITORING POINT DETAIL TYPE A		
QSAT REVIEW: G. KNIGHT	APPROVED FOR CONSTRUCTION BY ______ DATE ______	DATE: 2021.MAR.25	PROJECT: WA.RAI.2136
		SHEET: M-4	

PRELIMINARY

Not Approved for Construction

ABOVE GRADE
TEMPERATURE MONITORING POINT
TYPE B
(TYPICAL OF 2)



NOTE:
USE A WATER PUMP TO EVACUATE WATER FROM THE TMP CASING, IF WATER IS OBSERVED.

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

TEMPERATURE MONITORING POINT DETAIL
TYPE B

APPROVED FOR CONSTRUCTION

BY ______

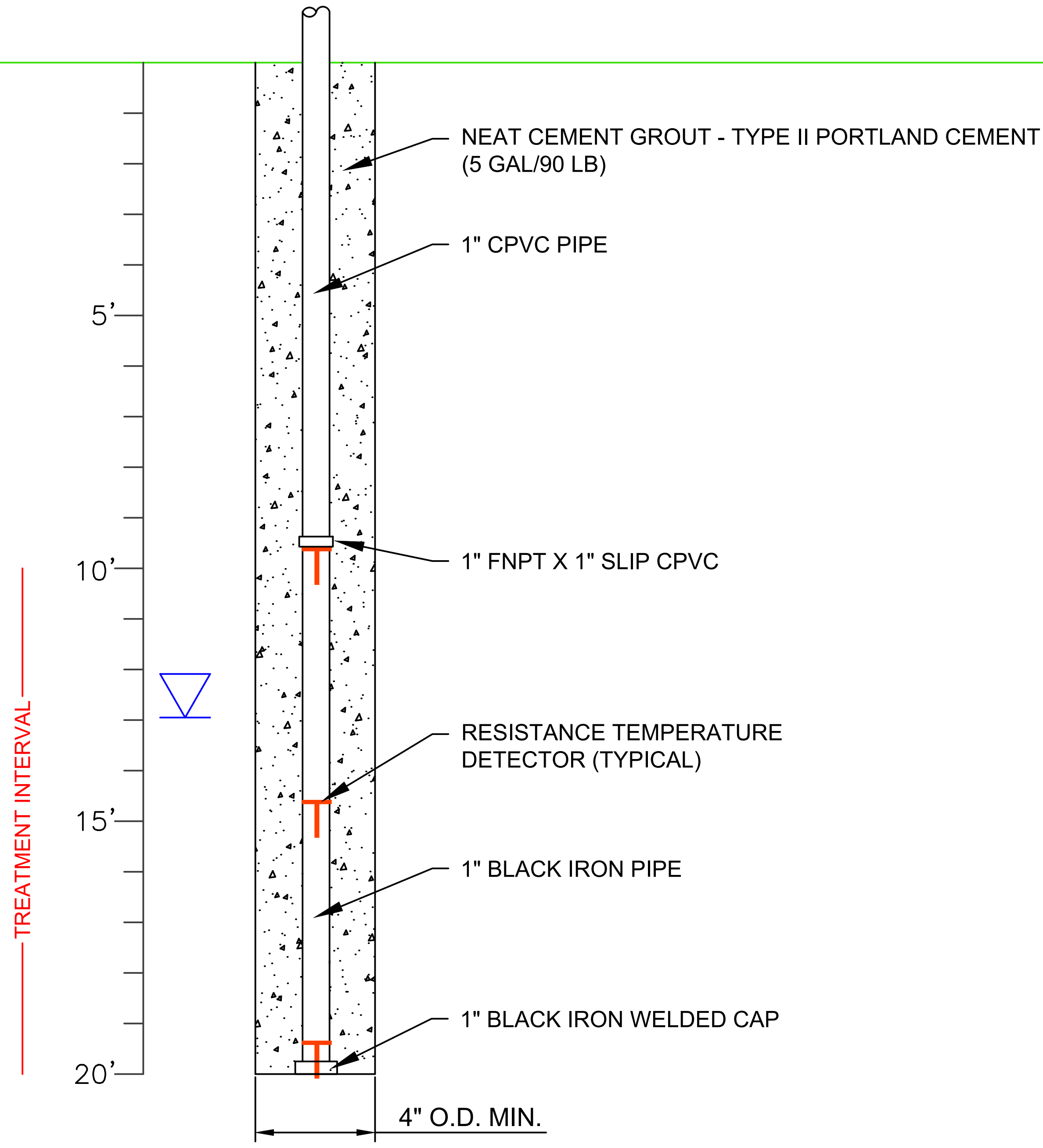
DATE ______

DATE	PROJECT	SHEET
2021.MAR.25	WA.RAI.2136	M-5

PRELIMINARY

Not Approved for Construction

ABOVE GRADE TEMPERATURE MONITORING POINT TYPE C (TYPICAL OF 4)



NOTE:
USE A WATER PUMP TO EVACUATE WATER FROM THE TMP CASING, IF WATER IS OBSERVED.

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

TEMPERATURE MONITORING POINT DETAIL TYPE C

APPROVED FOR CONSTRUCTION	BY ____ DATE ____
DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	M-6

PRELIMINARY

Not Approved for Construction

LEGEND

	ELECTRONIC SIGNAL
	ELECTRICAL CABLE
	PROCESS LINE LABELING SEE SHEET P-2 FOR DESCRIPTION
	SOLENOID
	BALL VALVE
	BUTTERFLY VALVE
	ANTI-SIPHON VALVE
	PVC TRUE UNION BALL VALVE
	SAMPLE PORT
	CHECK VALVE
	SELF-CONTAINED PRESSURE REGULATOR
	SPIGOT
	BACKFLOW PREVENTER
	FLANGE
	VACUUM RELEASE VALVE
XX XX	PIPING SPEC. # CHANGE
	PUMP
	BLOWER
	ROTARY LOBE BLOWER
	DIAPHRAGM PUMP
	COMPRESSED AIR FILTER
	HEATER COIL
SDTX	STEP DOWN TRANSFORMER

YC 1	COMPUTER OPERATED MONITORING, DATA COLLECTION AND CONTROLS
YC 1	HARDWIRE CONTROLS
PI	PRESSURE INDICATOR
PCV	PRESSURE CONTROL VALVE
PSL	PRESSURE SWITCH LOW
FE	FLOW ELEMENT
FI	FLOW INDICATOR
FQI	FLOW QUANTITY INDICATOR
FT	FLOW TRANSMITTER
FQI	FLOW QUANTITY INDICATOR
LI	LEVEL INDICATOR
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH-HIGH
LSL	LEVEL SWITCH LOW
LSLL	LEVEL SWITCH LOW-LOW
TAH	TEMPERATURE ALARM HIGH
TE	TEMPERATURE ELEMENT
TSL	TEMPERATURE SWITCH LOW
TSH	TEMPERATURE SWITCH HIGH
TSA	TEMPERATURE SWITCH ACTIVATOR
TI	TEMPERATURE INDICATOR
TT	TEMPERATURE TRANSMITTER
YC	CONTROLLER
T	TEMPERATURE SENSOR
CS	CARBON STEEL
CPVC	SCH 40. CPVC PIPE
PEX	PEX TUBING
FCV	FLOW CONTROL VALVE

P&ID LINE COLORS

Blue solid	SOFTENED/POTABLE/CLEAN WATER
Magenta solid	PROCESS WATER
Green solid	AIR
Purple solid	STEAM
Red solid	AIR/STEAM MIX
Cyan solid	SOLVENT/CHEMICALS
Yellow-orange solid	BLOWDOWN
Orange solid	FUEL
Blue dashed	COMPUTER OPERATED CONTROLS
Green dashed	HARDWIRE CONTROLS
Red dashed	POWER SUPPLY CABLE

NOTES

1. THIS IS AN ALL INCLUSIVE LEGEND SHEET. NOT ALL SYMBOLS WILL APPEAR ON EACH SHEET.

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

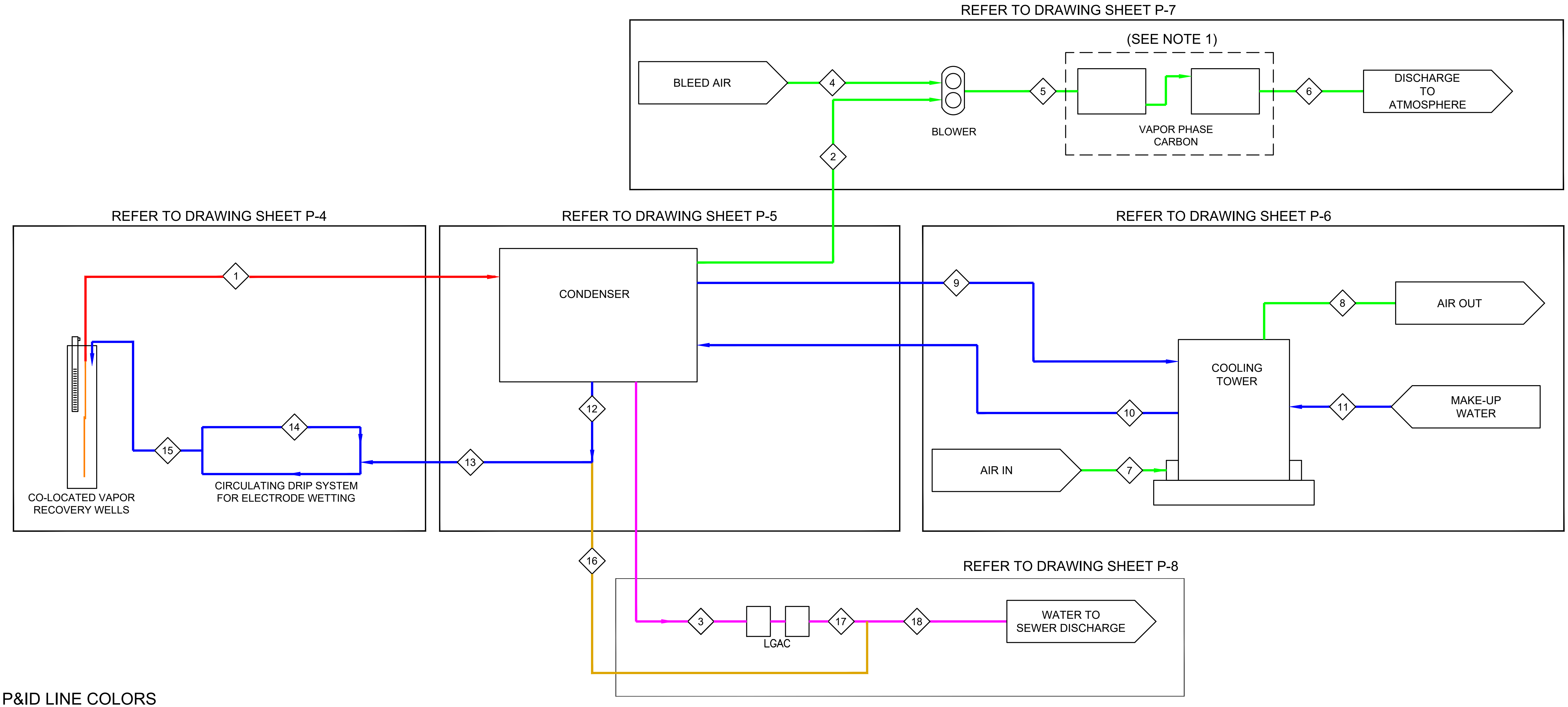
DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

LEGEND
PROCESS AND INSTRUMENTATION DIAGRAMS

APPROVED FOR CONSTRUCTION	BY ______ DATE ______
DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	P-1

PRELIMINARY

Not Approved for Construction



P&ID LINE COLORS

- SOFTENED/POTABLE/CLEAN WATER
- PROCESS WATER
- AIR
- STEAM
- AIR/STEAM MIX
- SOLVENT/CHEMICALS
- BLOWDOWN

NOTES:

1. VGAC IS AS REQUIRED BY LOCAL,STATE AND FEDERAL REQUIREMENTS.

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

PROCESS FLOW DIAGRAM

APPROVED FOR CONSTRUCTION

BY ______

DATE ______

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	P-2

PRELIMINARY

Not Approved for Construction

Process Stream	Location	Air		Water Vapor		Water		CVOCs		Temperature		Pressure
Description	#	(lb/min)	(scfm)	(lb/min)	(scfm)	(lb/min)	(gpm)	(lb/min)	(ppm)	°C	°F	(Δ from barometric)
Extracted air and steam from vapor recovery system	1	32	430	12.3	262	0	0.0	3.72E-04	1.25	75	167	2" Hg Vac
Discharge air from condenser after steam removal	2	32	430	0.9	19	0	0	3.72E-04	1.93	30	86	5" Hg Vac
Condensate discharge from condenser to LGAC	3	0	0	0	0	12	1.4	2.3E-07	0.02	30	86	30 psig
Bleed air to rotary lobe blower	4	0	0	0	0	0	0	0	0	14	57	N/A
Discharge air from rotary lobe blower	5	32	430	0.88	19	0	0	3.7E-04	1.93	60	140	1 psig
Discharge from carbon vessels	6	32	430	0.88	19	0	0	3.7E-06	0.02	35	95	N/A
Cooling air into cooling tower	7	2250	30,000	16.90	360	0	0	0	0	14	57	N/A
Air exhaust from cooling tower	8	2250	30,000	21	456	0	0	0	0	13	56	N/A
Recirculation water from condenser to cooling tower	9	0	0	0	0	4987	599	0	0	13	56	10 psig
Recirculation from cooling tower to condenser	10	0	0	0	0	4998	600	0	0	11	51	12 psig
Make-up water for cooling tower from potable source	11	0	0	0	0	16	1.9	0	0	20	68	50 psig
Water for drip system and blowdown	12	0	0	0	0	11	1.4	0	0	20	68	12 psig
Water to drip recirculation system	13	0	0	0	0	8	1.0	0	0	20	68	12 psig
Moving water in drip recirculation system	14	0	0	0	0	83	10	0	0	20	68	70 psig
Drip water to electrodes	15	0	0	0	0	8.3	1.0	0	0	20	68	70 psig
Blowdown water	16	0	0	0	0	2.9	0.4	0	0	20	68	12 psig
Condensate discharge after LGAC	17	0	0	0	0	11.8	1.4	1.2E-08	0.001	30	86	20 psig
Total Discharge	18	0	0	0	0	15	1.8	1.2E-08	0.001	30	86	20 psig

NOTES

1. LOCATION INDICATED IN THIS TABLE CORRESPOND TO THE LOCATION NUMBERS PROVIDED ON SHEET P-2.

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY D. SEILER
DRAWN BY A. PEABODY
CHECKED BY PENDING APPROVAL
PROJECT MANAGER TRS PERSONNEL
QSAT REVIEW G. KNIGHT

SITE RANIER MALL PROPERTY
LOCATION SEATTLE, WASHINGTON
CLIENT RANIER AND GENESEE, LLC

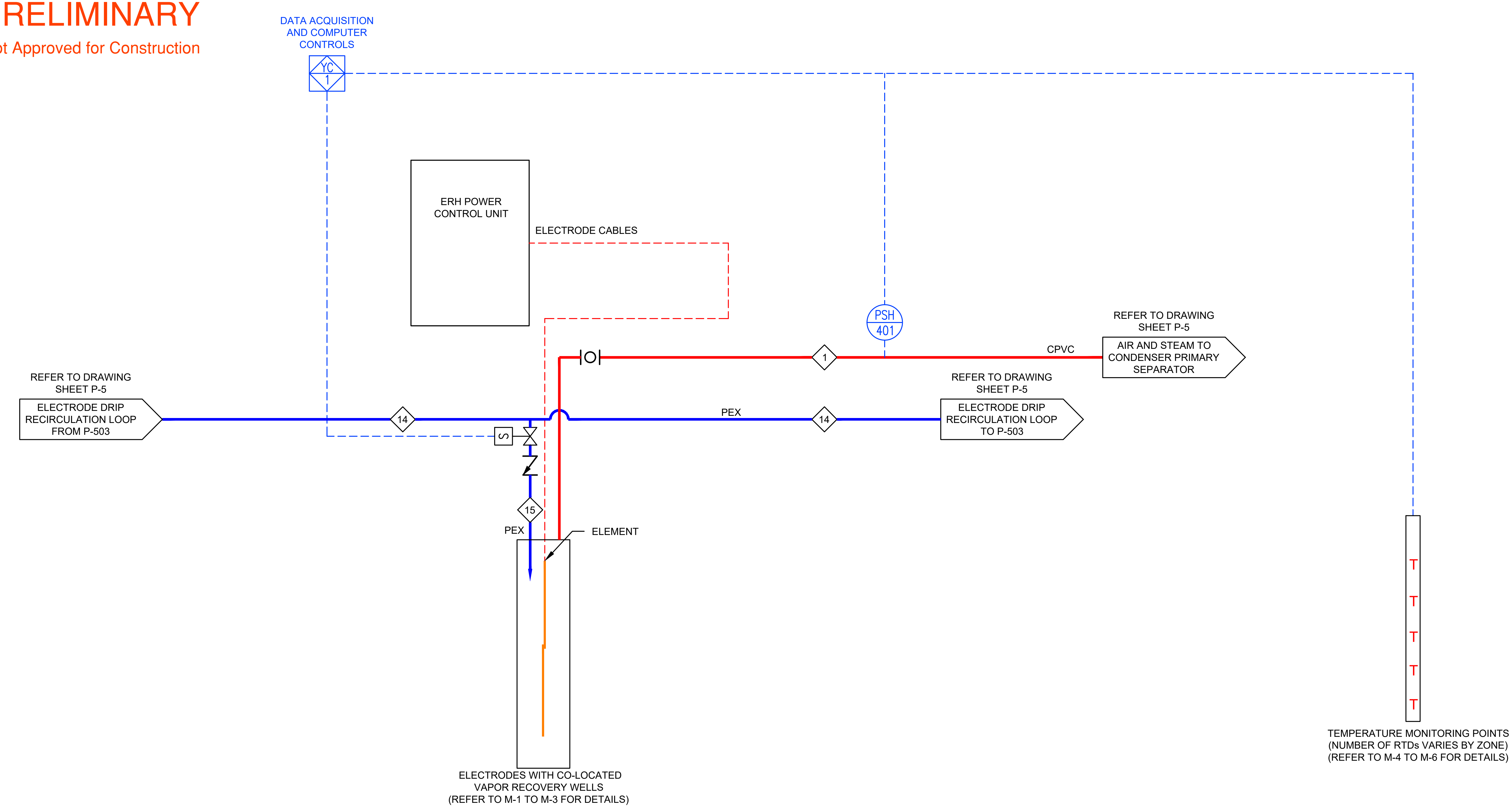
PROCESS FLOW MASS BALANCE

APPROVED FOR CONSTRUCTION
BY
DATE

DATE 2021.MAR.25
PROJECT WA.RAI.2136
SHEET P-3

PRELIMINARY

Not Approved for Construction



NOTES

1. SEE THE ELECTRODE AND TEMPERATURE MONITORING POINT DETAILS FOR MORE INFORMATION ON THEIR CONSTRUCTION.

2. PSH-401 WILL SHUT DOWN THE PCU IN THE EVENT OF A LOW FIELD VACUUM (LESS THAN 2" $H_2$0).

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

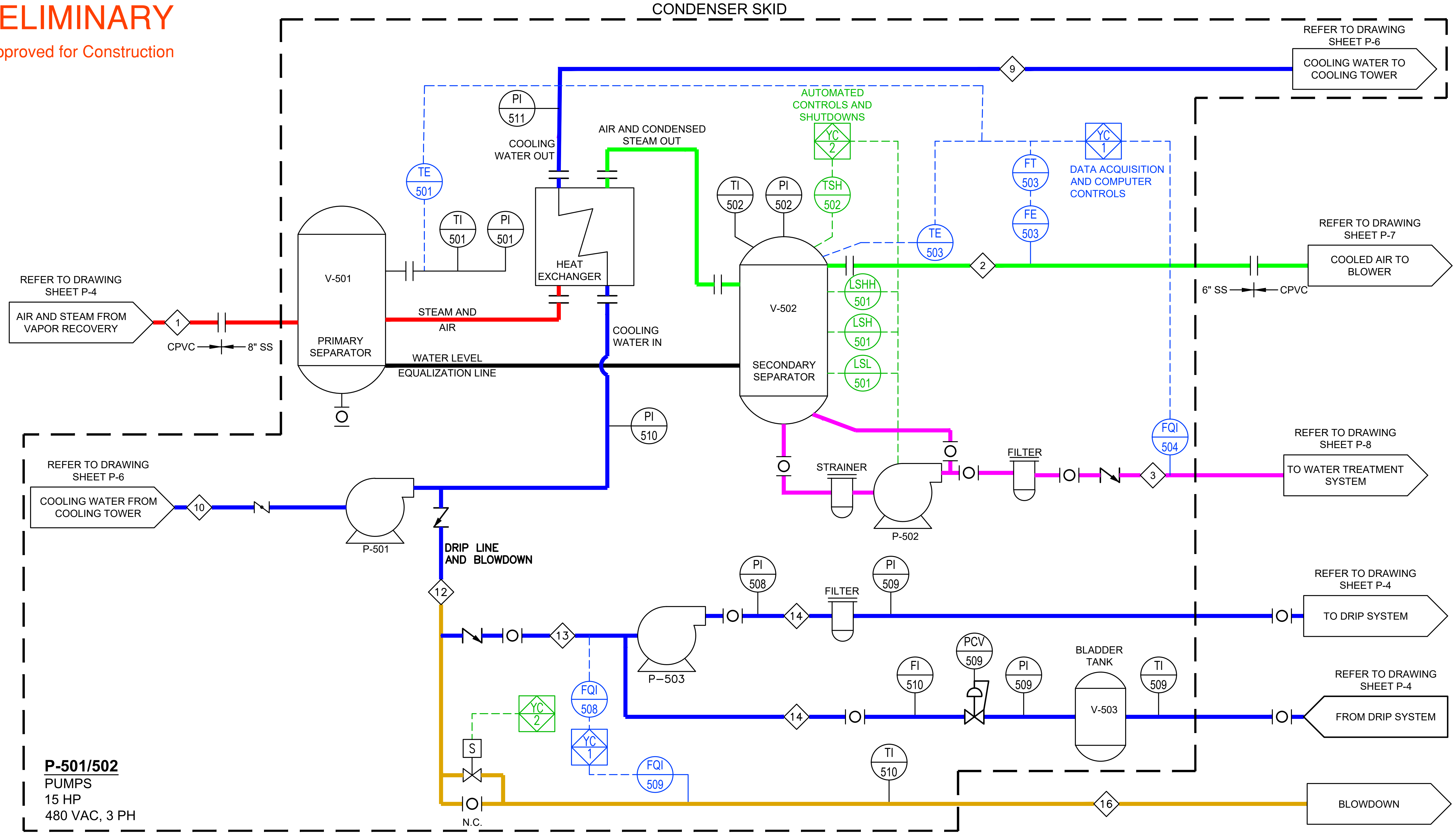
DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

FIELD
PROCESS AND INSTRUMENTATION DIAGRAM

APPROVED FOR CONSTRUCTION	
BY	
DATE	
DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	P-4

PRELIMINARY

Not Approved for Construction



NOTES:

1. LSHH-501 WILL SHUT DOWN THE VAPOR RECOVERY BLOWER (B-701) AND POWER TO THE ELECTRODES.
2. TSH-502 WILL SHUT DOWN THE VAPOR RECOVERY BLOWER (B-701). TEMPERATURE SET POINT IS 140°F.
3. PROCESS LINE 9 SPLITS WITH HALF THE TOTAL FLOW (PROCESS LINE 9A) GOING TO EACH COOLING TOWER (SEE P-6).
4. THE HEAT EXCHANGER IS ASME 2 RATED.

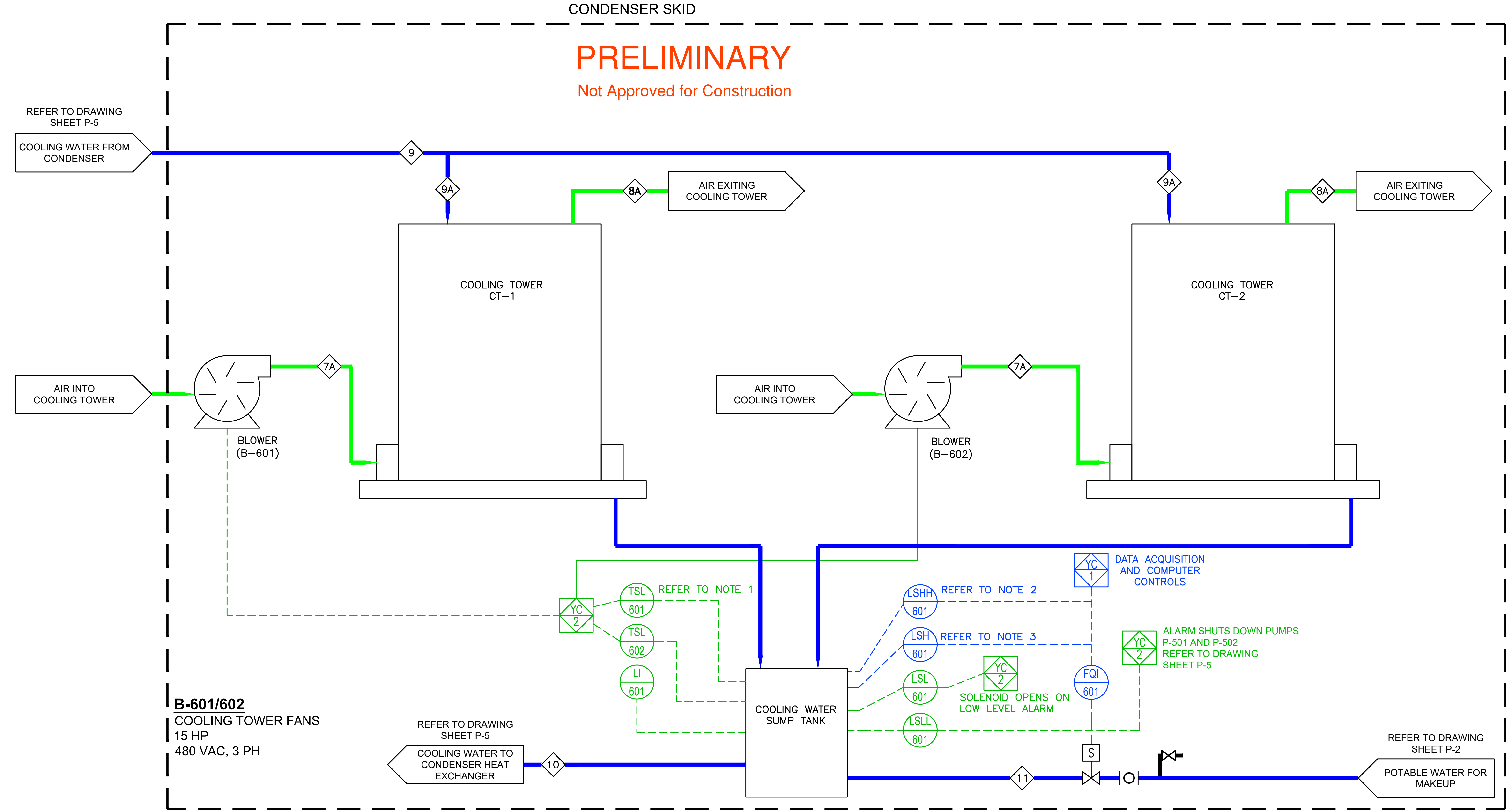
TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

CONDENSER
PROCESS AND INSTRUMENTATION DIAGRAM

APPROVED FOR CONSTRUCTION	
BY	
DATE	
DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	P-5



NOTES

1. TSL-601 AUTOMATICALLY SHUTS DOWN THE COOLING TOWER FAN AT 45° F. TSL-602 TURNS ON AN IMMERSION HEATER IN THE COOLING TOWER SUMP.
2. LSHH-601 SHUTS DOWN SYSTEM
3. LSH-601 OPENS BLOWDOWN SOLENOID AT CONDENSER.
4. LSL-601 MUST BE AT LEAST 2 FEET ABOVE PUMP INTAKE.
5. POTABLE MAKEUP WATER IS SUPPLIED TO THE COOLING WATER SUMP TANK, AS NEEDED, AT AN AVERAGE RATE OF 3-5 GPM IN 30 SECOND INCREMENTS.
6. PROCESS LINE 7 SPLITS WITH HALF THE TOTAL FLOW (PROCESS LINE 7A) GOING TO EACH COOLING TOWER (SEE P-2).
7. PROCESS LINE 8 IS THE COMBINATION OF PROCESS LINES 8A (ONE FROM EACH COOLING TOWER, SEE P-2).
8. PROCESS LINE 9 SPLITS WITH HALF THE TOTAL FLOW (PROCESS LINE 9A) GOING TO EACH COOLING TOWER (SEE P-2)

TRS *Accelerating Value*

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT

SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

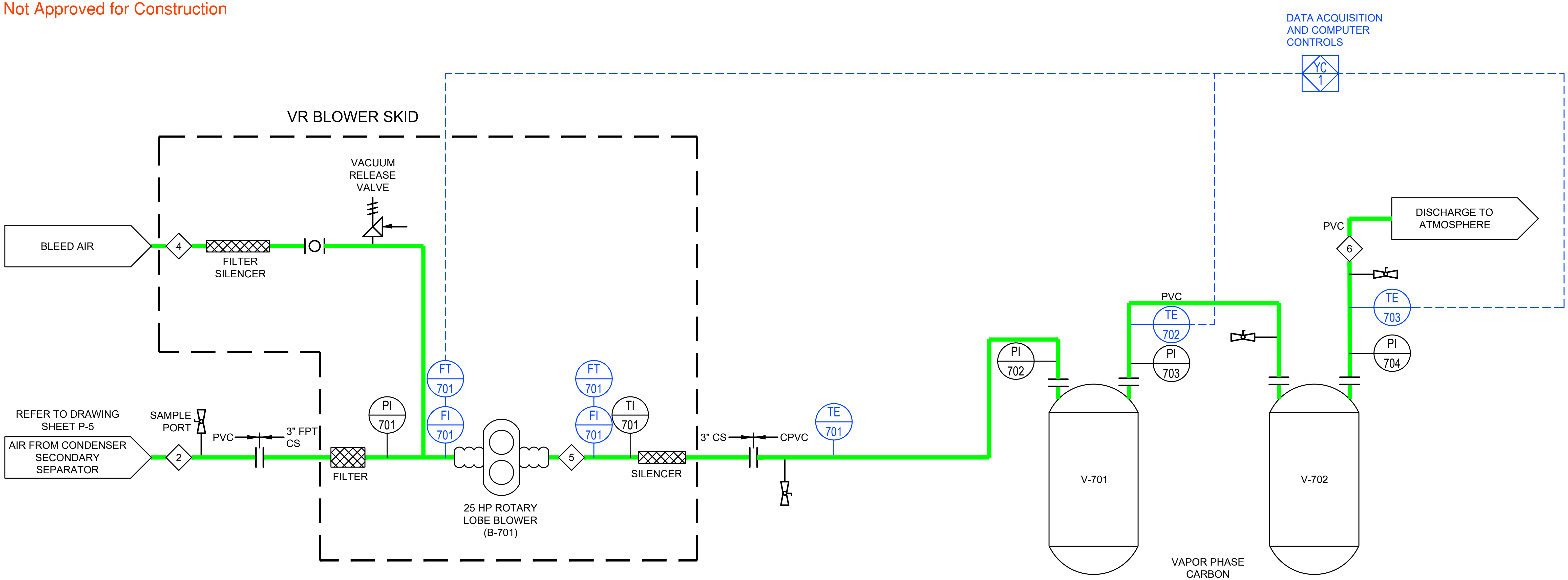
COOLING TOWER
PROCESS AND INSTRUMENTATION DIAGRAM

APPROVED FOR CONSTRUCTION
BY ______
DATE ______

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	P-6

PRELIMINARY

Not Approved for Construction



B-701
BLOWER
25 HP
480 VAC, 3 PH

VGAC
VAPOR CARBON VESSELS
CARBON STEEL
2000# GAC MEDIA
RATING: 2 PSIG @ 250°F
(VGAC IS AS REQUIRED BY LOCAL,STATE AND FEDERAL REQUIREMENTS.)

TRS
Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

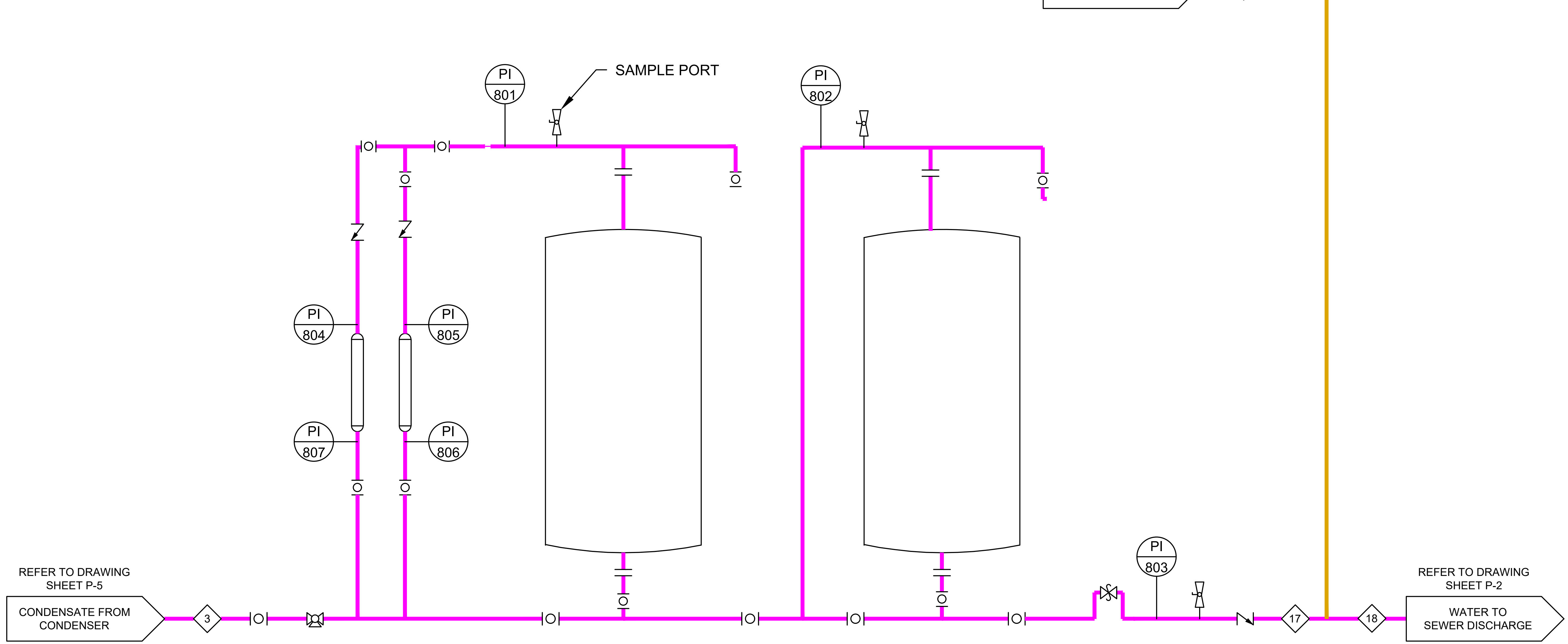
VAPOR TREATMENT
PROCESS AND INSTRUMENTATION DIAGRAM

APPROVED FOR CONSTRUCTION
BY ____________
DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	P-7

PRELIMINARY

Not Approved for Construction



NOTES:

1. VESSEL CONNECTIONS MAY VARY.
2. ALL PIPING FOR THE WATER TREATMENT SYSTEM SHOULD BE SCH80 PVC.
3. ALL VALVES TO BE TRUE UNION BALL VALVES.
4. BACKWASH VALVING IS OPTIONAL-USE ON SILT SITES
5. VESSELS TO BE FIBERGLASS, EVOQUA PG-200.
6. TRUE UNIONS SHOULD BE ADDED TO VESSEL INLETS AND OUTLETS OF EACH VESSEL TO AID IN GAC CHANGE-OUT AND SILT REMOVAL.
7. ANTI-SIPHON VALVE IS WATTS MODEL NO. LF288A-1

LGAC

LIQUID CARBON VESSELS
CARBON STEEL
200# GAC MEDIA
RATING: 2 PSIG @ 250°F

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

DESIGNED BY	D. SEILER
DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

WATER TREATMENT
PROCESS AND INSTRUMENTATION DIAGRAM

APPROVED FOR CONSTRUCTION

BY ____________________

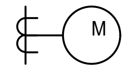
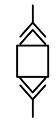
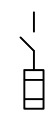
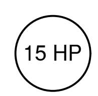
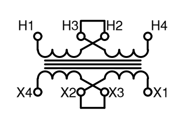
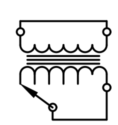
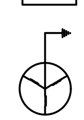
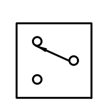
DATE ____________________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	P-8

PRELIMINARY

Not Approved for Construction

SYMBOLS

	UTILITY METERING
	MEDIUM VOLTAGE DRAW OUT CIRCUIT BREAKER
	FUSE
	DISCONNECT SWITCH
	FUSED DISCONNECT SWITCH
	CIRCUIT BREAKER
	N.O. CONTACT A NORMALLY OPEN (N.O.) CONTACT IS OPEN WHEN IT, OR THE DEVICE OPERATING IT, IS IN A DE-ENERGIZED
	N.C. CONTACT A NORMALLY CLOSED (N.C.) CONTACT IS CLOSED WHEN IT, OR THE DEVICE OPERATING IT, IS IN A DE-ENERGIZED STATE OR RELAXED STATE.
	THERMAL OVERLOAD
	PUMP/MOTOR
	TRANSFORMER
	VARIABLE OUTPUT 3 PHASE TRANSFORMER
	GENERATOR
	AUTOMATIC TRANSFER SWITCH

ABBREVIATIONS

A	AMPERES
ATS	AUTOMATIC TRANSFER SWITCH
FLA	FULL LOAD AMPS
HP	HORSEPOWER
KW	KILOWATT
KVA	KILOVOLT-AMPERES
KV	KILO-VOLTS
N.O.	NORMALLY OPEN
OL	OVERLOAD
P	POLE
PH, Ø	PHASE
SRGAC	STEAM REGENERATED GAS ACTIVATED CARBON
VAC	VOLTAGE ALTERNATING CURRENT
VFD	VARIABLE FREQUENCY DRIVE
V	VOLT
W	WATTS, WIRE

NOTE: THIS IS AN ALL INCLUSIVE LEGEND SHEET. NOT ALL SYMBOLS/ABBREVIATIONS WILL APPEAR ON EACH SHEET.

TRS
Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

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DRAWN BY	A. PEABODY
CHECKED BY	PENDING APPROVAL
PROJECT MANAGER	TRS PERSONNEL
QSAT REVIEW	G. KNIGHT
SITE	RANIER MALL PROPERTY
LOCATION	SEATTLE, WASHINGTON
CLIENT	RANIER AND GENESEE, LLC

ELECTRICAL ONE-LINE DIAGRAM LEGEND

APPROVED FOR CONSTRUCTION

BY ____________

DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	E-1

PRELIMINARY

Not Approved for Construction

GENERAL NOTES

1. PERFORM INSTALLATION IN ACCORDANCE WITH THE CURRENT EDITION OF THE NATIONAL ELECTRICAL CODE (NEC) AND THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSH ACT). EQUIPMENT SHALL BE LISTED BY A NATIONALLY RECOGNIZED TESTING LABORATORY (NRTL).
2. PROVIDE AND MAINTAIN A CLEAR WORKING SPACE ABOUT ELECTRIC EQUIPMENT IN ACCORDANCE WITH NEC ARTICLES 110.26 AND 110.34.
3. PROVIDE CIRCUIT BREAKERS WITH UL LISTED INTERRUPTING RATING (RMS SYMMETRICAL AMPERES) GREATER THAN THE AVAILABLE FAULT CURRENT SHOWN IN THE SHORT CIRCUIT REPORT.
4. PROVIDE PADLOCKING PROVISIONS FOR EACH TWO AND THREE POLE CIRCUIT BREAKERS.
5. USE #12AWG OR LARGER CONDUCTORS FOR POWER WIRING.
6. USE #14AWG OR LARGER CONDUCTORS FOR CONTROL WIRING UNLESS OTHERWISE SPECIFIED OR SHOWN ON THE DRAWINGS.
7. LIMIT USE OF ELECTRICAL METALLIC TUBING (EMT) AND SCHEDULE 40 PVC CONDUIT TO AREAS WHERE IT WILL NOT BE SUBJECT TO PHYSICAL DAMAGE.
8. USE LIQUID TIGHT FLEXIBLE METAL CONDUIT FOR FLEXIBLE CONNECTIONS TO EQUIPMENT OUTDOORS.
9. USE INTERMEDIATE METALLIC CONDUIT (IMT) OR RIGID GALVANIZED STEEL CONDUIT (RGS) OR SCHEDULE 80 PVC CONDUIT FOR WORK EMBEDDED IN CONCRETE OR EXPOSED TO PHYSICAL DAMAGE. THESE CONDUIT TYPES MAY BE USED IN ALL APPLICATIONS WHERE SCHEDULE 40 PVC OR EMT WOULD BE APPROPRIATE, AT THE DISCRETION OF THE DESIGN ENGINEER.
10. USE THE FOLLOWING CONDUCTOR COLOR CODES.

	240/120V	208Y/120V	480Y/277V	MED VOLTAGE	ELECTRODE CABLES
PHASE A	BLACK	BLACK	BROWN	RED	RED W/ELECTRODE MARKER
PHASE B	RED	RED	ORANGE	YELLOW	YELLOW W/ELECTRODE MARKER
PHASE C		BLUE	YELLOW	BLUE	BLUE W/ELECTRODE MARKER
NEUTRAL	WHITE	WHITE	GRAY		
EQUIP, GND	GREEN/BARE	GREEN/BARE	GREEN/BARE	GREEN/BARE	

ISOLATED GROUND SHALL BE GREEN WITH YELLOW TRACER.

11. USE ONLY COPPER CONDUCTORS.
12. POWER CONDUCTORS 10AWG AND SMALLER SHALL BE SOLID. POWER CONDUCTORS 8AWG AND LARGER SHALL BE STRANDED
13. FOR NON-ELECTRODE CIRCUITS, PROVIDE TYPE THHN/THWN WIRE INSULATION. XHHW INSULATION MAY BE USED FOR 1AWG AND LARGER. TYPE W AND DLO CABLE MAY BE USED FOR CIRCUITS WHICH REQUIRE FLEXIBILITY. CONDUCTORS THAT REQUIRE FLEXIBILITY ARE PERMITTED TO BE STRANDED REGARDLESS OF CONDUCTOR SIZE. USE OF WIRE FERRULES ON UN-LUGGED FLEXIBLE CABLE IS REQUIRED. SOW CABLE IS PERMITTED FOR SKID POWER FEEDERS.
14. ARRANGE CONNECTIONS FOR SINGLE PHASE CIRCUITS TO ACHIEVE THREE PHASE LOAD BALANCE WITHIN 10% OF THE AVERAGE PHASE LOAD CURRENT FOR SCR POWERED LOADS.
15. ARRANGE CONNECTIONS FOR SINGLE PHASE CIRCUITS TO ACHIEVE THREE PHASE LOAD BALANCE WITHIN 20% OF THE AVERAGE PHASE LOAD CURRENT FOR NON-SCR POWERED LOADS.
16. INSTALL OUTDOOR EQUIPMENT TO BE WEATHERPROOF AND TO EXCLUDE BIRDS AND RODENTS WITH A MAXIMUM ½” DIAMETER UNPROTECTED OPENINGS IN ENCLOSURES.
17. TEST CONDUCTORS FOR CONTINUITY AND FREEDOM FROM SHORTS AND UNINTENTIONAL GROUNDS.
18. ELECTRICAL MATERIALS AND CONSTRUCTION SHALL CONFORM TO TRS GROUP INC STANDARD CONSTRUCTION SPECIFICATIONS WHERE APPLICABLE.
19. IF A CONFLICT ARISES BETWEEN THE FIELD CONDITIONS AND THESE GENERAL ELECTRICAL REQUIREMENTS, STOP WORK AND CONTACT THE PROJECT ENGINEER.
20. TIE-INS TO EXISTING POWER SYSTEMS WILL BE PERFORMED BY OTHERS, WORKING UNDER THE DIRECTION OF A LOCALLY LICENSED ENGINEER OR UTILITY AUTHORITY. SEE TRS ELECTRICAL CONTRACTING SPECIFICATION FOR ADDITIONAL REQUIREMENTS IF PERFORMED BY TRS SUBCONTRACTOR.

TRS Accelerating Value

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ELECTRICAL ONE-LINE REQUIREMENTS

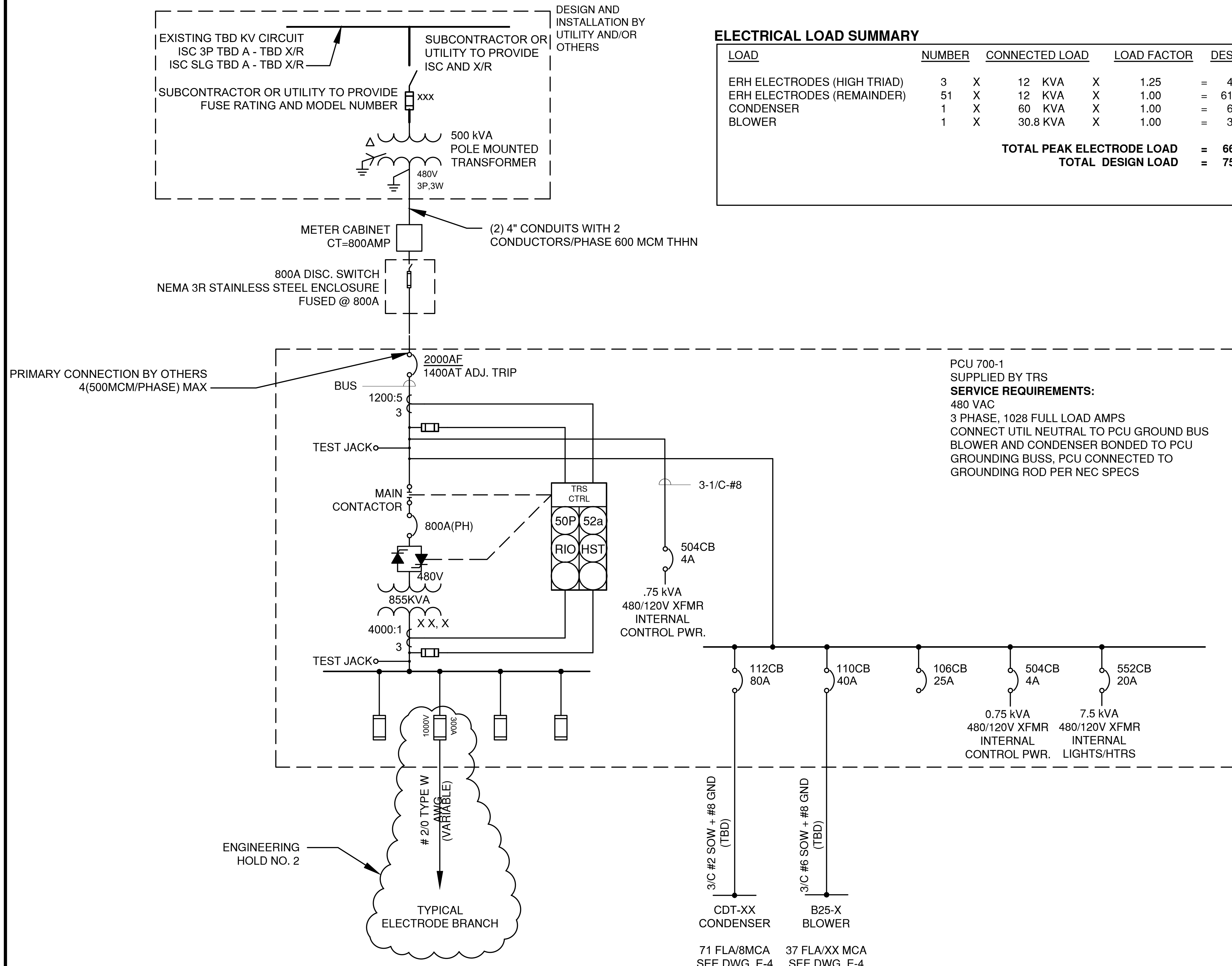
APPROVED FOR CONSTRUCTION

BY ________

DATE ________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	E-2

PRELIMINARY
Not Approved for Construction



ELECTRICAL LOAD SUMMARY

LOAD	NUMBER		CONNECTED LOAD		LOAD FACTOR		DESIGN LOAD
ERH ELECTRODES (HIGH TRIAD)	3	X	12 KVA	X	1.25	=	45 KVA
ERH ELECTRODES (REMAINDER)	51	X	12 KVA	X	1.00	=	615 KVA
CONDENSER	1	X	60 KVA	X	1.00	=	60 KVA
BLOWER	1	X	30.8 KVA	X	1.00	=	30.8 KVA

TOTAL PEAK ELECTRODE LOAD = 660 KVA
TOTAL DESIGN LOAD = 750.8 KVA

NOTES

1. GROUND CABLE SIZES ARE MINIMUMS
2. LIMIT AVERAGE ELECTRODE POWER TO 40.4 KVA PER ELECTRODE

DRAWING HOLDS

1. ENGINEERING HOLD PENDING OPTION SELECTION AND TRANSFORMER SELECTION.
2. ENGINEERING HOLD PENDING OPTION SELECTION.
3. ENGINEERING HOLD PENDING SETTINGS.

TRS Accelerating Value

TRS GROUP, INC. PO BOX 737 LONGVIEW, WA 98632

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DRAWN BY: A. PEABODY
CHECKED BY: PENDING APPROVAL
PROJECT MANAGER: TRS PERSONNEL
QSAT REVIEW: G. KNIGHT

SITE: RANIER MALL PROPERTY
LOCATION: SEATTLE, WASHINGTON
CLIENT: RANIER AND GENESEE, LLC

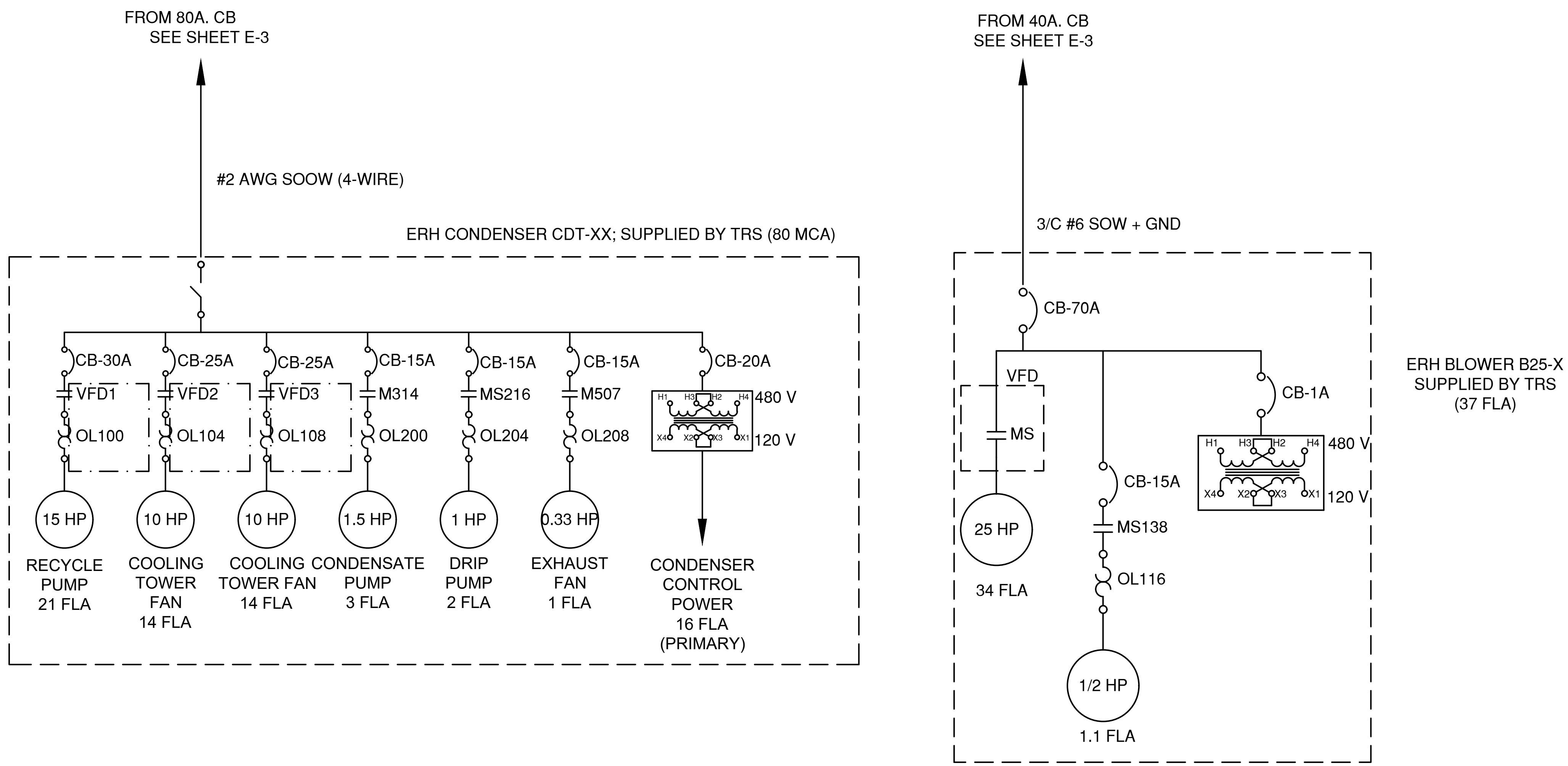
ELECTRICAL ONE-LINE DIAGRAM

APPROVED FOR CONSTRUCTION
BY ____________
DATE ____________

DATE: 2021.MAR.25
PROJECT: WA.RAI.2136
SHEET: E-3

PRELIMINARY

Not Approved for Construction



TRS Accelerating Value

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ELECTRICAL ONE-LINE DIAGRAM

APPROVED FOR CONSTRUCTION

BY ____________

DATE ____________

DATE	2021.MAR.25
PROJECT	WA.RAI.2136
SHEET	E-4

Appendix B: Regenesis Technical Documents

REGENESIS

Technology-Based Solutions for the Environment

ISCR-Enhanced Bioremediation

www.regenesis.com

S-MicroZVI®
Sulfidated Zero-Valent Iron

Summary

In Situ Chemical Reduction (ISCR) enhanced bioremediation is a remediation approach that combines zero valent iron (ZVI), an organic hydrogen donor, and contaminant-degrading microbes to degrade contaminants in soil and groundwater. This approach is most commonly used for chlorinated contaminants including chlorinated ethenes. ISCR-enhanced bioremediation is particularly effective because it stimulates anaerobic biological degradation by rapidly creating a reducing environment favorable to reductive dechlorination. Furthermore, ISCR-enhanced bioremediation may limit the formation of toxic daughter products such as cis-1,2-dichloroethene (*cis*-DCE) and vinyl chloride (VC) by degrading parent compounds abiotically, or via direct chemical reduction. This tech bulletin describes this remedial approach in more detail and showcases the performance of S-MicroZVI® a sulfidated zero-valent iron amendment developed by REGENESIS.

Background

In situ bioremediation is an established and cost-effective option for managing chlorinated groundwater contaminants. Traditionally, contaminants are treated by adding an organic hydrogen donor (e.g., fatty acids) and allowing anaerobic microbes (native or augmented) to convert the contaminants into harmless end-products. This strategy can be greatly enhanced by the addition of strong reducing agents like ZVI, which create favorable aquifer conditions for contaminant-degrading bacteria as well as directly reacting with many chlorinated compounds. This approach is referred to as ISCR-enhanced bioremediation. Regenesis offers S-MicroZVI® a sulfidated ZVI, which facilitates ISCR-enhanced bioremediation and owing to the sulfidation, is longer-lived and more reactive than standard ZVI. S-MicroZVI is a colloidal suspension containing 40% sulfidated ZVI (S-ZVI) by weight with < 5 µm iron particles suspended in food grade glycerol. S-MicroZVI is formulated to be easily injected, transport well in the subsurface during application and be long-lasting.

S-Micro ZVI®
Sulfidated Zero-Valent Iron

Enhanced Reductive Dechlorination

Enhanced reductive dechlorination (ERD) describes the bioremediation of contaminants by anaerobic bacteria that are supported by the molecular hydrogen produced by fermentation of organic hydrogen donors. The biological degradation pathway for perchloroethene (PCE) and trichloroethene (TCE) is provided in **Figure 1.** This pathway, also known as hydrogenolysis, involves the sequential replacement of a chlorine atom with a hydrogen atom and is always accompanied by the formation of chlorinated intermediates. Many common anaerobic bacteria can transform PCE to TCE and then to *cis*-DCE, but only *Dehalococcoides ethenogenes* (DHC) is known to transform *cis*-DCE and VC to ethene.

Supplementing dechlorinating bacteria with zero-valent iron and organic hydrogen donors can enable more rapid and complete biodegradation. ZVI quickly deoxygenates groundwater and provides an electrochemically reducing environment that is highly fertile for the microbes involved in anaerobic bioremediation. In many situations this favorable environment can be sustained for several years.

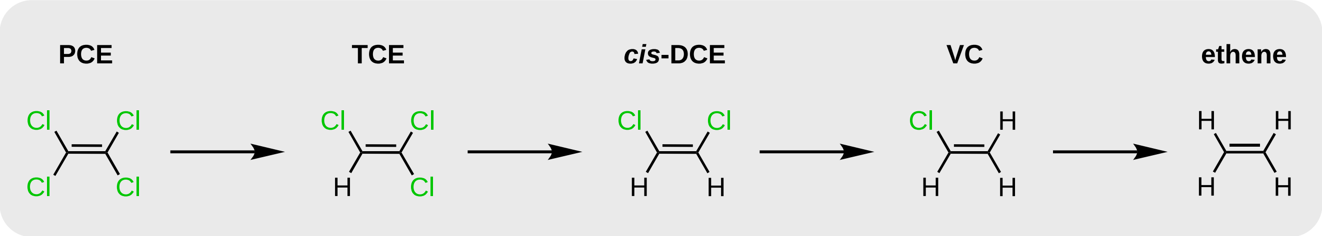

Figure 1. *Reductive dechlorination sequentially replaces chlorine atoms with hydrogen atoms. The intermediates cis-DCE and VC are more toxic than parent compounds PCE and TCE.*

Abiotic Degradation

Beyond the benefits of accelerated bioremediation, ZVI provides an abiotic degradation mechanism involving the direct reaction of ZVI with groundwater contaminants. The abiotic, beta-elimination pathway for chlorinated ethenes is shown in the bottom track of **Figure 2.** The beta-elimination pathway involves short-lived dichloroacetylene and chloroacetylene intermediates and bypasses the formation *cis*-DCE and VC intermediates. An ISCR-enhanced bioremediation approach can utilize both the reductive dechlorination and the beta-elimination pathways and reduce the observed concentrations of *cis*-DCE and VC relative to an approach using ERD alone.

Abiotic Degradation - Continued

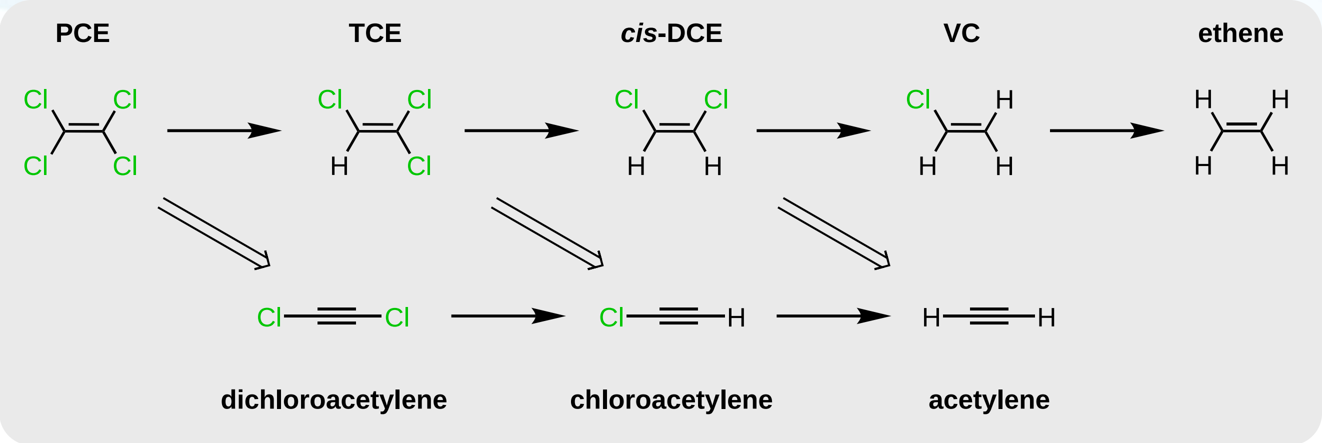

Figure 2. *ISCR-enhanced bioremediation allows the degradation of chlorinated contaminants by reductive dechlorination (single-line arrows) or beta-elimination (double-line arrows). Beta-elimination avoids the formation of cis-DCE and VC.*

When to Use ISCR-Enhanced Bioremediation

ISCR-enhanced bioremediation can be used to treat contaminants such as chlorinated solvents, haloalkanes, and chlorinated pesticides. Contaminants that are resistant to abiotic degradation (e.g.1,2-dichloroethane, dichloromethane) and compounds that can inhibit bioremediation (e.g. 1,1,1-trichloroethane, chloroform) may be effectively treated by ISCR-enhanced bioremediation. ISCR-enhanced bioremediation can be used for source zones, plumes, and barrier applications.

S-Micro ZVI
Sulfidated Zero-Valent Iron

Column Study Demonstrating ISCR-Enhanced Bioremediation

Study Objective:

The objective of this study was to demonstrate that the use of the combination of S-MZVI, dechlorinating bacteria, and an organic electron donor results in a more complete degradation of TCE with less formation of *cis*-DCE and VC compared to an approach using only dechlorinating bacteria and an electron donor.

Experimental Setup:

Three Omnifit™ columns, 25 mm in diameter and 500 mm in length, were dry-packed with medium-fine sand (200-500 µm), purged with carbon dioxide for 15 minutes, and filled with deoxygenated tap water. The column conditions were:

- **Sterile TCE control:** Column was sterilized with one pore volume (90 mL) of 200 mg/L sodium azide.

- **Biotic treatment:** One pore volume (90 mL) of deoxygenated lactate/nutrient solution (1000 mg/L sodium lactate, 10 mg/L nutrients) was flowed through the column. Next, an additional pore volume of dechlorinating bacteria solution (10^9 cells/L *Dehalococcoides ethenogenes*, 1000 mg/L lactate, 10 mg/L nutrients, prepared in deoxygenated water) was flowed through the column. The column flow was turned off for approximately 20 hours to allow the bacteria to acclimate.

- **ISCR-enhanced bioremediation treatment:** One pore volume (90 mL) of S-MicroZVI was flowed through the column as a dilute aqueous solution (1 % as iron). The column was then flushed with deoxygenated tap water until the effluent appeared clear. After this S-MicroZVI treatment, the column was prepared in the same manner as the Biotic control column described above.

After the conditioning, TCE was continuously flowed through all three columns as a 2 mg/L solution at a rate of one pore volume (90 mL) per week. The influent for the sterile control contained TCE as well as 200 mg/L sodium azide. The influent for the biotic control column and the ISCR-enhanced bioremediation column contained TCE as well as 100 mg/L lactate and 1 mg/L nutrients. Effluent samples from each column were collected weekly and analyzed by GC-MS for their TCE, *cis*-DCE, and VC concentrations.

Results & Discussion

The effluent concentration data from the columns are depicted in **Figure 3.**

The concentration of TCE in the sterile control trended upward for the first 10 pore volumes with no daughter products produced. The biotic column displayed conversion of TCE from the influent to *cis*-DCE and VC in the effluent. The ISCR-enhanced bioremediation column facilitated the complete removal of TCE from the effluent solution throughout the experiment. Some *cis*-DCE and VC were eluted during the first 7 pore volumes with a cumulative elution about 40% of the TCE eluted in the sterile column. After 7 pore volumes, no chlorinated ethenes were detected in the effluent solution. These results demonstrate the effectiveness of ISCR-enhanced bioremediation in promoting the complete degradation of TCE and limiting the formation of *cis*-DCE and VC.

S-Micro ZVI
Sulfidated Zero-Valent Iron

Column Study Demonstrating ISCR-Enhanced Bioremediation - Continued

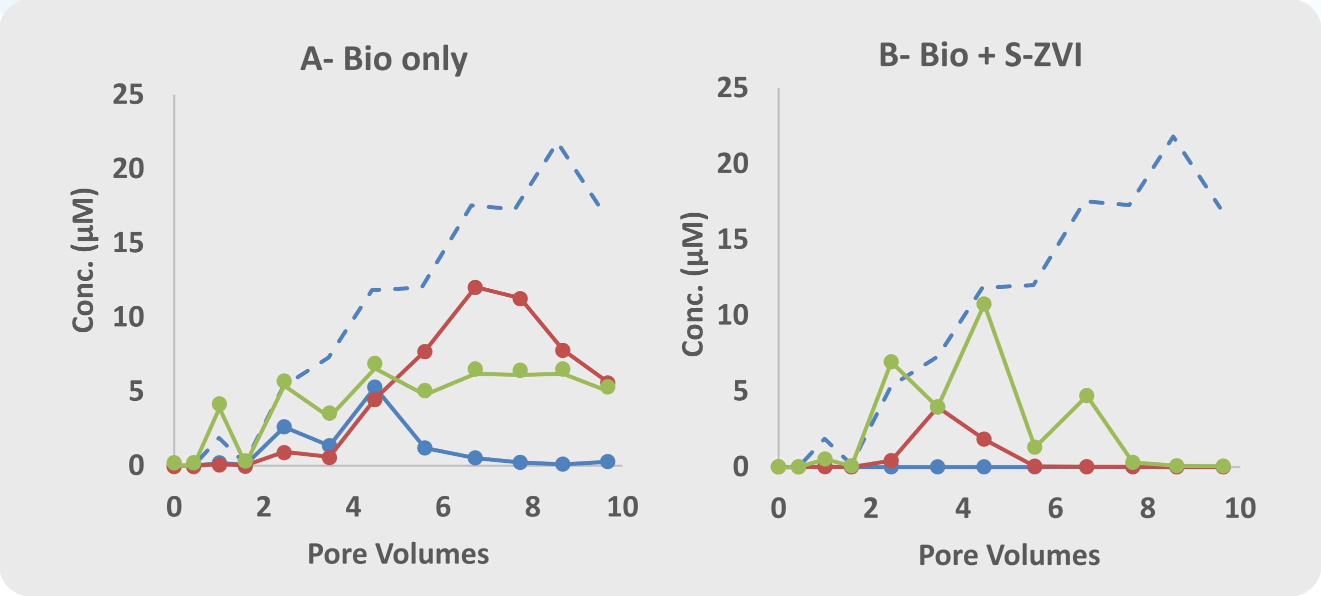

Figure 3. *Effluent concentration of chlorinated ethenes, A) Biotic Control and B) Biotic S-MicroZVI.*
Sterile TCE Control - - -   TCE ——   cDCE ——   VC ——

Conclusion

ISCR-enhanced bioremediation combines multiple degradation pathways to promote the rapid removal of chlorinated contaminants from solution. While chlorinated compounds can be slowly degraded using only an electron donor and dechlorinating bacteria, the addition of S-ZVI generates strongly anaerobic and reducing conditions that further enhance biologically-mediated ERD. The presence of S-ZVI also provides a secondary abiotic, beta-elimination pathway. The availability of multiple pathways allows the removal of parent compounds and lessens the potential for the formation of more toxic daughter products.

REGENESIS

Technology-Based Solutions for the Environment

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Zerovalent Iron Electrochemical Fundamentals

Oxidation Half Reaction: $4\ Fe \rightarrow 4\ Fe^{+2} + 8\ e^-$

Reduction Half Reaction: $C_2Cl_4 + 4H^+ + 8\ e^- \rightarrow C_2H_4 + 4\ Cl^-$

Add these together

Balanced Redox Reaction: $4Fe + C_2Cl_4 + 4\ H^+ \rightarrow 4\ Fe^{+2} + C_2H_4 + 4\ Cl^-$

Redox reactions involve the oxidation of one species. The electrons supplied by the oxidation reaction are used to reduce another compound. An example is the reduction of PCE (C_2Cl_4) by zero valent iron (Fe). In this reaction, 4 atoms of iron are oxidized to supply eight electrons that are required to convert C_2Cl_4 to ethene (C_2H_4). The four protons (H+) that are required for the reduction reaction are supplied by the hydrolysis of water.

Another way to write this includes the hydrolysis reaction with water as a reactant and hydroxide as a product.

Oxidation Half Reaction: $4\ Fe \rightarrow 4\ Fe^{+2} + 8\ e^-$

Reduction Half Reaction: $C_2Cl_4 + 4H^+ + 8\ e^- \rightarrow C_2H_4 + 4\ Cl^-$

Hydrolysis Reaction: $4\ H_2O$ è $4H^+ + 4OH^-$

Balanced Redox Reaction: $4Fe + C_2Cl_4 + 4\ H_2O \rightarrow 4\ Fe^{+2} + C_2H_4 + 4\ Cl^- + 4\ OH^-$

Appendix C: TRS Soil and Groundwater Sampling Protocols

TRS Accelerating Value	**STANDARD OPERATING PROCEDURE**	**PROCEDURE No: 3.1**

Procedure Title: # Hot Groundwater Sampling

Author:	TRS Team	**Issue Date:**	4/22/08

Revisions:

Date	Initials	Revision Description	Revision #
12/15/14	TP	Annual Review, MW access caution	6
12/4/17	GK	Annual review; procedure updates	7
12/02/19	GK	Annual Review, revised sample rate to 0.2 L/m, added steam reference	8

Reviewed and Approved by (initial and date):

SOP/ Revision #	Safety & Quality	Engineering
Original	4/22/08	4/22/08
REV 5	7/27/12	7/27/12
REV 6	1/21/16	1/21/16
REV 7	12/4/17	12/4/17
REV 8	12/2/2019	12/2/2019

1.0 PURPOSE

This standard operating procedure (SOP) provides uniform procedures for the safe collection of representative groundwater samples during or after the application of electrical resistance heating (ERH), Thermal Conduction Heating (TCH), or other *in situ* thermal remediation (ISTR) applications. This procedure specifically addresses sampling of groundwater that has been heated during the thermal remediation process.

2.0 SCOPE

This SOP provides the relevant information and steps for the collection of groundwater samples during or after the application of ISTR using modified low-flow sampling procedures. This SOP draws information primarily from the United States Environmental Protection Agency's (USEPA's) groundwater issue paper, Low-Flow (minimal drawdown) Ground-Water Sampling Procedure (Puls and Barcelona, 1996). Modifications to the EPA methodology have been made to accommodate groundwater temperatures that have been elevated from the application of ISTR. Only personnel trained to the minimum requirements outlined in **Section 7.0** of this SOP are authorized to collect hot groundwater samples at TRS ISTR project sites.

The USEPA guidance document recommends continual monitoring of water levels during the purge and sample process to ensure that minimal drawdown is occurring (Puls and Barcelona, 1996). Due to the safety hazards associated with opening groundwater monitoring wells where heated groundwater is present at ISTR project sites, groundwater level measurements (depth to groundwater) will not be collected as part of hot groundwater sampling activities. If the TRS project site has been constructed with pressure transducers to monitor groundwater gradients, readings from the transducers will be monitored as feasible to minimize groundwater drawdown. If previous sampling records or hydrogeologic data is available, this information shall be used to develop target flow rates for the groundwater sampling effort.

These procedures assume that dedicated sample tubing and pumping systems for each monitoring well have been established prior to application of electrical energy to the subsurface.

Caution - Access to groundwater monitoring wells during a TRS ISTR application is prohibited without TRS management approval. If intrusive work is required to complete the sampling efforts, or minimally accessing (removing) a well cap, an additional activity hazard analysis (AHA) must be created specific to the site and activity and reviewed and approved by the TRS project manager (PM), TRS Safety & Quality Manager (SQM), and, the TRS authorized employee approving the Start-Up Checklist (SUCL).

Samples collected using this SOP are generally used for optimizing system performance. Samples collected using this procedure may also be used for regulatory compliance and/or site closure.

TRS Group, Inc. (TRS) personnel shall use this procedure in conjunction with site-specific Health and Safety Plans (HASP), sample analysis plans, and permit requirements. These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required, dependent on-site conditions, equipment limitations, permit requirements, or limitations imposed by the procedure. The ultimate procedures, including any deviations from this SOP, shall be documented on the groundwater sampling form.

3.0 DEFINITIONS

Authorized employee

Any designated employee who locks out or tags out equipment in order to perform servicing or maintenance. This person must have completed the mandatory Lockout/Tagout (LOTO) training described in SOP 1.1 LOTO to be qualified as an authorized worker. Only an authorized worker installs and removes his or her own lock and tag as required by this program.

Competent Person

Any designated employee who has been trained in proper procedures for hot groundwater sampling at thermal remediation sites. This person must have completed the mandatory training outlined in **Section 7.0** to be qualified as a competent person.

ERH – Electrical Resistance Heating

ERH is a process whereby soils and groundwater are heated by passing an electrical current through the subsurface volume to be remediated.

TCH – Thermal Conduction Heating

TCH is a process whereby soils and groundwater are heated with electric heaters placed as an array into the subsurface volume to be remediated.

Bladder Pump

Submersible pump with external control unit used for pumping fluids at greater depths. The bladder pump consists of an internal flexible bladder that is positioned within a rigid pump body constructed of stainless steel. The inner bladder is equipped with one-way inlet and outlet valves and passively fills with water when the pump is at depth by virtue of hydrostatic pressure. Following the fill cycle, compressed air from a cylinder or compressor at the wellhead is delivered to the pump through tubing and is used to compress the bladder. The applied pressure then causes the flexible bladder to compress and closes the bottom check valve, forcing water from the bladder into the discharge tubing. During a vent cycle, the pressure is released from the drive tubing. The bladder returns to its initial state as water re-enters the pump, while the top check valve prevents water already in the discharge tubing from falling back into the bladder. The pumping sequence consists of repeated fill/compress cycles, using a pneumatic controller positioned at the wellhead.




LOTO

Lockout/Tagout. The practice of using a tag for visibility and awareness in conjunction with placement of a keyed device ("lock") on an energy isolating device, in accordance with TRS SOP 1.1, Lockout/Tagout to prevent the unwanted activation of mechanical or electrical equipment. Lockout ensures the equipment being controlled cannot be operated until the lock is removed.

Low-Flow Purging

A USEPA approved purge-and-sample method used to minimize stress on the formation (minimal drawdown) which results in less mixing of stagnant casing water with formation water. Additional advantages of using low-flow purging methods include the following:

- Samples are more representative of actual contaminant loading
- Disturbance at the sampling point is minimal which minimizes sampling artifacts
- Less operator variability occurs between sampling events
- Decreased amount of investigation-derived waste (IDW) is produced
- Need for filtration is reduced
- Sample consistency is increased
- Only small volumes are removed from the well, making flashing in the well less likely

Flow-rates during low-flow purging/sampling are site-specific, based on hydrology, but are generally in the order of 0.1 to 0.2 liters per minute (L/min). Proper screen location, screen length, well construction and well development techniques may impact the effectiveness of low-flow purging. (Puls and Barcelona, 1996). The total volume of water removed from the well should be minimized to the extent practicable to avoid flashing of groundwater in the well which will produce erroneous data. These factors must be considered when developing a consistent, site-specific groundwater sampling procedure.

Multi-probe and Flow-Through Cell

The flow through cell allows for in-line sampling of water quality parameters with the Multi-probe to determine stabilization for water sampling. At a minimum, groundwater quality parameters include pH, conductivity, temperature, dissolved oxygen (DO), and turbidity. Examples of multi-probes used for collecting water quality parameters include the Horiba U-22 and YSI 556 (shown below).

Peristaltic Pump

A positive displacement pump used for pumping fluids. Generally, flexible tubing is fitted inside a circular pump casing. A rotor with a number of "rollers", "shoes", or "wipers" attached to the external circumference compresses the flexible tube. As the rotor turns, the part of tube under compression closes thus forcing the fluid to move through the tube.

SHSO

Site Health and Safety Officer

Trip Blank

The purpose of trip blanks it to identify any potential contamination of samples during sample handling and shipment. These blanks are prepared in the laboratory by filling a volatile organic analysis (VOA) bottle with distilled/deionized water. Trip blanks shall accompany shipment of empty vials to the site and shipment of samples back to the laboratory.

VOA Vials

EPA recommended glass sample containers used to collect liquid samples for laboratory analysis. Volatile organic analysis (VOA) vials have a nominal volume of 40 milliliters (mL) and are manufactured of clear or amber borosilicate glass. Depending on type of analysis being conducted, the VOA vials may contain small amounts of preservative when shipped from the laboratory. When collecting samples in VOA vials, fill the vial completely full (ensure that a meniscus has formed at the top of the vial before securing the cap) and check that there are no air bubbles in the closed sample. If there is a preservative present, use caution to not overfill the vial.

4.0 EQUIPMENT LIST

The required equipment for groundwater sampling may differ from this SOP based on the requirements set by the local regulatory oversight agency. Typically, the required equipment will be as follows:

1) Groundwater Sampling Field Form and indelible pen.
2) Safety Glasses with side shields. Additional option: full face-shield (wear over safety glasses).
3) Cotton Gloves with nitrile over-gloves. Cotton gloves should be worn to protect against water having high temperatures (wear under outer nitrile gloves).
4) Site-specific personal protective equipment (PPE) requirements. Refer to site-specific HASP.
5) Pump and operating components:
    a) Peristaltic pump utilized when the depth to water is 20 feet below ground surface (ft bgs) or less. Dedicated tubing shall be installed prior to ISTR application.
    b) Dedicated bladder pump with compressed air for depth to groundwater greater than 20 feet. Dedicated pumps shall be installed prior to ISTR application.
6) Tubing (installed prior to ISTR application):
    a) Stainless steel and Silicone tubing (Masterflex®) for use with the peristaltic pump. Silicone tubing should be used only above the ground surface at the pump head in order to minimize potential for degradation by contaminants. The silicone tubing is then connected to the previously installed stainless steel tubing.
    b) Dedicated bladder pumps and tubing if using a bladder pump. Reminder: bladder pumps should have been installed prior to the start of ISTR operations.
    c) Caution – Once ISTR heating begins; wellhead access is prohibited without prior TRS management approval. See **Section 2.0** for details regarding the administrative process for monitoring well wellhead removal.
7) Cooler with ice, (one to two 10-pound bags of ice).
8) 10-ft length of ¼-inch (outside diameter) stainless steel tubing.
9) One-ft length of four-inch diameter pipe.
10) Tray or container for ice bath.
11) Field water quality measuring equipment w/flow-through cell or similar device for monitoring groundwater parameters (pH, conductivity, ORP, temperature, DO, etc.) and calibration standards.
12) Turbidity meter.
13) Buckets for purge water.
14) Sample containers (with preservative as required by the laboratory analytical method), labels, and chain-of-custody forms (as required by the laboratory for the analysis). Pre-printed labels are generally available from the laboratory if requested in advance.
15) Scissors or tubing cutter (for cutting tubing lengths).
16) Packaging material and shipping labels.
17) LOTO equipment as described in TRS SOP 1.1.

5.0 HOT GROUNDWATER SAMPLING PROCEDURES

Groundwater purging is generally accepted as a required component of groundwater sampling in order to remove non-representative water from the well casing (Puls and Barcelona, 1996). Low-flow purging (or micro-purging) and sampling techniques will be used to minimize the impact on groundwater chemistry and collect representative samples. This technique also reduces the amount of investigation-derived waste (IDW) produced from a well.

Generally, low-flow purging is considered to have been accomplished once the water quality parameters monitored have stabilized to within a 10 percent margin of error. Water quality parameters should be recorded at a frequency of intervals between 3 and 5 minutes until parameter stabilization occurs. The key to successful micro-purging is to minimize draw-down in the monitoring well (less than 0.33 feet). Due to the need for sealed monitoring wells during the thermal remediation process, special care should be administered to purge flow rates. **Purge flow rates are preferred to be between 0.1 and 0.2 L/min whenever possible**.

5.1 Safety Considerations

There are certain hazards associated with ISTR during the remediation of soil and groundwater. These hazards include possible contact with hazardous voltage, steam, hot water, or hazardous chemicals. Exposure to these hazards can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols, such as the following restrictions:

- For sample integrity, ground water sampling is performed while the ISTR power control unit (PCU) is off-line. The ISTR PCU output must be off and LOTO applied.
- Extreme temperatures, hot water, and steam may be encountered when collecting groundwater samples; the use of the proper personal protective equipment (PPE) is mandatory and caution is advised.
- Dedicated tubing and pumping systems shall be established prior to application of electrical energy to the subsurface.
- Refer to the site-specific Sampling and Analysis Plan (SAP) and HASP for site-specific requirements and restrictions.
- Personnel shall be trained on hazards and engineering controls associated with hot groundwater and potentially pressurized wells prior to sampling. Potential hazards include steam, hot groundwater, hot mud/soil, heated sampling equipment. Personnel should also be familiar with general site hazards identified in the site-specific HASP.

Refer to the site-specific Sampling and Analysis Plans (SAPs) and HASP for site-specific requirements and restrictions.

Caution: Exposure to hot groundwater and steam possible

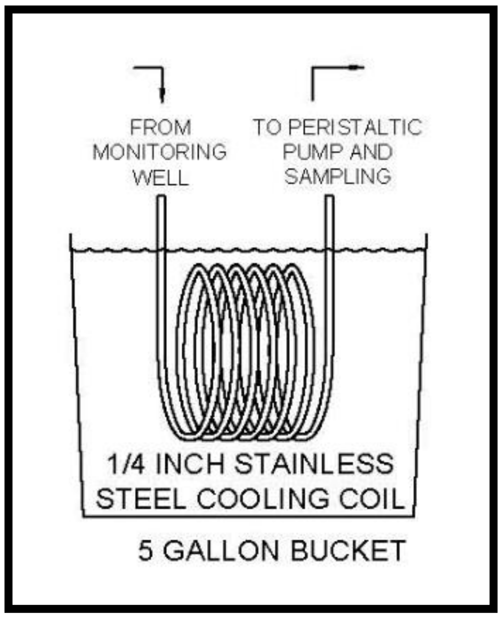
The removal of water and from a groundwater monitoring well can change the temperature/pressure conditions existing in the well by reducing the hydrostatic head in the well allowing hot water and steam to flash within the monitoring well casing. Improper sealing of the monitoring well wellhead may produce steam or hot groundwater leaks at the connection point.

5.2 Ice Bath Construction

Groundwater heated through the thermal remediation process presents both a potential safety hazard and a potential concern for collecting representative samples. If a boiling or near-boiling liquid is collected in a volatile organic analysis (VOA) vial, the formation of air bubbles as the sample cools within the VOA vial renders the sample non-representative. Additionally, hot liquids collected in the VOA vial may result in failure of the VOA septum.

The ice bath is designed to cool the groundwater prior to sample collection while limiting the impact on groundwater chemistry and contaminant concentrations. Cooling the groundwater prior to sample collection allows for both the safe handling of highly elevated water temperatures and prevents the formation of volatile organic compound (VOC) bubbles in the VOA vial after sample collection.

Prior to initial sampling, a cooling coil shall be constructed by wrapping a 10-ft length of ¼-inch outside diameter stainless steel tubing 6 full turns around a 4-inch diameter pipe. The ends of the tubing shall be fashioned such that both ends of the tubing extend upward, as shown in the figure below.



5.3 Pumps

Peristaltic pumps are used for purging and sampling wells that have a depth to water of 20-ft bgs or less. During the construction of the ISTR system, a dedicated ¼-inch sample tube will be set within the well and a ¼-inch stainless steel sample valve will be installed in the surface well cap for sampling with a peristaltic pump. Prior to commencing any ISTR operations, the well caps will be inspected for proper construction and installation and the well cap should not be removed during ISTR operations and/or sampling. Installation of the sample valve is mandatory in order to prevent steam from escaping from the well during ISTR application.

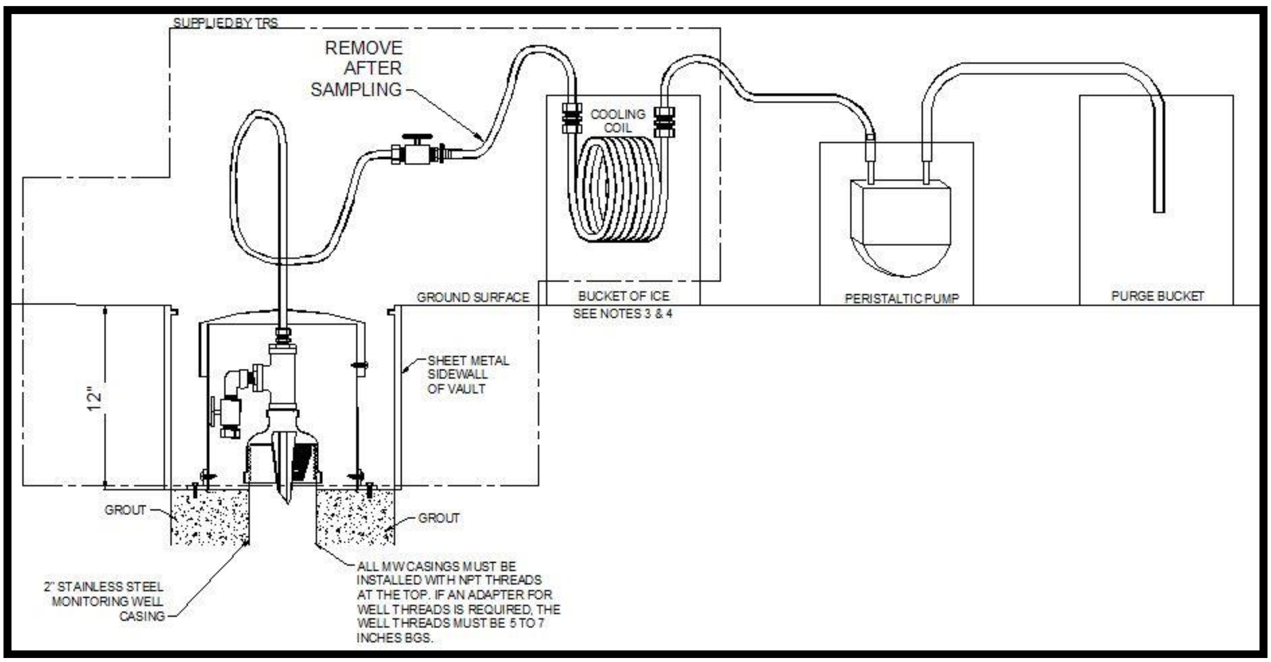
Pneumatically operated bladder pumps will be used for purging and sampling wells that with depth to water greater than 20 feet. The well head completion will be modified to allow for two tubes to pass independently through the sealed well head assembly. One tube will be used to deliver compressed air to the pump and the other tube will be used for sample recovery.

Either dedicated bladder pumps with Teflon® tubing or dedicated stainless steel tubing for use with a peristaltic pump will be installed prior to initiating heating of the ISTR treatment volume. The use of pre-installed, dedicated sample equipment will reduce the risk of exposure to steam, hot water, or contaminants, since the well head will not have to be opened.

Refer to the site-specific work plan or client directives on specific placement/depth of the sample tubing intake or dedicated pump in monitoring wells.

5.4 Well Head Construction

The TRS wellhead construction contains mandatory features that support the safe and representative collection of groundwater samples on a heated ISTR site. The detailed features of the Groundwater Monitoring Well are shown below.



This monitoring well head design provides the ability to collect groundwater samples from a screened monitoring well without needing to open the well head increasing exposure to steam and hot water. Once heating has commenced, entry to the wellhead is <u>**prohibited**</u> without TRS senior management approval (see **Section 2.0**).

Please note the relief valve at the well head is for venting purposes and used ***ONLY*** when accessing the interior of the monitoring well becomes necessary. This valve should ***NOT*** be opened prior to sampling as this may change the hydrostatic head pressure within the monitoring well and cause flashing within the monitoring well, resulting in unrepresentative groundwater samples. Should the valve be opened prior to sampling, additional time may be required for the well to stabilize before the collection of groundwater samples. Dependent on groundwater recharge rates, this stabilization period could range from hours to days.

5.5 Sample Collection Approach

For GW sampling, TRS typically extend stainless steel or Teflon™ tubing into the water table connected to a stainless steel, specialty wellhead and collect the groundwater samples by peristaltic pump. The groundwater partially flashes within the sample tube during recovery but the cooling coil re-condenses it so there is no VOC loss since heated GW contains almost zero dissolved gases.

<u>**Do not sample steam and air**</u>

Sampling personnel must be careful to make sure the tube extends fully into the water table to avoid collecting steam and air from inside the well casing. If steam and air are recovered from above the water table, rather than collecting groundwater, it causes the contaminant concentrations in the samples to be much higher than what is actually in the groundwater (opposite of what you would instinctively think). This occurs because there is mostly steam and very little air in the well casing and VOCs volatilize at a higher proportion in the steam. When the steam is condensed, it shows much higher concentrations than are typically in the groundwater. For example, 1 part per million (ppm) trichloroethene (TCE) in groundwater will boil to create steam that contains about 0.6 milligrams (mg) of TCE per liter of steam, but that one liter of steam condenses to only 0.6 mL of water so when that steam is condensed it can make it appear like the groundwater contains 1,000 mg/L of TCE rather than 1 mg/L. When the stainless steel or Tefon™ tube is submersed in the groundwater, the data are very comparable to that of water collected by submersible pump. However, flashing can occur throughout the entire depth of a monitoring well, so unusually high VOC concentrations can still be obtained by sampling a well by pumping too quickly or reducing the head in the well too dramatically when the sample collection point is well below the groundwater elevation. Sampling at a slow rate with as small of a volume removal as practicable from the wells will help produce quality samples.

5.6 Groundwater Sampling

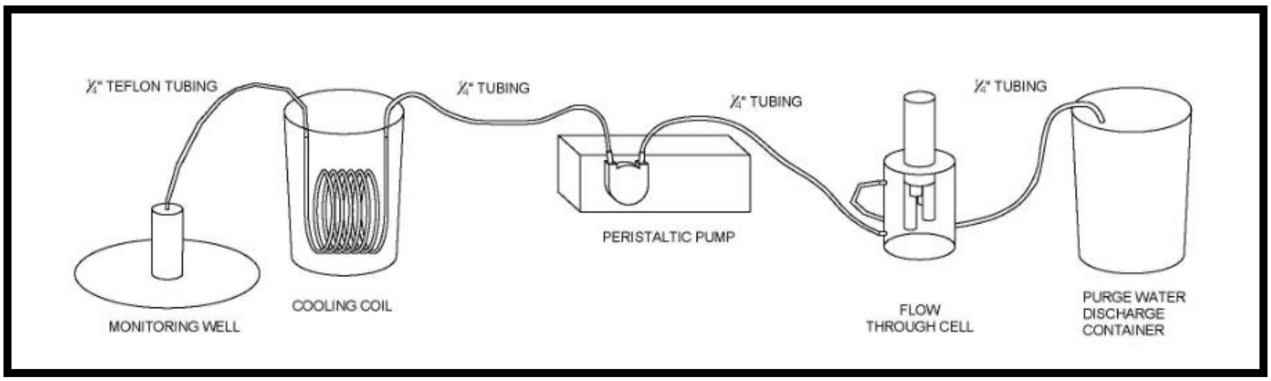
The TRS project team must coordinate, in advance, with all applicable parties to schedule an interruption to the ISTR application. The PM and SHSO shall determine a site-specific interruption period. Sampling shall be completed in order from the wells having the lowest anticipated concentrations of contaminants of concern (COC) to wells having the highest anticipated COC concentrations (usually from exterior wells to boundary control wells to wells located within the source area).

The groundwater sampling procedure is as follows:

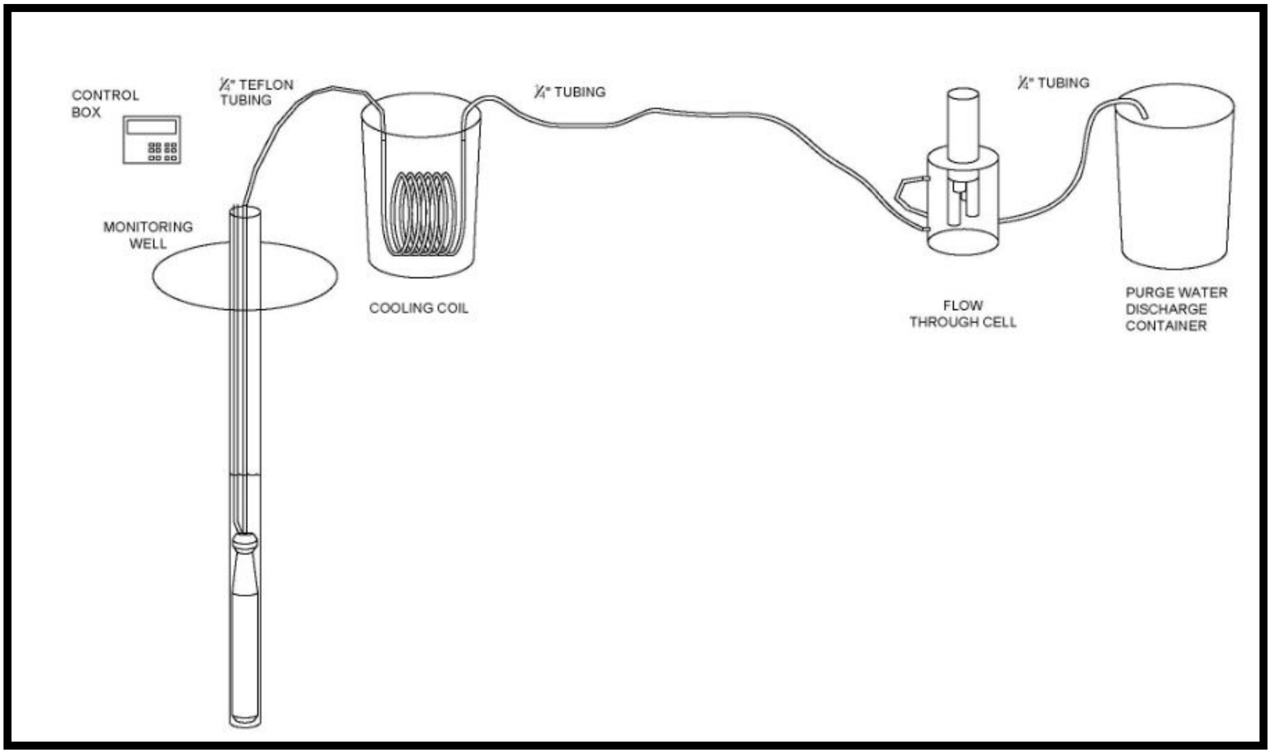
1) Calibrate probes used to monitor water quality parameters according to the manufacturer's instructions (as necessary). Calibration frequencies should adhere to the manufacturer's recommendations. Document all calibrations done to the probes used. Documentation should include: date, time, calibration solutions used, solution expiration dates, solution lot numbers, calibration results, outliers, and any illuminating comments.
2) Cease ISTR application to the treatment volume and perform LOTO procedures on the ISTR PCU as required by site-specific protocols. Note: LOTO application shall only be completed by personnel who have been trained and certified by TRS in accordance with SOP 1.1.
3) Connect ¼-inch sample tubing from the valve on the well to the cooling coil and place the coil in a bucket or cooler with ice to form the ice bath as described in **Section 5.2**.

4) Connect the pump to the cooling coil. For wells with a depth to water less than 25 feet, connect the cooling coil and peristaltic pump to the monitoring wellhead. For wells having a depth to water greater than 25 ft bgs, connect pump controls to the previously deployed bladder pump and connect the cooling coil and compressed air source. An in-line filter is only required for specific analyses (typically for dissolved metals analyses). Please confirm with laboratory for specific sample requirements.
5) Connect the cooling coil discharge tubing to a flow-through cell with the calibrated meter probes/sensors securely held in the flow-through cell.
6) Connect tubing from the discharge of the flow-through cell to the purge water collection bucket. For monitoring wells with low recharge rates, discharge purge water into a graduated cylinder (500 – 1,000 mL) for more accurate recording of purge rate and volume.

PUMPING SET-UP WITH PERISTALTIC PUMP



PUMPING SET-UP WITH SUBMERSIBLE PUMP



7) Begin purging the well at a low flow rate. Target pumping rates should generally be in the order of **0.1 to 0.2 L/min** to ensure stabilization of parameters and reduce mixing of formation water with stagnant well casing water. (Puls and Barcelona, 1996). If the pump must be temporarily operated at a higher flow to prime the system or maintain flow, the adjustment to the pumping rate is best made within the first 15 minutes of purging. The flow rate should remain constant during parameter stabilization monitoring.
8) The pumping rate is recorded on purge data sheets every 3 to 5 minutes during purging. Any adjustments to the pumping rate are recorded. At the initiation of well purging and after recording pumping rates, water quality parameters are measured and recorded with a multi-parameter water quality meter equipped with a flow-through cell. The measured water quality parameters are temperature, turbidity, specific conductance, pH, DO, and oxygen reduction potential (ORP or Redox). Pumping shall continue until the water quality parameters have stabilized (refer to **Section 5.6.1**). Hot water should generally contain a very low DO value and a negative ORP. If high DO or high ORP are observed, it could be an indicator that air is being introduced into the sample line.
9) After all water quality parameters have stabilized (refer to **Section 5.6.1**) sampling may begin. If all parameters have stabilized, but turbidity remains above 10 Nephelometric Turbidity Units (NTUs), decrease the pump rate and continue monitoring. If the pump rate cannot be reduced and turbidity remains above 10 NTUs, the information will be recorded and sampling initiated. For low yield wells, contact TRS Engineering group for evaluation and instructions for sampling.
10) Disconnect the tubing from the inlet side of the flow-through cell. The tubing from the pump outlet will be used to fill the groundwater sample vials. Samples for VOCs shall be collected first followed by semi-volatile organic compounds (SVOCs). All other parameters should be collected in order from most volatile to least.

11) Groundwater samples including quality control (QC) samples are labeled and preserved per the site-specific Sampling and Analysis Plan (SAP).
12) All pertinent information will be documented in the sample log book and on the chain-of-custody forms including: date, time of sample, sample identification, analysis being completed, and any other information deemed relevant to the sample results. The following additional information shall be documented in the sample logbook: time at beginning and end of monitoring well purging, flow rate and any changes during the monitoring well purge, equipment used for monitoring well purge, and water quality parameter readings used to determine sample time.
13) Package and ship samples with a laboratory supplied trip blank to the off-site laboratory for analysis.
14) Flow-through cells used for groundwater sampling effort shall be decontaminated according to manufacturer recommendations. Dispose of decontamination liquids and purge water in accordance with site-specific documents.
15) Following each sampling event, cooling coils should also be decontaminated using Alconox or a similar detergent with the peristaltic pump.

5.6.1 Water Quality Parameters

Readings are recorded on the purge data sheets every 3 to 5 minutes or at volume measurement intervals for monitoring wells with low recharge rates. Field parameters are monitored until stabilization occurs. Unless local regulatory requirements differ, readings are generally considered stable when three consecutive readings are within the following criteria:

- Specific conductance readings within 3 percent
- Redox potential within 10 millivolts (mV)
- pH within +/-0.1 standards units
- Turbidity and DO readings within 10 percent

5.6.2 Pump Assisted Grab Sample

To collect representative groundwater data, it is **critical that steam is not collected** during sampling. If steam is inadvertently sampled, the analytical results will be biased high. Geochemical parameter monitoring will provide indicators of whether steam is sampled. As the treatment volume reaches steaming conditions, DO concentrations in groundwater should be essentially zero. DO readings are therefore expected to reflect this but may be slightly higher as there can be sensor limitations. As the flow cell is nearly full, it should be tilted to remove any potential air bubbles. If elevated DO readings are observed, this is an indication that steam may have been sampled and the data may **not** be representative of groundwater. Significant swings in conductivity or a sudden drop in conductivity can also be an indication of steam influences that may impact the data quality.

If during the ISTR process, depth to groundwater levels have dropped and conditions do not allow for a representative sample to be collected (i.e., pumping activities draw down groundwater level below the sampling tube inlet), the following procedures will be used to sample the well and allow for recharge. Please note that this procedure cannot be followed if subsurface temperatures are indicative of steam generation occurring within the ISTR treatment volume. This method will recover steam if steam is present in the formation surrounding the monitoring well.

Pump Assisted Grab Sample Procedure:

1) A column of water is drawn in the cooling coil tubing with the pump.
2) The well sample valve and the peristaltic pump inlet valve are closed and the pump shut off.
3) The cooling coil is disconnected from the well sample valve.
4) The cooling coil is carefully removed from the ice bath.
5) The pump inlet valve is opened.
6) The sample is decanted into the sample vials from the pump end of the tubing via gravity flow.

The process is repeated until the sample volume is collected. Any other sample fractions (cations, anions) are sampled from the well end of the cooling coil tubing. It is important to note sampling with this procedure may not provide sample results representative of the formation. In addition, field notes/datasheets should explicitly detail all activities and actions when using this procedure.

6.0 RESPONSIBIITIES

TRS Safety & Quality Manager	• Develop and implement SOPs • Provide training and maintain training documentation. • Assist SHSO with modifying SOP to meet site-specific HASP and SAP requirements. • Work with PM to develop AHA for any intrusive work required to complete groundwater sampling efforts. • Periodically review and update procedures based on project feedback.
Project Manager	• Review procedures in conjunction with site-specific SAP requirements and scope of work (SOW). Coordinate changes to procedures as necessary. • Schedule and coordinate sampling effort. Ensure adequate supplies are available. • Work with HSO to develop AHA for any intrusive work required to complete groundwater sampling efforts.
Site Health & Safety officer	• Conduct orientations for subcontractors and employees. • Coordinate training needs with TRS SQM. • Review procedures in conjunction with site-specific HASP. Coordinate changes to procedures as necessary to maintain safe working procedures.
Sampling Personnel	• Complete training to the level of competent person prior to initiating sampling activities. • Follow procedures and document information related to groundwater sampling effort as identified in this SOP, including and deviations from the SOP.

7.0 TRAINING

Training in SOPs is provided upon initial assignment and annually thereafter. Practical training is provided on a project-specific basis. Additional retraining is provided if there is a change in procedures or if inadequacies are observed in the individual's application of procedures.

Competent persons in hot groundwater sampling are determined by the project PM and SHSO and must, at a minimum, complete the following requirements:

- Read this SOP (SOP 3.1) and understand the general process and the specific requirements of this SOP.
- Sign the training acknowledgement form.
- Obtain on-site instruction by a knowledgeable person on the task-specific hazards associated with hot groundwater sampling and the methods used to control these hazards.
- Obtain on-site instruction by a knowledgeable person on important technical components of the hot groundwater sampling program to ensure the collection of representative samples.

8.0 RECORD KEEPING

These are standard (i.e., typically applicable) procedures which may be varied or changed as required, dependent on-site conditions, equipment limitations, permit requirements or limitations imposed by the procedure. The ultimate procedures used during any sampling event, including any deviations from these procedures, shall be documented in the sample logbook. AHA's developed for any intrusive work conducted in conjunction with this SOP shall be maintained with the groundwater sample logbook.

Calibrations of water quality meters used to measure water quality readings shall be completed according to the manufacturer's recommendations. Calibration results shall be maintained in a written log kept at the site throughout the operational phase of the project.

At a minimum, the following information shall be maintained in the sample logbook related to well purging and groundwater sample collection:

1) Date
2) Sample/purge location identification
3) Type of pump used for well purge
4) Duration of well purge
5) Sample time
6) Flow rate (including changes throughout purge)
7) Meter(s) used for collection of water quality parameters and calibration documentation
8) Water quality parameter readings
9) Volume of purge water collected prior to sampling
10) Sample identifications and analysis to be performed
11) Chain-of-custody number
12) Shipping information
13) Procedures used for equipment decontamination
14) Deviations from this SOP

15) Any other information deemed relevant to the sample results

Copies of chain-of-custody forms and shipping documentation shall be maintained and kept with the sample log book.

9.0 REFERENCES

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, EPA/540/S-95/504.

Yeskis, Douglas and Zavala, Bernard, 2002, Ground Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA/542-S-02-001.

Vail, Jonathon, France, Danny, and Lewis, Bobby, 2013, SESD Operating Procedure Groundwater Sampling, EPA Region 4/SESDPROC-301-R3.

Environmental Protection Agency – Region 1, 2017, Low Stress (low flow) Purging and Sampling Procedure For The Collection Of Groundwater Samples From Monitoring Wells, EQASOP-GW4, Revision Number: 4.

Revision Record

SOP 3.1 Hot Groundwater Sampling

Training Acknowledgment

All personnel that receive training on this procedure will review and sign the acknowledgement form contained in this section.

I have been trained by TRS Group, Inc. (TRS) to perform non-intrusive hot groundwater sampling at ISTR project sites. By signing this document, trainee acknowledges that SOP 3.1 Hot Groundwater Sampling has been read and the contents of the document are understood. Trainee has received hands-on training from a competent person who is authorized to use and instruct others on sampling procedures at TRS project sites.

Date	Trainee (print)	Trainee (Sign)	Trainer

Revision Record

Date	Initials	Revision Description	Revision #
04/14/09		Update format, include pictures	2
06/27/09	LS	Add Scope, responsibilities, training, definitions, Recordkeeping, and new procedures	3
06/25/10	LS	Update Drawings	4
07/27/12	LS	Review and update SOP; changes to pump usage	5
12/15/14	TP	Annual Review, MW access caution	6
12/4/17	GK	Annual review; procedure updates	7
12/02/19		Annual Review, changed sample rate to 0.2 L/m, added steam reference	8

SOP/ Revision #	Safety & Quality	Engineering
Original	4/22/08	4/22/08
REV 2	4/14/09	4/14/09
REV 3	6/27/09	6/27/09
REV 4	6/25/10	6/25/10
REV 5	7/27/12	7/27/12
REV 6	1/21/16	1/21/16
REV 7	12/4/17	12/4/17
REV 8	12/2/19	12/2/19

	STANDARD OPERATING PROCEDURE	PROCEDURE No: 3.2

Procedure Title:

HOT SOIL SAMPLING

Author:	TRS Team	**Issue Date:**	4/22/08

Revisions:

Date	Initials	Revision Description	Revision #
01-04-10	LS	Add Scope, responsibilities, training, definitions, recordkeeping	1
5-6-14	TP	Added caution concerning hot water, steam expulsion	2
2-22-16	TP	Review, revised power off requirement	3
12-4-17	GK	Removed Geoprobe® Dual-Tube Sampler reference and revised determination for use of Teflon liners.	4
12-02-19	GK	Added section on hot sampling with sonic drill rig	5

Reviewed and Approved by (initial and date):

SOP/ Revision #	Safety & Quality		Engineering	
Original	4/22/08		4/22/08	
REV 1	1/4/10		1/4/10	
REV 2	5/6/14		5/6/14	
REV 3	2/24/16		2/22/16	
REV 4	12/4/17		12/6/17	
REV 5	[signature]	12/2/2019	[signature]	12/2/2019

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide a procedure for the safe collection of representative soil samples during, or after, the application of *in situ* thermal remediation (ISTR) technologies.

2.0 SCOPE

This SOP serves as a guideline for the collection of soil samples during, or after, the application of ISTR. To minimize the risk due to electrical hazards, lockout/tagout (LOTO) procedures must be applied to the ISTR power control unit (PCU) throughout the duration of the soil sampling effort. Only authorized persons trained in procedures and requirements described in SOP 1.1 are permitted to conduct LOTO on TRS equipment. Samples collected using this SOP are generally used for evaluating treatment effectiveness, and/or confirming treatment goals have been met.

TRS Group, Inc. (TRS) personnel shall use this procedure in conjunction with site-specific sample analysis plans and permit requirements. These are standard (i.e., typically applicable) operating procedures, which may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements, or limitations imposed by the procedure. The ultimate procedures, including any deviations from this SOP, shall be documented in the soil sampling form.

3.0 DEFINITIONS

Authorized Employee

Any designated employee who locks out or tags out equipment to perform servicing or maintenance. This person must have completed the mandatory LOTO training described in SOP 1.1 LOTO to be qualified as an authorized worker. Only an authorized worker installs and removes his or her own lock and tag as required by this program.

Competent Person

Any designated employee who has been trained in proper procedures for the application of ISTR to the subsurface at remediation sites.

ISTR – In Situ Thermal Remediation

A process whereby soil and groundwater are heated to the desired temperature to volatilize the target contaminants. Some ISTR technologies are electrical resistance heating (ERH), thermal conduction heating (TCH), and steam enhanced extraction (SEE).

LOTO – Lockout/Tagout

The practice of using a tag for visibility and awareness in conjunction with placement of a keyed device ("lock") on an energy isolating device, in accordance with SOP 1.1, to prevent the unwanted activation of mechanical or electrical equipment. Lockout ensures the equipment being controlled cannot be operated until the lock is removed.

4.0 EQUIPMENT LIST

1) Soil Sampling Field Form and pen (recommend indelible).
2) Drill rig and related equipment. Soil sampling is best achieved using a direct push drill rig such as a Geoprobe®. Alternative types of drilling methods are hollow stem auger (HSA) or rotosonic (sonic).

3) Ice bath for soil samples. An example is a cooler filled with ice. The cooler (or container) must be equipped with an opening at the bottom to allow water from melting ice to drain.

4) Standard cooking thermometer. Calibrated to both zero (0) degrees Celsius (°C) and 100°C (an infrared thermometer can be substituted when sampling denser soils or bedrock. Keep in mind the sample tube will likely be a few degrees cooler than the internal temperature of the sample).
5) LOTO equipment as described in TRS SOP 1.1.
6) Sample containers, labels, and chain-of-custody forms (as required by the laboratory for the analysis).
7) Safety Glasses with side shields. Additional option: full face-shield (wear over safety glasses).
8) Hearing protection adequate for sampling equipment decibel level. Refer to site-specific Health and Safety Plan (HASP).
9) Latex or nitrile gloves. Additional option: cotton or leather outer gloves (wear over inner latex gloves).
10) Site-specific personal protective equipment (PPE) requirements. Refer to site-specific HASP.
11) Packaging material, chain-of-custody seals, and shipping labels.

5.0 HOT SOIL SAMPLING PROCEDURES

A soil-sampling event begins with the shutdown and application of LOTO to the PCU. This is done to prevent any electrical hazards between the steel drill string and sampling personnel. The vapor recovery system should continue to operate to maintain capture of steam in the subsurface, rather than allowing it to exit through the sample borehole. Interim and final soil sampling is best achieved using a direct push drill rig such as a Geoprobe®. As the probe casing is extracted from the subsurface, it should be considered to be very hot, and handled with proper precaution and personal protective equipment.

Choose a sample sleeve compatible with the conditions being encountered. For example, if the sample location temperature is elevated above 100°C, then a stainless steel sleeve will be a better choice than a Teflon sleeve as the Teflon sleeve will become soft and deform at elevated temperatures. Consult engineering for the appropriate sleeve. Teflon sleeves are only recommended for sampling when expected subsurface temperatures will be at or below 70°C.

Note: sample sleeves can be custom fabricated if supplier inventories are inadequate. Please contact equipment@thermalrs.com *if additional resources are needed to procure sampling sleeves.*

5.1 Safety Considerations

There are certain hazards associated with the application of ISTR to contaminated soil and groundwater. These hazards include possible contact with hazardous voltages, steam, hot water, hot soil, other hot surfaces, and/or hazardous chemicals. Exposure to these hazards can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols such as the following restrictions:

- The ISTR PCU system must be turned off and LOTO applied during soil sampling activities. Only trained and authorized TRS personnel can perform LOTO of ISTR equipment.
- High temperatures, hot water, and steam may be encountered when collecting subsurface soil samples; the use of the proper PPE is mandatory and caution is advised.
- Contaminant vapors may be present at the borehole during sampling.
- Personnel shall be trained on hazards and engineering controls associated with drilling before beginning sampling operations. Potential hazards include rotating equipment, overhead loads, and slips trips and falls.

Refer to the site-specific Sampling and Analysis Plan (SAP) and HASP for site-specific requirements and restrictions.

Caution: Exposure to hot groundwater and steam possible

The removal of water and soil from the sample borehole can change the temperature/pressure equilibrium conditions existing within the borehole prior to drilling and sampling by reducing the hydrostatic head in the borehole, allowing hot water and steam to eject from the borehole. Review the site conditions prior to commencing drilling or boring. If sampling soil beneath the groundwater surface level elevation, always remove the boring equipment and samples slowly from the boring to allow the borehole conditions to safely re-equilibrate.

Stop and complete the attached Site Sampling Evaluation Checklist before proceeding with this procedure.

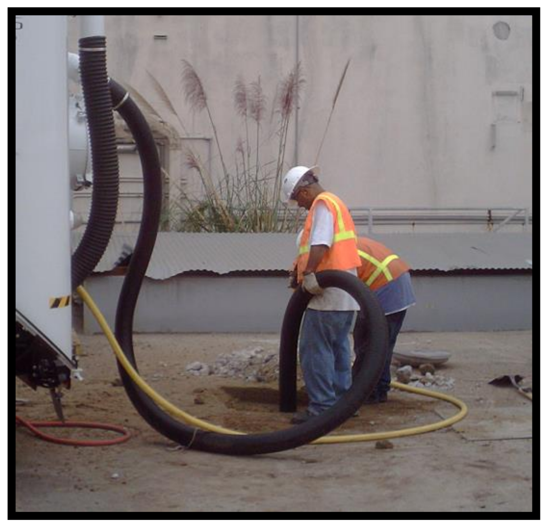
5.2 Hot Soil Sampling Procedures

Whenever possible, sampling shall be completed in order from sample locations having the lowest anticipated concentrations of contaminants of concern (COCs) to locations having the highest anticipated COC concentrations (i.e.; outside treatment area, treatment area boundary, locations within the source area). The steps outlined below must be followed for iterative, interim, and/or final hot soil sampling.

Contact the TRS Project Manager (PM) the day prior to sampling to coordinate a shutdown. A shutdown period of 4 hours is preferred prior to soil sampling.

1) An authorized person shall apply LOTO to the ISTR PCU by site-specific instructions. Note: Only personnel who have been trained and certified by TRS in LOTO procedures can complete this procedure.
2) Position drill rig in the area to be sampled and perform a visual check for any safety concerns. Potential concerns include: high voltage lines, uneven terrain, underground utilities, and egress limitations with rig placement.


3) Hand auger or air knife the first five (5) feet of the boring to clear the location for potential buried utilities.

4) Advance the push sampler to the depth required and collect samples. If subsurface temperatures are expected to be greater than 70°C, the sample sleeves used must be made of brass or stainless steel. Sample sleeves made of acrylic or other materials can melt and bias sample results.

5) The sample sleeves must be capped immediately and placed into the ice bath to begin the cool-down process. Water from melting ice must be allowed to drain, as the sample sleeves should not be submerged at any time.

6) The sample sleeves should be cooled until the soil nears ambient temperature (approximately 20°C or 70 degrees Fahrenheit [°F]). A standard cooking thermometer can be inserted through the end cap for temperature monitoring. The sample sleeve may be opened and sampled once near-ambient temperatures have been reached. Soil samples, including quality control (QC) samples, are collected, labeled, preserved, and shipped per the site-specific SAP.
7) Plugging/sealing of the soil borehole will be in accordance with Federal, State, and/or Local regulatory and client requirements.
8) Soil cuttings not consumed in the sampling process will be disposed of according to Federal, State, and/or Local regulatory and client requirements.

6.0 Hot Soil Sampling Using Rotosonic Method

The procedures for hot soil sampling with a Sonic rig are similar to the steps outlined in **Section 5.2**, except for the following deviations:

- Sonic drilling methods produce large soil cores, 4 to 6 inches in diameter. Cool the cores in a large trough of ice, with drainage of melt water. Ice consumption may range from 500-1,000 pounds per day depending on soil temperature, ambient temperature, and soil core production rate.
- In ambient temperature soil conditions, Sonic drilling methods use a low-density polyethylene (LDPE) sleeve to recover soil cores from the Sonic rig sample apparatus. The LDPE bags used for

this method of sample retrieval are typically only rated for temperatures below 90°C, therefore liners must be used with additional precautions:

  - Cool the exterior of the sonic barrel with a garden hose prior to contact with the LDPE liner and extraction of the soil core. It is recommended to double-bag hot soil cores in the LDPE liners. Have an ice bath ready for immediate cooling of the soil cores.
  - Direct contact with ice below and above the bagged soil core cools the soil cores in approximately 1 hour. Additional plastic may be preferred to further eliminate risk of cross contamination but does slow the cooling rate.

- For sampling at ISTR sites where soil temperatures are greater than 90°C, lexan polycarbonate liners (or equivalent) are an alternative. Lexan polycarbonate is rated to approximately 130°C.
- Some subsurface conditions may make the lexan polycarbonate liners prohibitive.
- Verify with the drilling subcontractor that a second sample core barrel is available to maintain production while the first sample core barrel is cooling and during core extraction.
- Extreme caution will be exercised in cutting the lexan polycarbonate liners when the soil core is ready to be sampled.

7.0 RESPONSIBILITIES

Role	Responsibility
VP Operations	• Develop and implement SOPs • Periodically review and update procedures based on project feedback • Provide training and maintain training documentation
TRS Safety & Quality Manager	• Assist VP Operations with providing training and maintaining training documentation. • Assist Site Health and Safety Officer (SHSO) with modifying SOP to meet site-specific HASP requirements.
PM	• Review procedures in conjunction with site-specific sample requirements and scope of work (SOW). Coordinate changes to procedures as necessary. • Schedule and coordinate sampling effort. Ensure adequate supplies are available.
SHSO	• Conduct orientations for subcontractors and employees • Coordinate training needs with TRS SQM • Review procedures in conjunction with site-specific HASP. Coordinate changes to procedures as necessary to maintain safe working procedures.
Sampling Personnel	• Complete training to the level of competent person prior to initiating sampling activities. • Follow procedures and document information related to soil sampling effort as identified in this SOP, including and deviations from the SOP.

8.0 TRAINING

Training in SOPs is provided upon initial assignment and annually thereafter. Additional retraining is provided if there is a change in procedures or if inadequacies are observed in the individual's application of procedures. Subcontractors must train their own employees. LOTO training requirements for personnel are outlined in SOP 1.1.

9.0 RECORD KEEPING

These are standard (i.e., typically applicable) procedures, which may be varied or changed as required dependent on site conditions, equipment limitations, permit requirements, or limitations imposed by the procedure. The ultimate procedures used during any sampling event, including any deviations from these procedures, shall be documented in the sample logbook.

At a minimum, the following information shall be maintained in the sample logbook related to hot soil sampling at ISTR sites:

- Date
- Sample identification and corresponding location
- Sample time
- Sample identifications and analysis to be performed
- Chain-of-custody number
- Shipping information
- Deviations from this SOP
- Any other information deemed relevant to the sample results

Copies of chain-of-custody forms and shipping documentation shall be maintained and kept with the sample logbook.

10.0 REFERENCES

TRS Group, Inc., 2013. SOP 1.1, Lockout/Tagout (LOTO), Most Recent Version.

US EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Most Recent Version (Method 5035)

SOP 3.2 Hot Soil Sampling

Training Acknowledgment

All personnel that receive training on this procedure will review and sign the acknowledgement form contained in this section.

I have been trained by TRS Group, Inc. (TRS) to perform hot soil sampling at TRS ISTR project sites. By signing this document, trainee acknowledges that SOP 3.2 Hot Soil Sampling has been read and the contents of the document are understood. Trainee has received hands-on training from a competent person who is authorized to use and instruct others on sampling procedures at TRS project sites.

Date	Trainee (print)	Trainee (Sign)	Trainer

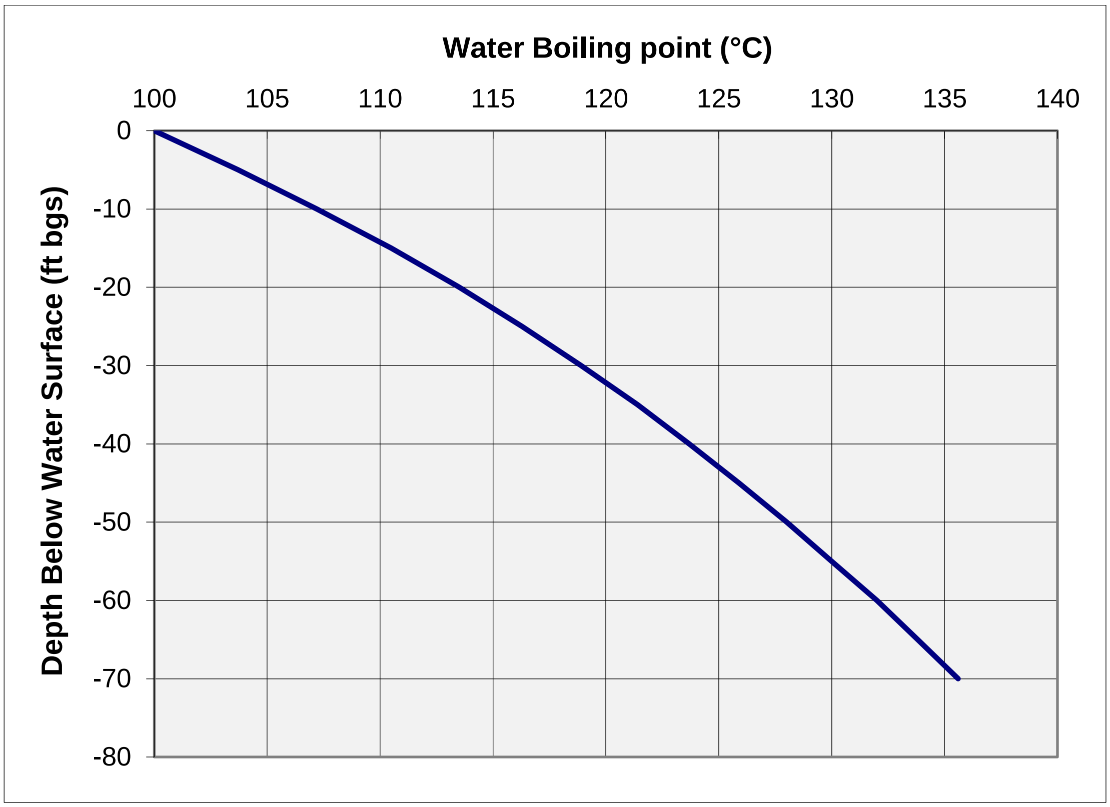
Site Sampling Evaluation Checklist

Project #: _________________

Date: _____________________

Subsurface Conditions

1) Are soil samples being recovered from beneath the groundwater surface?
2) What is the depth to groundwater at the time of sampling?
3) How deep below the groundwater surface elevation are we sampling?
4) What are the current temperatures at or near each boring location?
5) Are there confining layers on site? Clay or silt over saturated zone sand for example.
6) Use the figure below to determine where the sites actual temperatures fit on the boiling point curve.



7) Actual temperature for each depth elevation that is higher in value than the temperatures represented by this curve suggest a temperature value greater than the hydrostatic boiling point of water.

	STANDARD OPERATING PROCEDURE	PROCEDURE No: 3.11

Procedure Title:

Hot Groundwater Sampling-DPT

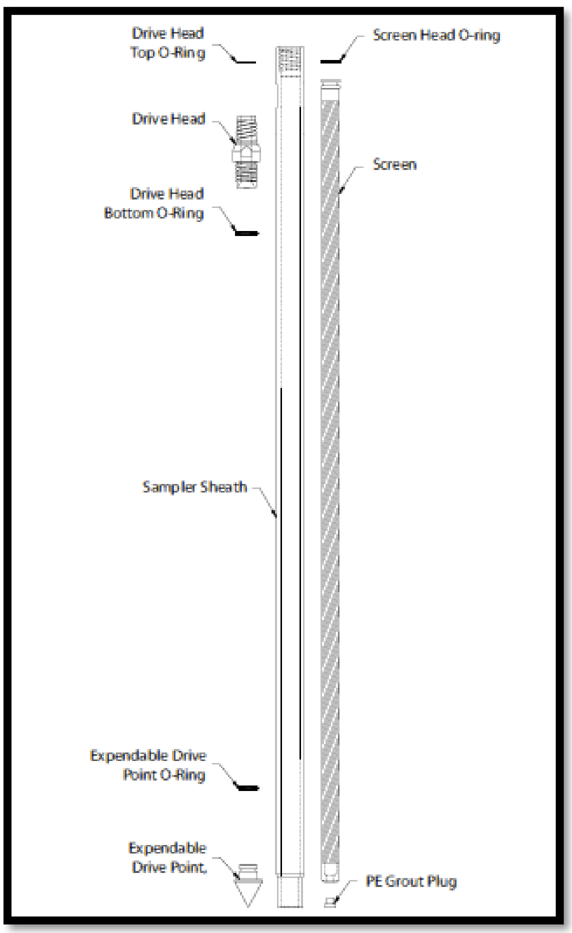
Author:	TRS Team	**Issue Date:**	8/4/16

Revisions:

Date	Initials	Revision Description	Revision #

Reviewed and Approved by (initial and date):

SOP/ Revision #	Health & Safety		Operations	
Original		8/4/2016		8/4/2016



1.0 PURPOSE

This standard operating procedure (SOP) provides uniform procedures for the safe collection of representative groundwater samples during or after the application of Electrical Resistance Heating (ERH) using direct push technology (DPT) to advance the sample screen to the desired depth. This procedure specifically addresses sampling of groundwater that has been heated during the ERH process.

2.0 SCOPE

This SOP provides guidance for the collection of groundwater samples during the application of ERH using modified low-flow sampling procedures in conjunction with the DPT screen advancement method. This SOP draws information primarily from the United States Environmental Protection Agency's (USEPA's) groundwater issue paper, Low-Flow (minimal drawdown) Ground-Water Sampling Procedure (Puls and Barcelona, 1996). Modifications to the EPA methodology have been made to accommodate groundwater temperatures that have been elevated as a result of ERH application. Only personnel trained to the minimum requirements outlined in Section 7.0 of this SOP are authorized to collect hot groundwater samples using this SOP.

The USEPA guidance document recommends continual monitoring of water levels during the purge and sample process to ensure that minimal drawdown is occurring (Puls and Barcelona, 1996). Due to the safety hazards associated with driving DPT sampling apparatus into the subsurface where heated groundwater is present, groundwater level measurements (depth to groundwater) will not be collected as part of hot groundwater sampling activities.

These procedures assume that new tubing will be used for each sample location. Samples collected using this SOP are generally used for optimizing system performance or may also be used for regulatory compliance and/or Site closure.

TRS Group, Inc. (TRS) personnel shall use this procedure in conjunction with site-specific Health and Safety Plans and any applicable sample analysis plans and/or permit requirements. These are standard (i.e., typically applicable) operating procedures that may be varied or changed as required, dependent on site conditions, equipment limitations, permit requirements, or limitations imposed by the procedure. The ultimate procedures, including any deviations from this SOP, shall be documented on the groundwater sampling form.

Since the procedure to drive a DPT sampling screen into the subsurface is similar to soil sampling procedures, under no circumstances will intrusive activities occur while ERH electrical power is being applied to the treatment volume. Refer to TRS SOP 1.1 Lockout/Tagout (TRS 2009), TRS SOP 3.2 Hot Soil Sampling (TRS 2008), the site-specific HASP, and consult with the Project Manager (PM) and Site Health and Safety Officer (SHSO) for additional site-specific requirements, restrictions, and/or additional information.

3.0 DEFINITIONS

Authorized employee – Any designated employee who locks out or tags out equipment in order to perform servicing or maintenance. This person must have completed the mandatory LOTO training described in SOP 1.1 LOTO to be qualified as an authorized worker. Only an authorized worker installs and removes his or her own lock and tag as required by this program.

Competent Person – Any designated employee who has been trained in proper procedures for the application of energy to the subsurface at ERH sites. This person must have completed the mandatory training outlined in **Section 7.0** to be qualified as a competent person.

ERH – Electrical Resistance Heating. ERH is a process whereby soils and groundwater are heated by passing an electrical current through the subsurface volume to be remediated.

DPT – a stainless steel and Teflon® *in situ* sampling tool that allows for the collection of representative groundwater samples without the installation of a groundwater monitoring well. The sampling screen is driven to the desired depth using DPT. Once at the desired sampling depth, the sampling screen is exposed and water is extracted from the temporary sampling location via tubing and above grade pump.

LOTO – Lockout/Tagout. The practice of using a tag for visibility and awareness in conjunction with placement of a keyed device ("lock") on an energy isolating device, in accordance with TRS SOP 1.1, Lockout/Tagout to prevent the unwanted activation of mechanical or electrical equipment. Lockout ensures the equipment being controlled cannot be operated until the lock is removed.

Low-Flow Purging – A USEPA approved purge-and-sample method used to minimize stress on the formation (minimal drawdown) which results in less mixing of stagnant casing water with formation water. Additional advantages of using low-flow purging methods include the following:

- Samples are more representative of actual contaminant loading.
- Disturbance at the sampling point is minimal which minimizes sampling artifacts.
- Less operator variability occurs between sampling events.
- Decreased amount of investigation-derived waste (IDW) is produced.
- Need for filtration is reduced.
- Sample consistency is increased.

Flow-rates during low-flow purging/sampling are site-specific, based on hydrology, but are generally in the order of 0.1 to 0.5 liters per minute (L/min). Proper screen location and screen length may impact the effectiveness of low-flow purging. (Puls and Barcelona, 1996)

Multi-probe and Flow-Through Cell – The flow through cell allows for in-line sampling of water quality parameters with a multi-probe to determine stabilization for water sampling. At a minimum, groundwater quality parameters include pH, conductivity, temperature, dissolved oxygen (DO), and turbidity. Examples of multi-probes used for collecting water quality parameters include the Horiba U-22 and YSI 556 (shown below).

Peristaltic Pump – A positive displacement pump used for pumping fluids. Generally, flexible tubing is fitted inside a circular pump casing. A rotor with a number of "rollers", "shoes" or "wipers" attached to the external circumference compresses the flexible tube. As the rotor turns, the part of tube under compression closes thus forcing the fluid to move through the tube.

SHSO – Site Health and Safety Officer

Trip Blank – The purpose of trip blanks it to identify any potential contamination of samples during sample handling and shipment. These blanks are prepared in the laboratory by filling a volatile organic analysis (VOA) bottle with distilled/deionized water. Trip blanks shall accompany shipment of empty bottles to the site and shipment of samples back to the laboratory.

VOA Vials – EPA recommended glass sample containers used to collect liquid samples for laboratory analysis. VOA vials have a nominal volume of 40 milliliters (mL) and are manufactured of clear or amber borosilicate glass. Depending on type of analysis being conducted, the VOA vials may contain small amounts of preservative when shipped from the laboratory. When collecting samples in VOA vials, fill the vial completely full (ensure that a meniscus has formed at the top of the vial before securing the cap) and check that there are no air bubbles in the closed sample. If there is a preservative present, use caution to not overfill the vial.

4.0 EQUIPMENT LIST

The required equipment for groundwater sampling may differ from this SOP based on the requirements set by the local regulatory oversight agency. Typically, the required equipment will be as follows:

1) Groundwater Sampling Field Form and indelible pen.
2) Safety Glasses with side shields and full face-shield (wear over safety glasses).
3) Hot water/Steam protective outer clothing (PVC rain gear is recommended).
4) Cotton Gloves with Latex (or equivalent) over-gloves. Cotton gloves should be worn to protect against water having high temperatures (wear under outer latex gloves). Leather gloves should be worn over sampling gloves when handling hot sampling equipment (i.e., DPT tubes).
5) Site-specific personal protective equipment (PPE) requirements. Refer to site specific HASP.
6) Peristaltic Pump.
7) Direct Push Technology (DPT) drill rig and associated equipment.
8) Geoprobe® SP-16 Groundwater Sampler assembly (or similar) and associated tools and supplies (stainless steel screens for this procedure are mandatory. Polyvinyl chloride (PVC)-type screens are not temperature rated for this application and are not acceptable). Associated equipment includes, but is not limited to:
    a) 1.5-inch probe rods,
    b) Drive and pull caps,
    c) Rod grip pull system,
    d) Drive head,
    e) Expendable drive points,
    f) Extension rods, quick links or couplers, and extension rod handle, and
    g) O-ring service kit.
9) Disposable Teflon™ and silicone tubing (Masterflex™) for use with the peristaltic pump. Silicone tubing should be used only above the ground surface at the pump head in order to minimize potential for degradation by contaminants. The silicone tubing is then connected to the Teflon™ tubing, which is lowered to depth within the DPT drive casing to the sampling screen. Tubing shall be replaced at each sampling location.
10) Power supply (12-volt automotive battery or similar, or portable generator).
11) Cooler with ample supply of ice.
12) 10-ft length of ¼-inch stainless steel or copper tubing.
13) One-ft length of four-inch diameter pipe.
14) Tray, bucket, or cooler for ice bath.
15) Field water quality measuring equipment w/flow-through cell or similar device for monitoring groundwater parameters (pH, conductivity, ORP, temperature, DO, etc.) and calibration standards.
16) Turbidity meter.
17) Empty buckets for purge water.

18) Sample containers (with preservative as required by the laboratory analytical method), labels, and chain-of-custody forms (as required by the laboratory for the analysis). Pre-printed labels are generally available from the laboratory if requested in advance.
19) Scissors or tubing cutter (for cutting tubing lengths).
20) Decontamination water and a non-phosphate detergent for decontamination of DPT sampling apparatus and components after each sample.
21) Packaging material, shipping containers (coolers), chain of custody forms, and shipping labels.
22) LOTO equipment as described in TRS SOP 1-1.

5.0 HOT GROUNDWATER SAMPLING PROCEDURES

A groundwater sampling event with DPT begins with the shutdown and application of LOTO of the ERH PCU in accordance with TRS SOP 1.1. This is required to prevent any electrical hazards between the steel drill string and sampling personnel. DPT sampling is best achieved using a DPT rig such as a Geoprobe® or similar. As the probe casing makes contact with the heated subsurface or is extracted from the subsurface, it should be considered to be very hot, and handled with proper precaution and use of the prescribed personal protective equipment (PPE). In addition, there is the potential for hazardous steam and/or hot water to be expulsed from the borehole due to changes in hydrostatic head of the soil bore during the extraction of advancement casings. To minimize the risk of expulsion of steam/soil/groundwater from the borehole during casing extraction, casing should be extracted at a significantly slower rate than at a non-heated site.

Groundwater purging is generally accepted as a required component of groundwater sampling in order to remove non-representative water from the well casing (Puls and Barcelona, 1996). Low-flow purging and sampling techniques will be used to minimize the impact on groundwater chemistry and collect representative samples. This technique also reduces the amount of investigation-derived waste (IDW) produced from a well.

5.1 Safety Considerations

There are certain hazards associated with ERH during the remediation of soil and groundwater. These hazardous include possible contact with hazardous voltage, steam, hot water, or hazardous chemicals. Exposure to these hazards can be mitigated through engineering controls and strict adherence to documented procedures and safety protocols, such as the following restrictions:

- The ERH PCU system must be turned off and LOTO applied during soil and/or groundwater sampling activities. Only trained and authorized TRS personnel are allowed to perform LOTO of ERH equipment.
- Extreme temperatures and steam may be encountered when collecting groundwater samples; the use of the proper personal protective equipment (PPE) is mandatory and caution is advised.
- Personnel shall be trained on hazards and engineering controls associated with drilling before beginning sampling operations. Potential hazards include rotating equipment, overhead loads, and slips, trips, and falls. Drilling equipment is to be operated only by trained drilling personnel.

- Personnel shall be trained on hazards and engineering controls associated with hot groundwater sampling. Potential hazards include steam, hot groundwater, hot mud/soil, and heated sampling equipment. Personnel should also be familiar with general site hazards identified in TRS SOP 3.1 Hot Groundwater Sampling, and TRS SOP 3.2 Hot Soil Sampling.

Refer to the site-specific Sampling and Analysis Plans (SAPs) and site-specific HASP for site-specific requirements and restrictions.

Caution: Exposure to hot groundwater and steam possible

The removal of water and steam from a DPT sampling screen can change the temperature/pressure equilibrium conditions existing in the subsurface prior to sampling by reducing the hydrostatic head in the borehole, allowing hot water and steam to flash within and along the outside of the sampling apparatus casing.

The stratigraphy of the Site can contribute to this issue. Sites with a semi-confined aquifer condition may present additional hazards because of the influence on hydrostatic head. Extreme caution should be used when driving the DPT sampling assembly into the water table and especially upon removal. The DPT assembly and drive casing should be removed at an extremely slow rate to minimize disturbance to the hydrostatic pressure within the borehole.

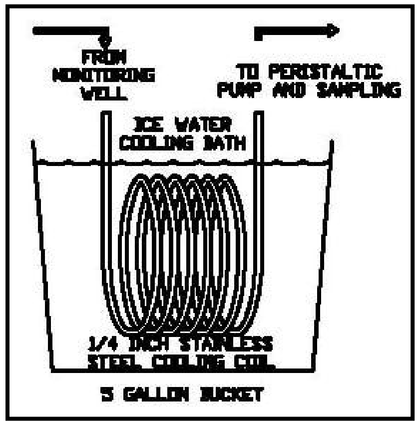
Stop and complete the attached Site Sampling Evaluation Checklist (attached) before proceeding with this procedure.

5.2 Ice Bath Construction

Groundwater heated through the ERH process presents both a potential safety hazard and a potential concern for collecting representative samples. If a boiling or near-boiling liquid is collected in a volatile organic analysis (VOA) vial, the formation of air bubbles as the sample cools within the VOA vial renders the sample non-representative. Additionally, hot liquids collected in the VOA vial may result in failure of the VOA septum.

The ice bath is designed to cool the groundwater prior to sample collection while limiting the impact on groundwater chemistry and contaminant concentrations. Cooling the groundwater prior to sample collection allows for both the safe handling of highly elevated water temperatures and prevents the formation of volatile organic compound (VOC) bubbles in the VOA vial after sample collection.

Prior to initial sampling, a cooling coil shall be constructed by wrapping a 10-ft length of ¼-inch stainless steel or copper tubing 6 full turns around a 4-inch diameter pipe. The ends of the tubing shall be fashioned such that both ends of the tubing extend upward, as shown in the figure below.



5.3 Peristaltic Pumps

Peristaltic pumps are used for purging and sampling wells that have a depth to water of approximately 20-ft bgs or less.

Each sample location will use a section of dedicated Teflon™ tubing for downhole use and a dedicated section of silicone tubing at the peristaltic pump.

The downhole end of the tubing shall be located in the middle or slightly above the middle of the screened interval. Placing the intake in the middle or near the middle of the screened interval, the amount of mixing between the overlaying stagnant casing water with the water within the screened interval is minimized. If the pump-intake is too close to the bottom of the well, increased entrainment of solids may occur. Pump-intake placement should only be used at the top of the water column in unconfined aquifers screened across the water table, where this is the required sampling point.

5.4 DPT Advancement

The TRS project team should coordinate, in advance, with all applicable parties to schedule an ERH system shutdown. The PM and SHSO shall determine a site-specific shutdown period. When possible, sampling shall be completed in order from the sampling locations anticipated to have the lowest concentrations of contaminants of concern (COC) to wells having the highest anticipated COC concentrations (usually from exterior wells to boundary control wells to wells located within the source area).

The TRS project team shall also determine the optimum pathways of approach for situating the DPT rig at the designated sample locations. ERH cabling and vapor recovery piping may need to be disconnected and removed to navigate the DPT rig to the sample locations. Interruption to the vapor recovery system may be required if removal of a section(s) of vapor recovery piping is required.

The DPT advancement procedure is as follows:

1) Cease power application to the treatment volume and perform LOTO procedures on the ERH PCU as required by site-specific protocols. Note: LOTO application shall only be completed by personnel who have been trained and certified by TRS according to SOP 1-1.
2) The drilling subcontractor will navigate and situate the DPT rig into position via the predetermined pathway to the desired sample location.

3) Proper PPE should be donned (i.e., face shield, leather gloves, hot water/steam protective clothing) at this time.

4) The drilling subcontractor will advance the DPT sample assembly into the subsurface. Additional casings are added incrementally and advanced until the desired sampling depth is reached. Advance the sampler with caution upon reaching the estimated water table depth.

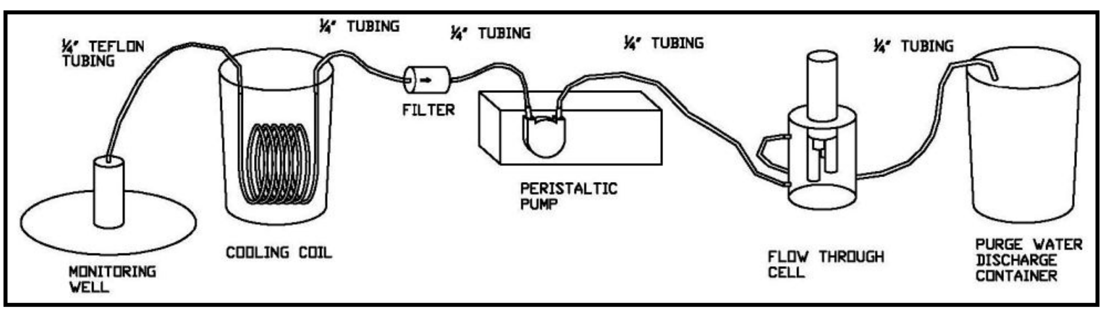
5) Using extension rods to keep the sample screen in place, the DPT assembly is retracted the distance of the screen length. Once the screen is exposed, remove the extension rods.

6) Proceed to **Section 5.5**, Groundwater sampling.

5.5 Groundwater Sampling

The groundwater sampling procedure is as follows:

1) At the start of the work day, calibrate probes used to monitor water quality parameters according to the manufacturer's instructions (as necessary). Calibration frequencies should adhere to the manufacturer's recommendations. Document all calibrations done to the probes used. Documentation should include: date, time, calibration solutions used, solution expiration dates, solution lot numbers, calibration results, outliers, and any illuminating comments.
2) The dedicated Teflon™ sample tubing will be inserted into the DPT drive casing until the approximate mid-point of the DPT sampling assembly screen is reached. Ensure tubing has entered the screen interval, tubing can catch at the top of the screen head simulating the feeling that the bottom of the screen has been reached.
3) Connect the sample tubing from the DPT sample screen to the inlet of the cooling coil and place the coil in a bucket or cooler with ice to form the ice bath as described in **Section 4.2**.
4) Connect the peristaltic pump tubing to a section of tubing connected to the outlet of the cooling coil. A filter can be placed between the cooling coil and the peristaltic pump if sample methods dictate filtering of sample.
5) Connect the peristaltic pump discharge tubing to a flow-through cell with the calibrated meter probes/sensors securely held in the flow-through cell.
6) Connect tubing from the discharge of the flow-through cell to the purge water collection bucket.



7) Begin purging the well at a low-flow rate. Target pumping rates should generally be in the order of 0.1 to 0.5 L/min to ensure stabilization of parameters and reduce mixing of formation water with stagnant borehole groundwater. (Puls and Barcelona, 1996). Depending on site parameters and pumping method used, maintaining a steady low-flow rate may require pumping up to a rate of 1 L/min. Adjustments to the pumping rate are best made within the first 15 minutes of purging to minimize purging time.

8) The pumping rate is recorded on purge data sheets every 3 to 5 minutes during purging. Any adjustments to the pumping rate are recorded. At the initiation of well purging and after recording pumping rates, water quality parameters are measured and recorded with a multi-parameter water quality meter equipped with a flow-through cell. The measured water quality parameters are temperature, turbidity, specific conductance, pH, DO, and oxygen reduction potential (ORP or Redox). Pumping shall continue until the water quality parameters have stabilized (refer to **Section 5.5.1**) or the minimum purge volume has been removed (refer to Section 5.4.2).

   After all water quality parameters have stabilized (refer to **Section 5.5.1**) and/or the minimum purge volume is purged (refer to **Section 5.5.2**), sampling may begin. If all parameters have stabilized, but turbidity remains above 10 nephelometric turbidity units (NTUs), decrease the pump rate and continue monitoring. If the pump rate cannot be reduced and turbidity remains above 10 NTUs, the information will be recorded and sampling initiated. For low yield wells, sampling commences as soon as the well has recovered sufficiently to collect the appropriate volume for the anticipated samples. If well purging has caused the well to become dry, refer to **Section 5.5.3** for sampling procedures.
9) Disconnect the tubing from the inlet side of the flow-through cell. The tubing from the pump outlet will be used to fill the groundwater sample bottles. Samples for VOCs shall be collected first followed by semi-volatile organic compounds (SVOCs). All other parameters should be collected in order from most volatile to least.
10) Groundwater samples including quality control (QC) samples are labeled and preserved per the site-specific Sampling and Analysis Plan (SAP).
11) All pertinent information will be documented in the sample log book and on the chain of custody forms including: date, time of sample, sample identification, analysis being completed, and any other information deemed relevant to the sample results. The following additional information shall be documented in the sample logbook: time at beginning and end of well purging, flow rate and any changes during the well purge, equipment used for well purge, and water quality parameter readings used to determine sample time.
12) Package and ship samples with a laboratory supplied trip blank to the offsite laboratory for analysis.
13) Meters, DPT sample apparatus, and drilling components used for groundwater sampling effort shall be decontaminated according to manufacturer recommendations. Dispose of decontamination liquids and purge water in accordance with site-specific documents.

5.5.1 Water Quality Parameters

Readings are recorded on the purge data sheets every 3 to 5 minutes. Field parameters are monitored until stabilization occurs. Unless local regulatory requirements differ, readings are generally considered stable when three consecutive readings are within the following criteria:

- Specific conductance readings within 3 percent;
- Redox potential within 10mV;
- pH within +/-0.1 standards units;
- Turbidity and DO readings within 10 percent.

5.5.2 Minimum Purge Volume

The purpose of low-flow purgin (or low stress approach) is to reduce the amount of water generated during this procedure. Generally, low-flow purging is considered to have been accomplished once the water quality parameters monitored have stabilized to within a 10 percent margin of error. The key to successful low-flow purging is minimize draw-down in the monitoring well (less than 0.33 feet). Purge flow rates are preferred to be between 0.1 and 0.5 L/min whenever possible, but rates up to 1.0 L/min are acceptable if hydrogeological conditions dictate. However, if the water quality parameters will not stabilize, a TRS established minimum purge volume will be used.

The minimum purge volume for the standard monitoring well purge approach is three times the static saturated well volume. To reduce investigative derived waste (IDW), the TRS minimum purge volume required when water quality parameters do not stabilize will be one well volume. The equation to calculate the minimum purge volume is:

$$V = 7.48*\pi r^2(td\text{-}dtw)$$

Where V = one purge volume in gallons; r= radius of well casing in feet; td = total depth of well in feet; dtw = typical depth to groundwater in feet.

5.5.3 Dry Borehole Sampling

If purging activities has caused the sampling borehole to become dry, the following procedures will be used to sample the well and allow for recharge:

1) A column of water is drawn in the cooling coil tubing with the pump.
2) The sample valve and the peristaltic pump inlet valve are closed and the pump shut off.
3) The cooling coil is disconnected from the sample valve.
4) The cooling coil is carefully removed from the ice bath.
5) The pump inlet valve is opened.
6) The sample is decanted into the sample vials from the pump end of the tubing via gravity flow.

The process is repeated until the sample volume is collected. Any other sample fractions (cations, anions) are sampled from the well end of the cooling coil tubing.

5.6 DPT Assembly Extraction and Grouting

The DPT sampling assembly can also be used to abandon the borehole during the casing extraction process. A removable plug allows for the deployment of grout through the drive casing into the subsurface, slowly filling the borehole with grout as the casing is removed from the borehole.

The DPT assembly extraction and grouting procedure is as follows:

1) Prepare grout to meet quantity and quality requirements specified by the borehole size, and local, state, federal, and/or other regulatory requirements**. Extreme caution should be exercised to minimize disturbance to the hydrostatic head within the borehole during the sealing process.**
2) Extract sample tubing from casing. Dispose of tubing as per site-specific requirements.
3) All extraction rates should be significantly slower than extraction rates used at non-heated sites. Carefully and slowly, raise the casing string to allow for the release the grout plug.

4) Advance the plug push adapter and extension rods down the casing string until the plug is reached. Apply pressure to extension rods until plug is released. Remove extension rods and plug push adapter form the casing string.
5) Attach grout nozzle to grout tubing and lower tubing into casing string until the bottom of the screen is reached. Connect grout tubing to grout pump.
6) As grout is pumped into the borehole, the casing string is slowly extracted from the subsurface. Each section of drive casing is removed as it clears the ground surface and allows for access to the threaded connections. Grouting ceases while the exposed casing section is removed. Coordinate grout pumping rates so grout fills the void at the speed the casing string is being extracted. Slower than average pumping rates are anticipated.
7) The drilling subcontractor will continue repeating the previous step until the DPT sample apparatus is extracted from the borehole. Extreme caution should be exercised to minimize disturbance to the hydrostatic head within the borehole during extraction. Extracted casings and DPT sample apparatus will be hot to the touch upon removal from the borehole.
8) Promptly clean all casings and DPT assembly to remove grout before it sets.
9) DPT assembly, casing, and components used in the sampling effort shall be decontaminated according to manufacturer recommendations after each sample location. Dispose of decontamination liquids and purge water in accordance with site-specific requirements.

6.0 RESPONSIBILITIES

Role	Responsibility
TRS Technical Group Lead	• Develop and implement SOPs • Periodically review and update procedures based on project feedback
TRS HSO	• Provide training and maintain training documentation. • Assist SHSO with modifying SOP to meet site-specific HASP and SAP requirements. • Work with PM to develop AHA for any intrusive work required to complete groundwater sampling efforts.
PM	• Review procedures in conjunction with site-specific SAP requirements and scope of work (SOW). Coordinate changes to procedures as necessary. • Schedule and coordinate sampling effort. Ensure adequate supplies are available. • Work with HSO to develop AHA for any intrusive work required to complete groundwater sampling efforts.
SHSO	• Conduct orientations for subcontractors and employees • Coordinate training needs with TRS HSO • Review procedures in conjunction with site-specific HASP. Coordinate changes to procedures as necessary to maintain safe working procedures.
Sampling Personnel	• Complete training to the level of competent person prior to initiating sampling activities. • Follow procedures and document information related to groundwater sampling effort as identified in this SOP, including and deviations from the SOP.

7.0 TRAINING

Training in SOPs is provided upon initial assignment and annually thereafter. Practical training is provided on a site-specific basis. Additional retraining is provided if there is a change in procedures or if inadequacies are observed in the individual's application of procedures.

Competent persons in hot groundwater sampling are determined by the ERH PM and SHSO and must, at a minimum, complete the following requirements:

- Read this SOP (SOP 3.11) and understand the general process and the specific requirements of this SOP.
- Sign the training acknowledgement form.
- Obtain onsite instruction by a knowledgeable person on the task-specific hazards associated with hot groundwater sampling and the methods used to control these hazards.
- Obtain onsite instruction by a knowledgeable person on important technical components of the hot groundwater sampling program to ensure the collection of representative samples.

8.0 RECORD KEEPING

These are standard (i.e., typically applicable) procedures which may be varied or changed as required, dependent on Site conditions, equipment limitations, permit requirements, or limitations imposed by the procedure. The ultimate procedures used during any sampling event, including any deviations from these procedures, shall be documented in the sample logbook. AHA's developed for any intrusive work conducted in conjunction with this SOP shall be maintained with the groundwater sample logbook.

Calibrations of water quality meters used to measure water quality readings shall be completed according to the manufacturer's recommendations. Calibration results shall be maintained in a written log kept at the site throughout the operational phase of the project.

At a minimum, the following information shall be maintained in the sample logbook related to well purging and groundwater sample collection:

- Date;
- Sample/purge location identification;
- Depth of DPT sample apparatus and screened interval;
- Type of pump used for well purge;
- Duration of well purge;
- Sample time;
- Flow rate (including changes throughout purge);
- Meter(s) used for collection of water quality parameters and calibration documentation;
- Water quality parameter readings;
- Volume of purge water collected prior to sampling;
- Sample identifications and analysis to be performed;
- Chain of custody number;
- Shipping information;
- Procedure and material used for borehole plugging/sealing;
- Procedures used for equipment decontamination;
- Deviations from this SOP, and;
- Any other information deemed relevant to the sample results.

Copies of chains of custody forms and shipping documentation shall be maintained and kept with the sample log book.

9.0 REFERENCES

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, EPA/540/S-95/504.

Yeskis, Douglas and Zavala, Bernard, 2002, Ground Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA/542-S-02-001.

Vail, Jonathon, France, Danny, and Lewis, Bobby, 2013, SESD Operating Procedure Groundwater Sampling, EPA Region 4/SESDPROC-301-R3.

Geoprobe®, 2006, Geoprobe® Screen Point 16 Groundwater Sampler, Standard Operating Procedure, Technical Bulletin No. MK3142.

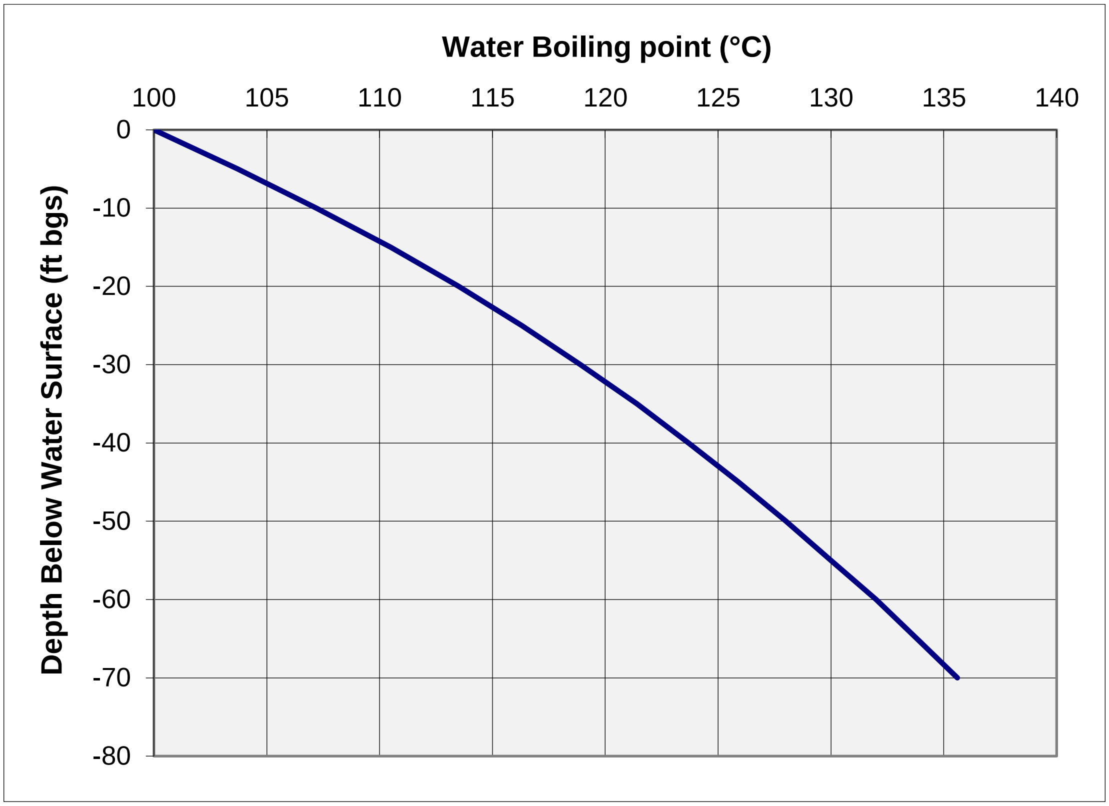
Edge, Russel W., and Cordry, Ken, 1989, The DPT: An *In Situ* Sampling Tool for Collecting Groundwater from Unconsolidated Sediments.

Site Sampling Evaluation Checklist

Project #: ________________
Date: _____________________

Subsurface Conditions

1) What is the anticipated depth to groundwater at the time of sampling?
2) How deep below the groundwater surface elevation are the screens?
3) What are the current temperatures at or near each boring location?
4) Are there confining layers on site? Clay or silt over saturated zone sand for example.
5) Use the figure below to determine where the site's actual temperatures fit on the boiling point curve.



6) Actual temperature for each depth elevation that is higher in value than the temperatures represented by this curve suggest a temperature value greater than the hydrostatic boiling point of water.

SOP 3.11 Hot Groundwater Sampling-DPT
Training Acknowledgment

All personnel that receive training on this procedure will review and sign the acknowledgement form contained in this section.

I have been trained by TRS Group, Inc. (TRS) to perform non-intrusive hot groundwater sampling at the SITE-SPECIFIC project site. By signing this document, trainee acknowledges that SOP 3.11 Hot Groundwater Sampling-DPT has been read and the contents of the document are understood. Trainee has received hands-on training from a competent person who is authorized to use and instruct others on sampling procedures at TRS project sites.

Date	Trainee (print)	Trainee (Sign)	Trainer

Appendix D: Anticipated Project Schedule

Conceptual Remediation Schedule

	Task Name	Start Date	End Date
1	REGULATORY APPROVAL OF CLEANUP ACTION PLAN	04/22/22	04/22/22
2			
3	GW PLUME - IN SITU CHEMICAL REDUCTION (ISCR)/ENHANCED REDUCTIVE DECHLORINATION (ERD)	04/22/22	11/03/22
4	Mobilize to Install injection Points	04/22/22	05/05/22
5	Inject MSZVI and 3DME	05/06/22	05/12/22
6	Inject MSZVI and 3DME	10/28/22	11/03/22
7			
8	SOURCE AREA - IMPLEMENT ZVI/ELECTRICAL RESISTIVE HEATING/SOIL VAPOR EXTRACTION (ERH/SVE)	04/01/22	03/17/23
9	UEP - Mobe: Water Supply, Decommi. MWs, Fencing, Remove Gas Line/Drums/Sewer	04/01/22	04/28/22
10	TRS - Mobe: Electrode Installation and Wiring SVE System Install	04/22/22	06/16/22
11	TRS - Installation of ERH Power Controls, Checks, Start Up	06/17/22	08/11/22
12	Quarterly GW Monitoring - Baseline before ERH/SVE; Post ISCR/ERD	05/13/22	05/19/22
13	ERH - Operations and Monitoring	08/12/22	01/06/23
14	Perimeter GW Monitoring	09/16/22	09/22/22
15	ERH - Progress Monitoring (PM) at 90 degrees	12/16/22	12/29/22
16	ERH Opns "Deemed Complete by TRS" Based on Energy Use and Air/Vapor Checks	01/06/23	01/06/23
17	Post Remediation Confirmation Sampling	01/09/23	01/23/23
18	Ecology Review of GW Compliance Data	01/24/23	02/06/23
19	ERH Remediation Successful - Remdial Goals Achieved and Confirmed	02/06/23	02/06/23
20	Demobilization of ERH Equipment	03/06/23	03/10/23
21	Install Replacement GW Compliance Points	03/13/23	03/17/23
22	Electrode and Resource Well Decommissioning	03/06/23	03/10/23
23			
24	COMPLIANCE GROUNDWATER MONITORING	02/20/24	11/25/24
25	Quarterly GW Monitoring	02/20/24	11/25/24
26	POC - Quarterly GW Monitoring 1	02/20/24	02/26/24
27	POC - Quarterly GW Monitoring 2	05/21/24	05/27/24
28	POC - Quarterly GW Monitoring 3	08/20/24	08/26/24
29	POC - Quarterly GW Monitoring 4	11/19/24	11/25/24