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Engineering Design Report

Former Circle K Site 1461, Seattle, Washington

10 December 2021

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Prepared for

DEPARTMENT OF ECOLOGY
State of Washington

Toxics Cleanup Program
3190 160th Avenue SE
Bellevue, Washington 98008-5452

KJ Project No. 2196008*00

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List of Acronyms

%	percent
AACE	Association for the Advancement of Cost Engineering
ACFM	actual cubic feet per minute
bgs	below ground surface
BMP	best management practice
BOD	biochemical oxygen demand
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	cleanup action plan
CD	Consent Decree No. 82-2-08095-8
cfm	cubic feet per minute
City	City of Seattle
CLARC	Cleanup Levels and Risk Calculation
COC	contaminants of concern
COD	chemical oxygen demand

CSWPPP	Construction Stormwater Pollution Prevention Plan
CULs	cleanup levels
Ecology	Washington State Department of Ecology
EDR	engineering design report
EFR	enhanced fluid recovery
GAC	granular activated carbon
GIS	geographic information system
GRO	gasoline-range organics
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
Hg	mercury
ID	identification
IDW	investigative-derived waste
Kennedy Jenks	Kennedy/Jenks Consultants, Inc.
LNAPL	light non-aqueous phase liquid
MFR	multiphase fluid recovery
mg/kg	milligrams per kilogram
MPE	multiple phase extraction
MTCA	Model Toxics Control Act
O&M	operations and maintenance
OPCC	opinion of probable construction costs
PAH	polycyclic aromatic hydrocarbon
PCS	petroleum hydrocarbon-containing soil
PID	photoionization detector
PPE	personal protective equipment
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
ROI	radius of influence
SAP	Sampling and Analysis Plan
SCFM	standard cubic feet per minute
site	Former Circle K Station #1461
SPU	Seattle Public Utilities
SSD	sub-slab depressurization
SVE	soil vapor extraction
TCLP	Toxicity Characteristic Leaching Procedure
TEA	terminal electron acceptor
TPH	total petroleum hydrocarbons
UST	underground storage tank
VI	vapor intrusion
VMP	vapor monitoring point
VOC	volatile organic compound
WAC	Washington Administrative Code

Section 1: Introduction

This Engineering Design Report (EDR) describes specific activities and engineering design requirements for implementing the remedial action of petroleum hydrocarbons in soil and groundwater at the Former Circle K Station #1461 (site). The site is generally located at 2350 24th Avenue East in Seattle, King County, Washington (see Figure 1). This EDR has been prepared to satisfy the requirements of the Model Toxics Control Act (MTCA) regulations published in Washington Administrative Code (WAC) 173-340-400(4)(a), (Ecology 2007). This site is listed on the Washington State Department of Ecology's (Ecology's) Site Information System and Hazardous Sites List as Circle K 1461, under cleanup site ID 5086 and facility/site ID 2322. Ecology has assigned the site a hazard ranking of 3 out of 5, with 1 being the highest risk and 5 being the lowest risk (Ecology 1994).

1.1 Project Description and Regulatory Framework

A remedial action is planned to address petroleum hydrocarbon-affected soil and groundwater at the site. Hydrocarbons detected in soil and groundwater have been attributed to a leaking underground storage tank (UST) that was discovered in August 1989.

In April 1992, Ecology entered into Consent Decree No. 82-2-08095-8 (CD) with Mr. Kuk Jin Choung and Ms. Kathy-Kyung D. Choung, owners of the property, to conduct a remedial investigation and feasibility study (RI/FS) and develop a cleanup action plan (CAP) for the site. After completion of the RI/FS and CAP, the CD requires performance of the cleanup action to protect human health and the environment in accordance with MTCA regulations. The RI/FS and CAP were finalized in December 2017. Implementation of the site cleanup action is continuing under the CD with Ecology oversight, under Ecology contract number C2100069.

1.2 Remedial Action Contacts and Information

Per the CD, Ecology is responsible for cleaning up the site and for owning, operating, and maintaining the remedial system during and after construction [(WAC) 173-340-400(4)(a)(iii)]. Kennedy/Jenks Consultants, Inc. (Kennedy Jenks) will be the Engineer of Record for the remedial system design. Site and project contact information are summarized below:

Ecology Site Manager:	Dale Myers, Ecology Northwest Regional Office (NWRO) 3190 160th Avenue SE, Bellevue, Washington 98008 (425) 649-4426 damy461@ecy.wa.gov
Project Consultant:	Kennedy Jenks 32001 32nd Avenue South, Suite 100 Federal Way, Washington 98001 (253) 835-6400 Project Manager: Ryan Hultgren, PE Engineer of Record: Ben Fuentes, PE Contract No. C2100069

1.3 Purpose of the Engineering Design Report

The purpose of this EDR is to satisfy the requirements of WAC 173-340-400(4)(a) and the requirements established under the CD. The EDR documents engineering concepts and criteria used during design of the cleanup action and provide sufficient information to develop and review construction plans and specifications. Specific information required by WAC 173-340-400(4)(a) and included in this EDR includes:

- Site owner, operator, and other remedial action contact information (Section 1).
- General site information, including a summary of the RI/FS and current conditions (Section 2).
- Remedial action goals and cleanup requirements (Section 3).
- Facility maps showing the location of contaminants and proposed cleanup action. (Figure 1 through Figure 9)
- Characteristics, quantity, and location of materials to be treated or removed (Section 2.4).
- Schedule for final design and construction (Section 11).
- Conceptual plan of the planned remedial action (Section 5).
- Engineering design criteria, assumptions, and facility-specific design issues (Section 4).
- Design features to control hazardous material spills and manage hazardous materials (Section 4).
- Design features to assure short- and long-term safety of site workers and local residents (Section 4).
- Permit requirements (Section 3).
- Construction testing that will be used to demonstrate adequate quality control (Section 6).
- Compliance monitoring measures implemented during and after the cleanup to meet WAC 173-340-410 requirements (Section 7).
- Health and safety measures to comply with the safety and health requirements of WAC 173-340-810 (Sections 4 and 5).
- Financial assurance information (Section 9).
- Institutional controls information (Section 10).

Section 2: Site Description and Background

The sections below summarize general information about the site, the current and historical site uses, and previous investigations completed at the site, per WAC 173-340-400(4)(a)(ii).

2.1 Site History and Description

The site is located on the southeastern corner of the intersection of 24th Avenue East and East McGraw Street, in Seattle, Washington. From 1968 to 1990, the site was operated as a Circle K-branded gasoline service station. During operation, four gasoline USTs, one pump island, one waste oil UST, and one heating oil UST were located at the site. Historical site features are shown on Figure 2. The site was redeveloped in 1990 and 1991 to its current configuration. Two businesses currently operate at the site including a general store (Mont's Market) and a dry-cleaning business (Jay's Cleaners).

The site is located on Tax Parcel 6788201335 and is zoned for commercial use. According to the King County Department of Assessments, the tax parcel is currently owned by Mr. Kuk Jin Choung and Kathy-Kyung D. Choung. The legal description of the parcel is:

PIKES 2ND ADD TO UNION CITY 1 & 2 LESS E 6 FT; PLAT BLOCK 29, PLAT LOT 1-2

Jay's Cleaners is operated by the Choung family. The Mont's Market space is owned by the Choung family but is leased out and operated by another party.

The site is located in an approximately two-block long commercial area within the Montlake neighborhood of the City of Seattle (City), a primarily residential neighborhood. To the west of the site, 24th Avenue East is a major north-south arterial. A King County Metro Transit hybrid-electric bus route runs along 24th Avenue East with associated bus stop and overhead power lines adjacent to the site. East McGraw Street is located to the north of the site. The intersection of East McGraw Street and 24th Avenue East is controlled by a traffic light.

Nearby properties include a public library to the northwest, several restaurants to the south, an antique store to the west, and residential properties to the north and east. An elementary school is located one block west of the site. The Washington Park Arboretum, a 230-acre preserve, is located approximately 700 feet to the east of the site.

The closest water bodies to the site are Portage Bay, approximately 2,100 feet to the northwest; the Montlake Cut, approximately 2,500 feet to the north; and Duck Bay, approximately 1,500 feet to the northeast. Duck Bay is connected to Union Bay, and Union Bay and Portage Bay are connected via the manmade Montlake Cut.

The site and the surrounding area to the east are relatively flat and slope to the east towards the Washington Park Arboretum and Duck Bay. A small hill is present to the west of the site, across 24th Avenue East.

According to site maps, Geographic Information System (GIS) information obtained from the City, and private utility locators, several underground utilities are present near the site (see Figure 2). Seattle Public Utilities (SPU) owns and operates 12-inch and 8-inch-diameter cast iron water distribution mains that run along the eastern side of 24th Avenue East and the northern side of East McGraw Street, as well as an 8-inch-diameter concrete sewer main located north of the site along the center of East McGraw Street. King County owns and operates a 90-inch-diameter reinforced concrete sewer mainline that runs along the center of 24th Avenue East. The King County sewer main flows to the north and the SPU sewer main flows to the east, both by gravity. The site's sanitary sewer and storm drain catch basins are connected to the SPU main along East McGraw Street.

2.2 Site Conditions

Site conditions encountered during remedial investigation activities are summarized in the sections below, per WAC 173-340-400(4)(a)(ii). Additional site condition details are presented in the RI/FS (Kennedy Jenks 2017a) and CAP (Kennedy Jenks 2017b).

2.2.1 Geology and Hydrogeology

2.2.1.1 Soil

Based on a review of boring logs generated during the RI activities conducted in 2016/2017 and previous investigations (primarily from GeoEngineers 1990), three generalized stratigraphic units are identified at the site, as summarized below:

- Silt – Typically encountered from the ground surface (beneath pavement and subgrade fill) to depths of approximately 2 to 8 feet below ground surface (bgs) but extends to greater depth (up to approximately 13 feet bgs) in the northern portion of the site. The unit is generally described as soft to stiff, brown to gray, silt to sandy silt, locally with gravel and/or organics.

- Sand/silt – Typically encountered below the silt layer to depths of approximately 17 to 22 feet bgs, and typically described as gray to brown, fine sand, silty fine sand, or sandy silt locally containing cobbles. The unit is described as loose, medium dense, dense, and very dense with vertical and lateral variation. This unit generally includes the uppermost, possibly weathered, portion of the underlying glacial till unit.

- Till – Typically encountered below the sand/silt starting at approximately 17 to 22 feet bgs and generally described as gray silt, silty sand, or sandy silt with sand and gravel. The till unit is typically described as dense to very dense, as indicated by increased drilling pressure and increases in blow counts required to drive split-spoon soil samplers.

Fill has also been encountered at the site, including pea gravel that was placed within the former excavation area to depths of approximately 17 feet bgs.

None of the site monitoring/multi-purpose remediation wells or soil borings has been advanced through the till unit; however, a well installed by Landau Associates near site well MW-4 in 2013 (Landau 2013) was advanced to approximately 90 feet bgs. This well was part of an investigation for a separate site, Montlake Neighborhood Former Dry Cleaner, located west of the Former Circle K site. The log for the 2013 Landau well (designated MW-3, see Figure 2) shows the upper contact with the till at 18 feet bgs, dense (unweathered) till at 30 feet bgs, and gray fine to medium sand beneath (or possibly interbedded with) the till from approximately 80 to 90 feet bgs.

2.2.1.2 Groundwater

The depth to shallow groundwater at the site ranges from 3 to 12 feet bgs, based on water levels measured from April to December 2016. This zone of shallow groundwater appears to be perched on top of the till unit. Although a seasonal water table fluctuation of a foot or less was generally observed near the former UST area during the April and December 2016 monitoring event, a fluctuation nearly 6 feet has been recorded at northernmost monitoring well MW-11.

Previous reports have indicated that the hydraulic gradient and presumed direction of groundwater flow is towards the northeast and that while the onsite recovery system was operating from 1989 to 2000, a stable cone of depression was located near the recovery well. Following shutdown of the recovery system, water levels measured in August 2006 (EA Engineering 2006) suggest that the groundwater flow direction on the northern edge of the site was generally southeast, towards the former UST area. In general, a potentiometric low has been previously observed in the vicinity of MW-6. The groundwater gradient within the parking lot area is relatively flat, with a very shallow gradient and a groundwater flow direction of north-northeast. More recently, groundwater levels in the parking lot area during December 2016 show groundwater flow direction near MW-11 and MW-15 was south to southeast. No monitoring wells were present on the southern portion of the site in 2006. Deeper groundwater units are not expected to be impacted by the gasoline release at this site and have not been evaluated as part of the site investigation activities.

2.2.2 Monitoring and Multipurpose Well Information

There are currently 19 groundwater monitoring wells and nine multi-purpose wells on site. Monitoring wells MW-1 through MW-16 were installed in 1989. Monitoring wells MW-17 through MW-19 and nine multi-purpose wells (MW-20, MW-21, and RW-1 through RW-7) were installed on site as part of the RI activities in 2016 and 2017. Table 1 lists each well, along with the installation date and screen interval. Well locations are shown on Figure 2. Six of the wells (MW-1, MW-2, MW-3, MW-5, MW-12, and MW-13) have been abandoned. Existing wells will be utilized as part of the monitoring program and as part of the remedial system design.

2.3 Site Discovery and Previous Remedial and Investigation Activities

In 1989, a leak was discovered in one of the four onsite gasoline USTs. It was estimated that approximately 4,000 to 6,000 gallons of gasoline were released to the subsurface. Following the discovery of the release, all six onsite USTs and the pump island were removed. In addition, approximately 900 cubic yards (cy) of petroleum hydrocarbon-containing soil (PCS) were excavated and removed from the site. Additional remedial and investigation activities were conducted between 1989 and 2006 including 1) Construction and sampling of 16 groundwater monitoring wells, 2) light non-aqueous phase liquid (LNAPL) recovery, 3) groundwater extraction and treatment, 4) soil vapor extraction (SVE), and 5) enhanced fluid recovery (EFR). Additional details regarding these pre-2016 RI remedial systems is summarized below.

2.3.1 Pre-2016 Remediation Systems

A free product recovery, groundwater treatment, and vapor extraction system were installed at the site prior to 6 December 1989 by Chemical Processors, Inc., Environmental Services Division. The SVE component of this system was installed within the former excavation and consisted of horizontal slotted polyvinyl chloride (PVC) vapor extraction piping connected to a blower. Soil vapor was routed through a condensate trap, particulate filter, and a series of granular activated carbon (GAC) filters for treatment. The SVE system reportedly operated from the early 1990s until 1997, at which time it was shut down because no significant hydrocarbons were detected in the extracted soil vapor for 2 consecutive months. GeoEngineers' SVE Schematic Plan indicates the blower was sized to provide a maximum vacuum of 49 inches of water and a maximum extraction flow rate of 98 standard cubic feet per minute (SCFM). GeoEngineers' 6 March 1990 report indicates the SVE system was initially set to operate at 15 inches of water column vacuum and 80 SCFM. The continued operational details from this system (e.g., flow rates, influent vapor concentrations, radially induced vacuums) were unavailable for review; however, operational details from this system are not expected to be representative of SVE conditions throughout the site as the former SVE system was installed within the UST excavation backfill.

Eco-Vac Services, Inc. of Woodstock, Georgia, tested enhanced or multiphase fluid recovery (MFR) on 9 June 2005 (Eco-Vac Services, 2005). During the testing, vacuum stingers were installed at depths ranging from 15 to 17.5 feet bgs in wells MW-4, MW-8, MW-9, and MW-13 and total fluid extraction was carried out using a vacuum truck. A total of 1,597 gallons of liquid was removed and an estimated 112 pounds of hydrocarbons were removed in the vapor phase, where vapor concentrations were observed ranging from 50,000 parts per million (ppm) down to 7,200 ppm at the end of the 8-hour test. Vapor extraction rates ranged from 29 to 118 cubic feet per minute (cfm) at extraction vacuums ranging from 13 to 19 inches of mercury. Vacuum influence was observed out to a distance of 22 feet during testing. The results indicate that the site may be characterized as having very low permeability soils.

2.3.2 2016 Remedial Investigation and Feasibility Study

A draft RI/FS was completed for the site in 2009 by Ecology (Ecology 2009). Additional RI field activities were completed by Kennedy Jenks in 2016 and 2017 to address data gaps remaining after the initial RI/FS. RI field activities completed in 2016 and 2017 included:

- Collection and laboratory analyses of groundwater samples from accessible monitoring wells in April and December 2016.
- Advancement of 16 direct-push soil borings (KJB-1 through KJB-16) for soil and reconnaissance groundwater sample collection and analysis.
- Drilling and construction of three groundwater monitoring wells (MW-17, MW-18, and MW-19) and nine multi-purpose remediation wells (MW-20, MW-21, and RW-1 through RW-7). Soil samples were collected for laboratory analysis during monitoring well and multi-purpose well installation.

The RI/FS identified gasoline-range organics (GRO) and benzene, toluene, ethylbenzene, and xylenes (BTEX) as the primary contaminants of concern (COCs) at the site. Based on soil and groundwater samples collected during the RI, detected concentrations of GRO and BTEX in soil and groundwater were highest in the western-central portion of the site below the parking lot area, and appear to extend off-property to the north and west. The lateral extent of impacted soil appears to be limited on the southern side to a short distance south of the location of boring KJB-13, on the eastern side to the approximate western edge of the on-property building footprint (may extend beneath this building), and on the northern side to a short distance north of boring KJB-4. The highest detected concentrations of GRO and benzene in soil, at 43,000 milligrams per kilogram (mg/kg) and 63 mg/kg, respectively, were detected in borings KJB-9 and KJB-10, located in the central portion of the parking lot. The vertical extent of GRO and benzene concentrations in soil above MTCA Method A cleanup levels (CULs) is generally limited to depths from 8 to 20 feet bgs. LNAPL was not encountered during 2016-2017 RI field activities.

The RI/FS also confirmed that GRO and BTEX were still present in groundwater at the site, primarily beneath the parking lot and extending off-property to the north and west. During the RI/FS, groundwater samples were collected from monitoring wells and from borings (reconnaissance samples). The highest detected concentrations of GRO and benzene in groundwater were in samples collected from MW-21 [GRO at 163,000 micrograms per liter (µg/L) and benzene at 21,400 µg/L] during the December 2016 event. The extent of groundwater impacts above 1,000 µg/L is bounded along the north side of East McGraw Street, extends to the south to MW-17, and likely extends partially beneath the onsite building to the east and 24th Avenue East to the west. Groundwater along the western side of 24th Avenue East did not contain concentrations of GRO or BTEX constituents above laboratory reporting limits. The presence of glacial till identified in a significant number of borings at a depth of approximately 17 to 22 feet bgs consists of sandy silt with clay and presents a natural impediment to downward groundwater migration. Consequently, lateral movement of COCs along the top surface of the till would be expected to be more extensive than vertical movement.

The results of the groundwater samples indicate that the petroleum hydrocarbon plume appears to be stable and diminishing in size over time. Source removal (e.g., UST and fueling infrastructure removal) and subsequent remedial activities in conjunction with natural attenuation processes have contributed to plume stability. A shallow groundwater gradient across much of the site may also limit the lateral migration of dissolved-phase petroleum hydrocarbons in groundwater over time.

A bioremediation pilot test was conducted at the site to assess the effectiveness of enhancing biodegradation of dissolved petroleum hydrocarbons in groundwater. The pilot test was conducted in general accordance with the Pilot Study Work Plan (Kennedy Jenks 2017c) submitted to Ecology on 4 February 2017. The pilot study demonstrated that although site hydraulic conditions are not ideal, a groundwater recirculation system could be effectively established to support implementation of a bioremediation system.

2.3.3 Vapor Intrusion Assessment

Kennedy Jenks conducted an initial (Tier 1) assessment of the potential for vapor intrusion (VI) into the main site structure and adjacent residences following the methods described in the EPA's *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites* (EPA 2015). The results of the Tier 1 assessment are presented in the RI/FS (Kennedy Jenks 2017a) and are summarized as follows:

- The occupied on-property commercial structure is within the lateral VI inclusion zone based on the maximum benzene, toluene, and xylene concentrations detected in groundwater near the building.
- Although groundwater at the site is typically encountered about 10 feet bgs adjacent to the building, exceeding EPA's vertical groundwater separation distance criterion of 6 feet for bio-attenuation of petroleum hydrocarbons, the presence of underground utilities could provide a preferential pathway(s) for soil vapors to enter the onsite building. Consequently, the VI pathway into the onsite structure is considered potentially complete pending further characterization of preferential vapor pathways.
- The potential for VI into nearby residential structures appears to be very low based upon the proximity of the soil and groundwater contamination to such structures; however, in the absence of additional sampling at the residential properties to confirm subsurface conditions, the VI pathway for off-property residential areas must be regarded as potentially complete.

[Note: In addition to possible VI conduits, potentially explosive conditions could be created within sewer lines if substantial concentrations of gasoline vapors from proximal contaminated soil and groundwater were to accumulate.]

2.4 Nature and Extent of Contamination

The following sections describe the nature and extent of contamination at the site and identify areas requiring cleanup as required in WAC 173-340-400(4)(a)(v). The discussion below is based on the findings of the RI/FS, which includes the most current data set for the site.

2.4.1 Contaminants of Concern

As noted above, based on the results from RI field activities, GRO and BTEX constituents are present in soil and groundwater at concentrations above MTCA Method A CULs. These constituents are considered to be the primary COCs in soil and groundwater and are related to former fueling activities at the site. GRO and benzene are used to describe the extent of impacted media below; while toluene, ethylbenzene, and xylenes are also considered to be COCs and are present in site media at concentrations above MTCA Method A CULs, where toluene, ethylbenzene, and xylenes are reported in soil and groundwater, GRO and/or benzene are also reported.

2.4.2 Impacted Soil

The extent of GRO- and benzene-impacted soil at concentrations above the MTCA Method A CUL is shown on Figure 3. Based on analytical results and field observations, the vertical extent of GRO concentrations exceeding the soil CUL appear to be generally limited to the zone from 8 to greater than 20 feet bgs. The horizontal extent of GRO-impacted soil (approximately 5,300 square feet) is generally located beneath the onsite parking lot and may extend beneath the onsite building and into the roadways to the north and west of the property. The lateral and vertical extents of benzene, toluene, ethylbenzene, and xylenes concentrations that exceed the soil CUL appear to coincide with the distribution of GRO; therefore, targeting the zone in which GRO concentrations exceed soil CULs for remediation will also address cleanup of the aromatic gasoline constituents.

2.4.3 Impacted Groundwater

The extent of GRO- and benzene-impacted groundwater at the site is shown on Figure 4. Petroleum hydrocarbons in groundwater at the site are limited to dissolved-phase impacts; LNAPL was not observed in any of the monitoring wells during RI groundwater monitoring events. The extent of dissolved-phase petroleum hydrocarbons (approximately 10,900 square feet) and related compounds is bounded on the north side of East McGraw Street, and generally extends beneath the onsite parking lot. Dissolved-phase impacts may also extend beneath the onsite building and to the west beneath 24th Avenue East, though groundwater impacts are bounded along the western side of the street.

Although residual concentrations of dissolved-phase COCs are high, groundwater monitoring results indicate that the dissolved petroleum hydrocarbon plume at the site is either stable or diminishing in size. Source remediation and ongoing processes that have contributed to mitigating the spread of dissolved petroleum hydrocarbon concentrations in groundwater include:

- Removal of the USTs in 1989, including excavation of petroleum contaminated soil.
- Past remedial efforts including groundwater extraction, operation of the SVE system, and LNAPL recovery.
- Natural attenuation processes such as biodegradation, dispersion, dilution, sorption, and volatilization.

2.4.4 Areas Requiring Cleanup

Areas with COCs above CULs, as established in the RI/FS and discussed further in Section 3.2 below, require cleanup to meet remedial goals. Points of compliance are discussed further in Section 3.3.

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Section 3: Cleanup Requirements

3.1 Remedial Action Objectives

The objective of the cleanup action is to reduce potential risks to human health and the environment. Because the Site is zoned as "Neighborhood-Commercial", the proposed soil cleanup standards must be protective of unrestricted land use. Specific risk-based remedial action objectives include:

- Reduce the potential for human contact with soil and groundwater containing COCs at concentrations exceeding the selected CULs.
- Protect groundwater quality by addressing dissolved phase petroleum hydrocarbons exceeding the selected CULs.
- Reduce the potential for human exposure to vapors (primarily vapor intrusion into buildings) associated with soil and groundwater containing COCs at concentrations exceeding the selected CULs.

3.2 Cleanup Levels

The cleanup standards for soil and groundwater, as selected in the RI/FS, are noted below per WAC 173-340-400(4)(a)(i).

- **Soil:** MTCA Method A soil CULs for unrestricted land use based on WAC 173-340-740 and/or obtained from Ecology's CLARC database. For those compounds where MTCA Method A levels may not be available, soil CULs will be based on MTCA Method B values and/or leaching to groundwater values.
- **Groundwater:** MTCA Method A groundwater CULs for fuel components (GRO and BTEX constituents) based on WAC 173-340-740 and/or obtained from Ecology's CLARC database. For those compounds where MTCA Method A levels may not be available, groundwater CULs will be based on MTCA Method B values.
- **Vapor Intrusion:** CULs will be based on MTCA Method B groundwater screening levels for the vapor intrusion pathway obtained from Ecology's CLARC database. If sub-slab soil gas samples are collected, they will be compared to Method B sub-slab soil gas screening levels obtained from Ecology's CLARC database.

CULs for unrestricted land uses are proposed as part of the cleanup standards for this site. These standards are protective of human exposure via direct contact pathway and are protective of groundwater and surface water.

Groundwater CULs selected for the site are based on MTCA Method A CULs for fuel components (GRO and BTEX). MTCA Method A groundwater CULs for GRO and BTEX were selected for fuel components because they are the most applicable and protective standards for gasoline-range hydrocarbon compounds (including BTEX).

3.3 Points of Compliance

The points of compliance, based on the potential chemical exposure routes, are those points where cleanup levels established for the site shall be achieved.

The points of compliance for site media were established as follows:

- **Soil:** Based on WAC 173-340-740, the point of compliance for soil is as follows:
    - Throughout the site for protection of groundwater.
    - From the ground surface to the depth of shallow groundwater for possible VI.
    - From the ground surface to a depth of 15 feet below grade for protection of humans based on direct contact.
- **Groundwater:** In accordance with WAC 173-340-720(8), throughout the site from the uppermost saturated zone to the lowest depth potentially affected by site contaminants.
- **Air:** In accordance with WAC 174-340-750(6), in ambient air throughout the site.

3.4 Permits

All actions carried out by Ecology or Ecology's contractor must be performed in accordance with all applicable federal, state, and local requirements, including requirements to obtain necessary permits, except as provided in RCW 70.105D.090 which allows an exemption from the procedural requirements of State and local permits. The permits or other federal, state, or local requirements that the agency has determined are applicable and that are known at this time include:

Federal Requirements

- Resource Conservation and Recovery Act (RCRA)
- Occupational Safety and Health Act (29 CFR 1910)
- Rules for Transport of Hazardous Waste (49 CFR 107, 49 CFR 171, 40 CFR 263)
- Safe Drinking Water Act, including Underground Injection Control (e.g., 40 CFR 144, 145, 146, and 147)
- Clean Air Act
- National Pollutant Elimination Discharge System (NPDES) permit.

State Requirements

- Model Toxics Control Act (WAC 173-340)
- Dangerous Waste Regulations (WAC 173-303)
- State Environmental Policy Act (RCW-43.21C)
- Environmental Checklist (WAC 197-11-960)

- Minimum Standards for Construction and Maintenance of Wells (WAC 173-160)
- State Clean Air Act (RCW 70.94)
- Washington Industrial Safety and Health Act Regulations (WAC 296-62)
- Water Pollution Control Act (RCW 90.48)
- Water Quality Standards for Groundwater of the State of Washington (WAC 173-200)
- Underground Injection Control (WAC 173-218)
- Maximum Environmental Noise Levels (WAC 173-60).

Local Requirements

- King County Sewer Discharge Requirements
- King County Metro Transit
- Puget Sound Clean Air Agency (PSCAA) air discharge permit
- Seattle Building Code
- Seattle Electrical Code
- Seattle Stormwater Code
- Seattle Department of Transportation
- Seattle Noise Ordinance (Seattle Municipal Code 25.08).

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Section 4: Engineering Design

The cleanup alternative chosen in the RI/FS and CAP included an SVE system for remediation of residual soil impacts and implementation of a groundwater recirculation system with injection of bioaugmentation reagents. As part the data gaps process and alternatives analysis completed during pre-design, an alternative process option of multiple phase extraction (MPE) was identified and chosen. Similar to SVE, MPE addresses residual hydrocarbon contamination of the vadose zone and can also be designed to protect against VI. MPE would also be utilized to extract groundwater, which would be treated with reagents and reinjected similar to a groundwater recirculation system. Both the remedial option detailed in the RI/FS and CAP (SVE and groundwater recirculation) and an MPE system would pull water and air from the ground for treatment, but they differ in the method and level of vacuum applied. Through consultation with Ecology, it was agreed that MPE was not a change to the chosen remedial alternative and so a revision of the RI/FS and CAP was not required. The data gaps memo (Kennedy Jenks 2021) and alternatives analysis documenting these decisions are attached in Appendix A.

4.1 Conceptual Plan of the Remedial Action

Per WAC 173-340-400(4)(a)(vii), this section describes actions, treatment units, facilities, and processes associated with the remedial action. The remedial action described in this section will be implemented in order to meet the cleanup standards as noted in Section 3.2. The selected remedial action involves installation of a MPE and groundwater recirculation system and groundwater and soil compliance monitoring. The layout and primary elements of the remedial action are shown on Figure 5. The remedial action involves installation of a MPE and groundwater recirculation system and groundwater and soil compliance monitoring.

As part of the MPE system installation, three (3) new vertical wells and three (3) new slant wells will be installed at locations identified as most likely to reduce the concentrations of the contaminants of concern. Seven (7) existing remediation/monitoring wells will also be used as part of the system. The locations of these wells are shown on Figure 5. The proposed vertical wells will be drilled with a hollow-stem auger rig and the proposed slant wells will be drilled with a sonic rig. All wells will be constructed with 4-inch diameter, Schedule 40 PVC well casings and screens.

Two of the three new vertical wells will be drilled to a depth of approximately 20 feet bgs, with a screened interval of approximately 5 to 20 feet bgs. The third vertical well will be drilled to a depth of approximately 30 feet bgs, with a screened interval of approximately 23 to 28 feet bgs. The three new slant wells will be drilled to approximately 20 feet bgs, with a screened interval of approximately 5 to 17 feet bgs. A cross-section is shown in plan view on Figure 6 and the cross-section is shown on Figure 7. The cross-section shows the approximate extent of GRO and benzene impacts in the soil and the approximate locations of the proposed wells. The cross-section line does not run through all the wells included in the cross-section; wells not on the line were superimposed over the cross-section to create a more comprehensive understanding of the vertical extent of the system.

In addition to the above wells, three (3) sub-slab depressurization wells and four (4) vapor monitoring points will be installed in and around the existing onsite structures for monitoring and potential mitigation of sub-slab vapor concentrations.

An approximately 8-foot wide by 18-foot-long enclosure for some of the treatment system components will be located alongside the side of the building in the southern portion of the property. Liquid and vapor phase GAC vessels will be located outside of this shed for accessibility for carbon replacement. The thermal oxidizer and water storage tanks will also be located outside of the shed. Heat tracing will be provided for vessels located outside of the enclosure as required. A security fence will be installed around exterior treatment system components. A proposed layout of the treatment system is shown on Figure 8.

Trenching and excavation activities will take place to install piping and electrical wiring between wellheads and the treatment shed. Non-impacted soils may be segregated and stockpiled on site, if space allows, to be used as backfill material pending laboratory analytical results. Impacted soils will be excavated and loaded directly for disposal at an appropriate landfill. Individual wells will be connected to a manifold via 1-inch high-density polyethylene (HDPE) extraction and reinjection lines.

Soil vapor and extracted groundwater will be treated by carbon adsorption using GAC with a provision for the use of a thermal oxidizer to treat vapors during the startup phase of the project.

Groundwater initially extracted from the system is expected to be discharged after treatment with GAC to the sanitary sewer. Once groundwater concentrations become nearly asymptotic and carbon usage has stabilized, surfactants will be used to increase hydrocarbon recovery rates. A few months after surfactant treatment has begun, bioremediation treatment will be implemented. This includes treating recovered groundwater with GAC, and adding oxygen and/or other electron acceptors, petroleum-degrading bacteria, and nutrients before reinjecting amended groundwater. Excess water not reinjected will be discharged to the sanitary sewer. Groundwater concentrations will be monitored closely to determine when to transition from sanitary sewer discharge to bioremediation amendment. These groundwater concentrations will also be monitored to assist with the bioremediation injection volumes and concentrations. Volumes and flow rates of discharge and reinjection will be continually determined during operation. Guidance on these decisions will be established within the operations and maintenance (O&M) plan.

During system operation, concentrations of COCs in the groundwater will be monitored according to the performance monitoring outline in Section 7. Adjustments will be made to extraction and injection well configuration and flow rates to achieve optimal remediation of the impacted groundwater and soil on site.

After site CULs have been achieved, the fencing, treatment shed, and other treatment system components will be removed from the site. The wells will be decommissioned, except for the monitoring wells that will be left in place for ongoing compliance monitoring. Details on monitoring is included in Section 7.

4.1.1 Process Flow Diagrams

Figure 9 shows a conceptual process flow diagram of the system, including the extraction, treatment, and reinjection components. As described above, vapor and groundwater are extracted from the vertical and slant wells and then passed to a knockout tank, where the mixture is separated into vapor and liquid streams.

The vapor stream is passed through treatment (a thermal oxidizer at the beginning of operation, then vapor GAC vessels) before being discharged.

The liquid stream is pumped to a water storage tank until sufficient volume has been accumulated before being pumped through a bag filter and liquid GAC vessels into a separate storage tank to be re-injected to groundwater or discharged by gravity drain to the sanitary sewer. The volume of water will be based on the required minimum flowrate through the GAC vessels.

Once the concentrations have stabilized, the groundwater will be amended with a surfactant prior to reinjection to release additional hydrocarbons from the soil. This will be followed months later by bioremediation.

Once the bioremediation phase is implemented, the water from the GAC will enter the post GAC storage tank and then be transferred into a mixing tank. The groundwater is then amended with oxygen, and/or other electron acceptors, petroleum degrading bacteria, and nutrients prior to reinjection into multi-purpose wells.

4.1.2 Treatment Options

Soil vapor and extracted water will be treated by carbon adsorption using GAC vessels. During startup, provision will be made to treat vapors with a thermal/catalytic oxidizer until concentrations have decreased to a level suitable for treatment via the vapor GAC vessels. The thermal oxidizer will then be removed, and vapor directed to vapor-phase GAC vessels for treatment prior to discharge. The specific sizing for the GAC vessels is based on the estimated flowrate and maximum expected concentration of petroleum hydrocarbons in both vapor and groundwater observed during previous investigation activities (Appendix B). Initial concentrations are expected to be less than 50,000 µg/L GRO, resulting in an initial mass removal rate of 0.11 pounds per day (lb/day). It is expected that concentrations will start high during initial system startup and then decrease over time. The exact GAC vessel changeout schedule will be determined during system operations based on the utilization rate, vendor guidance on changeout frequency, and measurement procedures. Details will be provided as part of the O&M plan.

After treatment, the groundwater recirculation system will use a variety of amendments to enhance the removal and/or aerobic/anaerobic biodegradation of total petroleum hydrocarbons (TPH) and volatile organic compounds (VOCs) in saturated soils and groundwater. This process typically includes adding terminal electron acceptors (TEAs) for microbial respiration (such as dissolved oxygen or nitrate), depleted macronutrients (typically nitrogen as ammonia and phosphorous as phosphate), and bacteria that are selectively cultured for their petroleum-degrading capabilities. Surfactants are also recommended to remove the hydrocarbon mass from the soil matrix and release it into the groundwater to reduce the remediation timeframe. It is anticipated that, upon injection of the surfactants, petroleum hydrocarbon concentrations in groundwater will increase temporarily, indicating mass is coming off the soil matrix and is more available for the extraction via the remediation wells and the bioremediation process. The amendments that will be used are designed to accelerate the microbial degradation of remaining petroleum-hydrocarbon-impacted vadose zone and groundwater.

Generally, aerobic respiration yields the fastest bioremediation rates; however, oxygen concentrations are typically utilized within days to a few weeks. Nitrate levels are typically longer lasting *in situ*; an anaerobic bioremediation is typically effective for several months following injection. Due to the high biochemical oxygen demand/chemical oxygen demand (BOD/COD) mass balance of these bioremediation systems, additional TEAs and macronutrients will be required to maintain robust microbial activity. The depletion of TEAs and macronutrients causes the microbial kinetic rates/growth rates to decrease by orders of magnitude, inhibiting the biodegradation of contaminants. Consequently, additional injection of the TEAs and macronutrients is necessary to maintain ongoing bioremediation.

4.1.3 Remedial Action Components

The extraction and injection system of wells will include the following:

- Two new, 4-inch PVC remediation wells installed to a depth of 20 feet bgs.
- One new, 4-inch PVC remediation well installed to a depth of 30 feet bgs with a screened interval between 23 to 28 feet bgs.
- Three new, 4-inch PVC slant wells, installed to a depth of approximately 20 feet bgs.
- Three new sub-slab depressurization wells installed at a depth of 3 feet.
- Four vapor monitoring points (VMPs) installed to allow sub-slab vapor monitoring within the existing onsite buildings.

The excavation and trenching activities will include the following:

- Approximately 1,750 square feet of trenching.
- Approximately 1,500 linear feet of pipe.
- Approximately 250 cubic yards of excavation. Trenches will be approximately 2 feet wide and 3 feet deep on average.

Process equipment will include the following:

- A knockout tank for separating the mixture extracted from the wells into vapor and liquid only streams for treatment and discharge.
- Water storage tank. Approximately 400 gallons in size for storage of water prior to treatment to allow for sufficient flow through liquid GAC vessels.
- Two vapor-phase GAC vessels operated in a lead-lag arrangement. The GAC vessels will contain approximately 2000 lbs of carbon each.
- Four liquid-phase GAC vessels operated in a lead-lag arrangement. The GAC vessels will contain approximately 200 lbs of carbon each.
- An oil-sealed liquid ring pump. The pump will have a capacity of approximately 300 actual cubic feet per minute (acfm) at 29 inches of mercury (Hg) vacuum. The blower will be placed over a dense rubber vibration mat to reduce vibration and noise.
- Post-GAC water storage tank. Approximately 300 gallons in size for storage of water prior to discharge or reinjection.

Reinjection equipment and amendments will include the following:

- Batch/mixing tank and mixer. Approximately 300 gallons in size. The tank and mixer will be used to dissolve and mix powdered amendments prior to injection.
- Injection pump and controls.
- Oxygenation equipment. To oxygenate water prior to reinjection.
- Bacteria. Injected with the water to create an *in situ*, hydrocarbon-degrading microbial population that biochemically oxidizes the contaminants into carbon dioxide and water.
- Micro and macro nutrients. Specific blend of critical nutrients like nitrogen, phosphorous, and potassium to support ongoing biological growth.
- Surfactants. To release additional hydrocarbons that have been adsorbed to the soil into the groundwater/soil vapor for degradation and extraction.

Monitoring equipment will include the following:

- Three (3) 3-foot-long horizontal sub-slab depressurization wells
- Four vapor monitoring pins.

4.2 Design Criteria

The following sections describe the design elements of the remedial action and present the design criteria and rationale in accordance with the requirements specified in WAC 173-340-400(4)(a)(viii)(A).

4.2.1 Design Assumptions

The well locations shown on Figure 5 were selected to maximize the extents of the vapor and groundwater extraction. These well locations were chosen in a manner such that the radius of influence (ROI) of the wells would encompass a majority of the impacted soil or groundwater area. The ROI for each well was estimated based on site conditions and the information known about the geology and hydrogeology of the site. An ROI of 20 feet was estimated for vapor and an ROI of 30 feet was estimated for groundwater. The multiphase extraction ROI was selected based on the field testing performed at the site by Eco-Vac Services (Eco-Vac Services 2005) in 2005. The groundwater ROI was calculated based on the assumptions listed in the calculation provided in Appendix C. These values were chosen conservatively, and the actual ROI of the wells may be greater than assumed.

Horizontal wells were originally proposed as part of the conceptual design in the CAP. However, Macauley Trenchless conducted a review of horizontal well installation methods that could be employed at the site and determined that horizontal wells were not cost-effective for the site and installation location. Macauley Trenchless recommended using slant wells as an alternative to address areas beneath 24th Avenue East. The technical memorandum from Macauley Trenchless is included as Appendix D.

The Corrective Action Plan for the site notes that “the vapor intrusion pathway into the onsite structures is considered potentially complete pending further characterization...” To address this pathway, three (3) sub-slab depressurization (SSD) wells will be installed on the western and northern sides of the existing onsite structures. In addition, four (4) vapor monitoring points will be installed with the building. These will be used during the system install and operation to complete the assessment of the vapor intrusion pathway, and, if necessary, provide a vacuum adjacent to the sub-slab area to mitigate the potential for vapor intrusion. Sub-slab depressurization is a presumed remedy for vapor intrusion and has documented its effectiveness at many sites. The monitoring elements will allow both the characterization to be completed and the effectiveness documented, if necessary.

4.2.1.1 Efficiencies

The efficiencies of the proposed treatment technology are included in this section, per WAC 173-340-400(4)(a)(viii)(B).

GAC vessel manufacturers report typical removal efficiencies of 95 percent (%) of contaminants from a waste stream. Placing multiple vessels in series provides for additional treatment and removal of contaminants. Multiple vessels also allow for monitoring of breakthrough of the lead vessel to signal GAC replacement.

The thermal oxidizer is expected to achieve a removal efficiency of 97%, in accordance with the Puget Sound Air Pollution Control Agency requirements. For higher concentrations of contaminants, the destruction removal efficiency may be even higher.

4.3 Facility-Specific Design Issues

The facility plans to maintain operation as a commercial facility during operation of the remedial system and during system construction (as possible). Per WAC 173-340-400(4)(a)(xii), the following facility-specific design issues have been identified and are explained below.

- Design and construction staging should allow for the operation of the existing facility during construction and operation of the remedial system. This includes operation of the onsite businesses as well as neighboring infrastructure such as the adjacent bus line and bus stop. Utilities must be protected in place during construction, and construction will need to be coordinated with bus operations. Where possible, the system will be designed to preserve parking lot spaces. Alternative parking areas may need to be designated during construction activities.
- Limited site footprint for staging during construction and during operation of the remedial system. A construction staging plan and timeline will be important components of the project manual to ensure that sufficient room is available for constructing the remedial system. Where possible, soils generated during construction should be transported offsite without the need for staging.
- Pedestrian traffic to the site is high; access to the system must be restricted by fencing to prevent pedestrians from being exposed to system components. During construction, channelizing devices should be used to keep pedestrians from entering the construction area.
- Noise levels during operation of the remedial system must comply with state and local ordinances.

- System design should account for operation at temperatures and humidity expected throughout the year.
- Seismic activity and flooding are possible, but not expected; the site is located away from potential flooding areas. The system should comply with local building codes for seismic activity.
- The shallow perched groundwater present at the site is expected to fluctuate seasonally; the system will be designed to account for the range of water level fluctuation observed at the site over the last 30 years.
- The extent of impacted media beneath the onsite building and beneath 24th Avenue East are not fully characterized; conservative design assumptions must be utilized to ensure that impacted media in these areas will be addressed by the remediation system.
- If Ecology will be responsible for paying for power costs for system operation, a new power drop and meter may be needed. Existing power at the site is located in the northeastern corner of the site.

The system will be designed to allow the facility to remain open during operation of the remedial system, and as possible, during system construction. This may require additional measures to protect the short-term (e.g., traffic and pedestrian control) and long-term (e.g., noise) safety of the community.

4.4 Demonstration of Efficacy of the Remedial Action

MPE has shown to be effective at removing petroleum hydrocarbons through past activities at the site, historical case studies, and scientific literature. A brief description of the efficacy of MPE is included in this section, per WAC 173-340-400(4)(a)(viii)(C).

The EPA states that MPE can address contamination in both the saturated and vadose zones, and affects mass removal by volatilization, dissolution, and advective treatment. MPE is advantageous in that it can provide contaminant source removal in lower permeability settings, can remediate multiple phases of contamination, and potentially create a large ROI affecting a greater capture area (EPA 1999). MPE also requires fewer wells than other remediation systems due to its ability to maximize fluid recovery at the wellhead and reduces the drawdown necessary to obtain a given flow rate (EPA 1999). In the *EPA's Multi-Phase Extraction: State-of-the-Practice* document, three case studies were reviewed to determine the effectiveness of MPE systems. All three of these case studies found that an MPE system was effective in removing VOC contamination from the vadose zone and groundwater. In one case study, the maximum reduction in VOC concentrations in groundwater was reduced by over 98% within 1 year of operation. Another case study found that over 40% of the VOC mass was removed from the vadose zone during the first month of operation.

In June 2005, Eco-Vac Services, Inc. of Woodstock, Georgia, conducted a mobile dual phase extraction technology pilot test at the site. This technology used a combination of a truck-mounted vacuum and liquid handling system integrated with a mobile hydrocarbon vapor treatment system. High vacuum is applied to one or more monitoring wells to remove multiple phases of hydrocarbons (liquid, dissolved, adsorbed, and vapor phase) simultaneously. This system extracted from four wells on site over an 8-hour period to determine the ability to induce a vacuum on site and extract groundwater, soil vapor, and petroleum hydrocarbons. A total of

112 pounds of petroleum hydrocarbons (equivalent to 18 gallons of gasoline) were removed during this event. Several extraction well configurations were tested with vapor-phase hydrocarbon removal rates ranging from 1.9 to 38 pounds per hour, with the largest removal rate occurring when extracting from MW-4, MW-8, and MW-9 (all located near the former UST excavation area) together. The range of vacuum readings at the individual extraction wells were also measured and ranged from 13 to 19 inches of mercury. This pilot study showed that a similar MPE system would also be effective at removal of petroleum hydrocarbons in various phases from the site.

In addition, the efficacy of the system will be confirmed through the monitoring of concentrations of COCs in groundwater, soil, and vapor samples. More details on the Sampling and Analysis Plan and confirmation monitoring to document to the reduction in COCs on site is included in Section 7.

4.5 Spill Control During Construction

Spill potential during the remedial action is limited to fuel and lubrication oil from construction equipment and chemicals involved in the treatment system. Per WAC 173-340-400(4)(a)(ix), spill potential during the remedial action will be addressed as follows:

- All chemicals will be stored with secondary containment.
- Areas containing chemicals will be secured and locked to prevent unauthorized access.
- The contractor will maintain a spill control kit for equipment-related spills during installation of the system.

4.6 Protection of Human Health and the Environment

Short-term protection of human health and the environment pertains to implementation of the remedial action. Long-term protection involves the period beginning at the startup of the system through the compliance monitoring period. Based on site conditions, the most likely exposure routes of concern are the potential inadvertent ingestion or inhalation of soil or dust, inhalation of VOCs, and dermal absorption of site surface materials. A description of the short- and long-term protection measures to be included in the remedial action, per WAC 173-340-400(4)(a)(x), are included below.

4.6.1 Short-Term Protection

Short-term protection of human health and the environment involves risks associated with the hazardous constituents in site material and risks typically related to construction activities.

Materials below the surface of the site may present potential risks to human health or the environment during construction. Cutting and removing paving and asphalt, excavating soil material, and backfilling the trench may expose workers to hazardous substances. Workers will use personal protective equipment (PPE) to reduce the risks involved with handling hazardous site materials. If site construction activities produce visible dust, the contractor will apply water to surface materials to control fugitive dust emissions.

The contractor will decontaminate all equipment that may be exposed to contaminated site materials and describe such decontamination procedures as part of the construction submittals. The contractor will dispose of all waste materials in accordance with applicable federal, state, and local laws and regulations. All workers on site will be required to have up-to-date Hazardous Waste Operations and Emergency Response (HAZWOPER) certification.

The remedial action also involves activities typically associated with construction sites that could pose risks to human health. These activities include working near moving heavy equipment, noise from heavy equipment, tripping and falling hazards, and lifting heavy objects. The remediation contractor's Health and Safety Plan (HASP) will address construction-related safety hazards to site workers. The contractor may specify within their HASP to monitor air for harmful VOC levels during system installation. Contractor shall monitor ambient air concentrations while trenching, excavating, or working with other sub-surface materials to ensure concentrations do not exceed permissible exposure limits identified within their HASP.

A security fence will surround the construction activities to prevent unauthorized personnel from entering the construction areas. Signage will also be displayed prominently on fencing and in other locations. Traffic control measures will be enacted where necessary. Traffic control measures will be conducted to minimize interference with normal traffic patterns.

4.6.2 Long-Term Protection

During operation of the MPE system, vapor monitoring pins located in the buildings on site will be used to monitor indoor air concentrations to protect occupants. Vapor monitoring events will be conducted quarterly. Horizontal sub-slab depressurization wells will be installed as part of the system implementation to mitigate intrusion of vapors with COCs from underneath the buildings on site.

The contractor will provide secondary containment for any chemicals located in the treatment shed area. The treatment shed area will be secured with fencing. If any equipment is located outside the fencing, it will be secured with locks to prevent access.

A dense rubber vibration mat will be placed underneath the blower to reduce noise levels to acceptable levels. The blower and other equipment will be located within the treatment shed, which will also reduce noise levels.

Long-term protection will be achieved by removing the contaminated materials and reducing exposure to the COCs present onsite.

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Section 5: Remedial Action

Engineering plans and specifications will be developed to provide details of the remedial design and to serve as a basis for contractor bidding. The engineering drawings and specifications will be submitted separately from the EDR. The following section summarizes the remedial action work elements that will be set forth in the engineering plans and specifications.

5.1 Sequencing of Work

The anticipated phases of work for the implementation of the system are summarized as follows:

- Phase 1. Install the three new vertical and three new slant wells on site. Install the vapor pins and horizontal sub-slab depressurization wells.
- Phase 2. Conduct trenching and excavation for the placement of piping from each well head to the treatment shed. Backfill the trench after piping has been installed. Repave.
- Phase 3. Install treatment system shed, GAC vessels, security fencing, and other treatment system components.
- Phase 4. System operation and compliance monitoring.
- Phase 5. Site restoration will occur after CULs have been met. Site restoration activities will include decommissioning of wells, removal of the treatment shed, GAC vessels, and other treatment system components. Piping will be left in place. Some wells may be left in place for groundwater monitoring activities.

5.2 Mobilization and Site preparation

Contractor mobilization and site preparation includes preparation of construction plans; mobilization of equipment, materials, and staff; and preparing for construction activities. Mobilization and site preparation will consist of:

- Prepare construction plans, including a HASP and Work Plan.
- Install a temporary chain-link fence along the perimeter of the work areas to prevent unauthorized access to work areas. Install locking gates at the construction entrances.
- Place signs announcing the construction activities, safety warnings, and traffic control.
- Construct a decontamination facility for site equipment and construction personnel.
- Mobilize equipment and materials to the site.
- If sampling is required to profile soil for disposal, this sampling will be completed prior to excavation and trenching activities.

It is not expected that the contractor would place a temporary office trailer or establish a parking area at the site. The treatment shed area will serve as a site laydown and equipment staging during well installation and trenching and excavation activities. Workers will be required to park off site. All construction activities shall be conducted to minimize disruption to the site.

5.3 Health and Safety Plan

Each contractor that will work on the site is responsible for the safety of their employees. Each contractor will prepare their own HASP [per WAC 173-340-400(4)(a)(xv) and WAC 173-340-810] that will outline the health and safety protocols including the names of key personnel responsible for site health and safety, details of personal protective equipment to be used for each site task and operation, site control and decontamination procedures, an Emergency Response Plan, and procedures to report injuries or illness, property damage, or near miss incidents.

In addition, each worker conducting activities on site must have current HAZWOPER certification in accordance with 29 CFR Part 1910.120.

In general, potential hazards that may arise due to the trenching, excavation, and system installation activities involved in the remedial action include, but are not limited to:

- Heavy equipment
- Excavations and Trench work
- Tripping and falling hazards
- Heat stress
- Cold exposure
- Underground/overhead utilities
- Motor vehicle hazards
- Biological exposure
- Equipment hazards
- Chemical exposure
- Fire/explosion hazard.

Appropriation precautions to minimize the risk of injury, illness, property damage, or a near miss incident include, but are not limited to:

- Wearing approved hardhats, safety vests, safety glasses, and safety-toe boots.
- Wearing hearing protection if maximum noise levels are expected to exceed 85 decibels at any time during site operations.
- Maintaining visual contact with equipment operators at all times within or near the equipment operating radius.
- Identification of overhead electrical hazards and potential ground hazards prior to drilling and trenching.
- Paying attention to exposed bare surfaces, stairs, platforms, concrete walkways, truck beds, etc. for potential trip and fall hazards.
- Taking extra care in the event of wet or frozen ground.

- Drinking sufficient water and taking breaks, when necessary, when temperatures exceed 75 degrees Fahrenheit on site.
- Wearing appropriate clothing and taking appropriate rest periods during low temperatures or high wind-chill factors.
- Maintaining personal awareness in regard to vehicle, truck, and equipment traffic.
- Inspecting all hand and small power tools prior to use and immediately removing from service any tool or piece of equipment that is damaged.

Additional health and safety precautions relevant to the site are included in the site HASP, which is included in Appendix E.

5.4 Erosion and Sediment Control

The City of Seattle Stormwater Code establishes requirements for municipal stormwater permits for construction and lists exemptions specific to remediation projects.

The proposed remedial action will maintain natural drainage patterns and the existing discharge point. The site is not considered a flood prone area. To be conservative, it is assumed that more than 2,000 square feet and less than 5,000 square feet of the site will be disturbed during implementation of the remedial action, triggering requirements for a Construction Stormwater Pollution Prevention Plan (CSWPPP). The CSWPPP will establish construction access protocols, Best Management Practices (BMPs), and other activities to prevent erosion and sediment transport from the site to protect downstream properties and receiving waters. The CSWPPP will require erosion control BMPs, secondary containment, and spill kits on site and identify maintenance or inspection procedures. The selected contractor will be required to comply with the provisions outlined within the CSWPPP during the implementation and operation of the remedial action.

5.5 Structures Removal and Demolition

It is not anticipated that any structure demolition or removal will be required for implementation or operation of the MPE system.

5.6 Utility Replacement

Utilities located on site will be protected in place. Contractor shall have personnel on site that are prepared to repair electrical, water, sanitary, or other utilities if necessary. Contractor shall take care when crossing utilities.

5.7 Waste Disposal

Waste, e.g., investigative-derived waste (IDW), is expected to be generated during system construction (e.g., soil from well construction and trenching) and during system operation (e.g., extracted groundwater). Vapor-phase effluent will also be generated as part of system operation and will be discharged into ambient air under guidance and permits from the Puget Sound Clean Air Agency. Per WAC 173-340-400(4)(a)(xi), the section below details methods expected to be employed to manage and/or dispose of soil IDW and extracted groundwater generated as part of system construction and operation.

Petroleum-impacted soil generated from system construction will be field screened with a photoionization detector (PID) to confirm the presence of volatile compounds, and will be profiled and disposed of offsite. Due to limited site space for stockpiling soil, the contractor will be expected to sample shallow soils prior to trenching in order to generate analytical information to be used for soil profiling and disposal. Soil samples will be analyzed for GRO and BTEX constituents by NWTPH-Gx and EPA Method 8260, Toxicity Characteristic Leaching Procedure (TCLP) for benzene, along with other analyses as required by the disposal facility. TCLP is likely to be required for benzene as the concentrations of benzene present in soils at the site may be above the limit for disposal at a Subtitle D landfill (10 mg/kg), and potentially over the limit for Subtitle C. Depending on the concentrations of benzene present in soil, excavated soil may need to be disposed of as dangerous waste; however, based PID concentrations observed in shallow soils during the RI/FS, it is expected that shallow (0-4 foot) soils can be disposed of at a Subtitle D landfill and will not need to be disposed of as dangerous waste. Soils should be direct loaded whenever possible to maintain space at the site during construction.

If pre-sampling by the contractor indicates that concentrations of GRO and BTEX constituents in soil are below MTCA Method A CULs in soils to be excavated, then soil may be reused as backfill.

IDW water generated during construction from well development and decontamination of equipment would be drummed onsite, and a composite sample would be collected from the IDW water. Based on the concentrations of GRO and BTEX constituents, the water would be profiled and disposed of by one of the following methods: Subtitle D or C landfill, treatment by a third party (e.g., Clean Earth) and discharged to the King County Publicly Owned Treatment Works, or incineration.

Groundwater is expected to be generated as part of system operation. Groundwater will be treated using GAC designed for liquid-phase treatment. Treated groundwater is expected to be initially discharged to the sanitary sewer. Once groundwater concentrations have decreased to nearly asymptotic concentrations, surfactants will be used, followed by bioremediation amendments, which are expected be effective in treating groundwater. Groundwater will be treated to concentrations equal to or below the MTCA Method A CULs for groundwater, and then amended and reinjected at the site in accordance with a UIC permit.

If the liquid-phase treatment system is operating, IDW water generated during groundwater sampling activities can be added to the water waste stream for treatment and either discharge to the sanitary sewer or reinjection. If the liquid-phase treatment system is not operating, then IDW water will be disposed of as noted above for IDW water generated during construction.

GAC, from both liquid and vapor phase treatment streams, will need to be changed out at regular intervals to ensure treatment efficacy. Used GAC will be sampled and shipped back to the provider for regeneration, if possible. If GAC cannot be reused via regeneration, it will be disposed of offsite at the appropriate landfill (based on analytical results).

5.8 Site Restoration

Site restoration activities can be broken into two phases: (1) at the conclusion of the installation of the MPE system and (2) at the conclusion of operation of the system.

The site restoration activities for the first phase includes:

- Repaving disturbed asphalt or concrete on site.
- Restriping parking spaces.
- Installation of security measures (locks, fences) surrounding the treatment shed and other treatment system components.
- Installation of signage at the treatment shed and security fence.

The site restoration activities for the second phase includes:

- Decommissioning wells not used for groundwater monitoring in accordance with WAC 173-160.
- Abandoning underground piping from wells to treatment system.
- Removal of treatment shed, GAC vessels, and other treatment system components from the site.
- Restriping parking spaces covered by the treatment system area, if necessary.

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Section 6: Construction Quality Assurance/Quality Control Procedures

Design submittals will be produced at the 50%, 90%, and 100% completion status. Construction specifications will also be included in a project manual as part of the 90% and 100% design submittal package. Per WAC 173-340-400(4)(a)(xiii), the following section provides a general description of the construction quality assurance/quality control (QA/QC) procedures to be defined in the project manual.

6.1 Materials

Materials used in construction of the remedial action will be tested for compliance with the specifications included in the project manual. In general, specifications for the following materials will be included in the project manual:

- Well casing and screening material and drilling procedures.
- Imported backfill for backfilling the trenching. Backfill will be tested prior to import.
- Piping material for the piping between extraction/injection wells and the manifold, piping between the manifold and the treatment shed, and piping within the treatment shed.
- Paving and resurfacing materials for replacing disturbed pavement and asphalt.
- Storage containers for chemicals to be used as part of the treatment system.
- Pipe bedding for the piping between the extraction/injection wells and the manifold.
- Equipment anchorage for GAC vessels and other tanks associated with the treatment system.
- Electrical equipment associated with the blower, pumps, and other treatment system components.

The contractor will submit test results for materials to the engineering for review. Upon favorable review, the contractor will be allowed to ship the materials onsite.

6.2 Construction

The engineer will monitor and enforce compliance with the following construction quality assurance activities during remedial action operation.

- Well Installation. Wells will be installed by a licensed driller in accordance with WAC 173-160.
- Clean Fill. Representative soil samples will be collected from soil stockpiled and analyzed for site COCs to determine whether soil is suitable for reuse as excavation backfill, per the Guidance for Remediation of Petroleum Contaminated Sites (Ecology 2016). If onsite soil is not reused, imported soil to be used for backfill will be analyzed for common environmental contaminants [e.g., petroleum hydrocarbons, metals, VOCs,

polycyclic aromatic hydrocarbons (PAHs)] prior to import onsite in order to show that imported fill is not contaminated.

- Backfilling. Materials will be placed to bring the finished site grade to the existing grade prior to construction. All materials will meet 95% compaction as specified by ASTM Method D1557 Modified. The remediation contractor will perform compact testing at a frequency of one test for every 500 square feet for every 2 feet of fill.
- Storing, Loading, and Transporting Materials. All stockpiled materials will be lined, bermed, and covered when not in use to prevent those materials from being dispersed via wind or rainfall. When materials are loaded onsite, proper measures shall be in place to prevent dispersion of materials in areas other than original or final locations. All soils taken offsite for disposal shall be properly manifested, and final disposition of materials shall be recorded.

6.3 Documentation

After completion of the installation of the MPE and groundwater recirculation system, a construction completion report will be prepared and provided to Ecology. The construction completion report will provide the following information:

- As-built drawings showing the area and volumes of soil removed for disposal, location of the piping, and location of the treatment system components.
- Waste disposal documentation, including soil disposed of at the Subtitle D landfill.
- Performance monitoring results and sample locations.
- Appendices providing pertinent information cited in the construction completion report.

Section 7: Compliance Monitoring

This section describes the objectives, locations, and methods for compliance monitoring activities that will be performed at the site as part of the remedial action. Compliance monitoring activities identified in this section will fulfill requirements for ongoing monitoring of this remedial action in accordance with MTCA (WAC 173-340-410) and WAC 173-340-400(a)(xiv). A Sampling and Analysis Plan (SAP), meeting the requirements of WAC 173-340-820, will be prepared as part of the O&M Plan. The SAP will identify the soil, groundwater, and vapor sampling frequencies and analytical tests to be performed during cleanup activities (protection and performance monitoring) and for the duration of the compliance period. The following sections include description of the monitoring activities expected to be include as part of the SAP.

Existing site monitoring wells not included as part of the remedial action will remain onsite for possible future use during confirmational monitoring. The existing locations of these monitoring wells are shown on Figure 2.

7.1 Protection Monitoring

Health and safety measures are required for those individuals working at and visiting the site. The contractor will prepare a site HASP, which will describe health and safety measures, including any protection monitoring necessary during construction activities.

During construction and operations and maintenance activities, the contractor will confirm that human health and the environment are protected in accordance with the site HASP and federal and local regulations. Within the contractor's site HASP, details will be included on procedures for vapor and air space monitoring for protection of construction workers.

Specific on-site protection monitoring will include vapor monitoring to assess the possibility of a vapor intrusion pathway into the buildings on site. Vapor monitoring will be conducted via the sampling of vapor pins to be located within the buildings on site. Vapor monitoring will continue through site restoration activities.

7.2 Performance Monitoring

Performance monitoring will be conducted to confirm that the remedial action has attained the site CULs and met the RAOs outlined in Section 3.

Performance monitoring to be completed during construction activities will include soil screening and sampling. Soil sampling will be submitted for chemical analysis of total petroleum hydrocarbons as gasoline- and diesel-range hydrocarbons. Soil samples for chemical analysis will be stored in a cooled ice chest pending transportation to a certified analytical laboratory under chain-of-custody protocol. QA/QC samples will be collected during each field sampling activity.

Groundwater monitoring will be conducted during system operation. During initial operation and transitions between treatment methods, monitoring may be conducted more often at selected wells. Performance of the liquid treatment system will be confirmed via sampling and analysis of the influent and effluent, in accordance with recommendations from the City of Seattle and King County. Performance of the vapor treatment system will be confirmed via sampling and analysis of the influent and effluent, in accordance with recommendations from the Puget Sound Air Pollution Control Agency. Additional details on performance monitoring will be included in the O&M Plan (under separate cover).

7.3 Confirmation Monitoring

Confirmation monitoring will be conducted to assess the long-term effectiveness of the remedial action once cleanup standards have been attained and/or once the remediation system is no longer actively operating. Confirmation monitoring at the site will likely include soil sampling to confirm soil meets site cleanup levels, and four consecutive quarters of groundwater monitoring to show that groundwater concentrations meet site cleanup levels. The specific requirements for future groundwater, soil, and vapor monitoring activities at the site will be included in the SAP. The SAP will identify groundwater, soil, and vapor sampling methods, analyses to be performed, and sampling frequency. The monitoring wells to be used for confirmational monitoring will also be identified in the SAP.

Section 8: Operations and Maintenance Plan

An operations and maintenance plan will be prepared separately. A draft operations and maintenance plan is expected to be completed by second quarter 2022. A final operations and maintenance plan with public works contractor submittals is expected to be completed by first quarter 2023.

Generally, the operations and maintenance plan is expected to include at least the following items:

- Procedures for switching from thermal oxidation to the GAC vessels for treatment once vapor concentrations have decreased.
- Details on the scheduling of replacement of carbon in the GAC vessels and inspection the vessels for leaks or channeling.
- Groundwater, soil, and vapor sampling procedures as described in the SAP.
- Procedures for the adjustment of flow rates from wells and the adjustment of which wells are used for extraction versus reinjection to optimize contaminant removal.
- Monitoring of noise levels from the blower.
- Periodic drainage of any water that may accumulate at low spots in header lines. Inspection of water or gas lines for leaks.
- Performance of pressure tests of pneumatic lines.
- Inspection of extraction/injection wells for signs of leaking or clogging.
- Inspection of blower bearings or seals for damage or wear. Inspection of valves between the blower and the extraction wells.
- Establishment of a recordkeeping system for documenting the operation and remedial progress of the system.

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Section 9: Financial Assurance

Financial assurance [e.g., WAC 173-340-400(4)(a)(xviii)] is not applicable to this remedial action, and no discussion of financial assurance is provided. Per the CD, Ecology is responsible for funding the remainder of the remedial action.

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Section 10: Institutional Controls

The goals of the remedial action are to remediate COC-impacted media to concentrations below the site CULs. It is expected that the proposed remedial action will achieve this goal; therefore, institutional controls [e.g., as noted in WAC 173-340-400(4)(a)(xix)] such as land use restrictions are not expected to be needed. If confirmation monitoring indicates that the remedial action did not succeed in reducing COC concentrations to below site CULs, the need for institutional controls will be reevaluated. Possible institutional controls could include requiring ongoing groundwater and/or indoor air monitoring, a deed restriction, or maintenance of an asphalt cap.

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Section 11: Remedial Action Schedule and Opinion of Probable Costs

A general remedial action schedule, as required in WAC 173-340-400(4)(a)(vi), is outlined below.

The design plans and construction specifications are expected to be completed in second quarter 2022. A contractor is expected to be selected by third quarter 2022. The installation of the system is expected to be completed in 4 to 6 weeks as outlined below.

Estimated Project Schedule

Project Phases	Estimated Duration
Phase 1. Mobilization and Well Installation	1 week
Phase 2. Excavation and Trenching	1 to 2 weeks
Phase 3. Treatment System Installation	2 to 3 weeks
Phase 4. Operation and Compliance Monitoring	3 to 10 years
Phase 5. Site Restoration	1 to 2 weeks

As indicated above, each phase will be completed consecutively. The actual time required to complete the remedial action may vary depending on site conditions, weather conditions, and the rate of decrease in the constituents in the groundwater and vapor on site.

The opinion of probable construction costs (OPCC) based on the conceptual remedial action plan outlined in this document is included in Appendix F. The estimated cost of the system ranges from approximately $1,736,000 to $2,821,000 based on a 40% design progress and Class 3 estimate in accordance with the Association for the Advancement of Cost Engineering (AACE).

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Kennedy Jenks. 2017c. Pilot Study Work Plan, Former Circle K Site. 1 February 2017.

Kennedy Jenks. 2021. Technical Memorandum Re: Existing Project Data Review and Design Data Gap Analysis, Contract C2100069. 16 June.

State of Washington Department of Ecology. 2016. Guidance for Remediation of Petroleum Contaminated Sites. Publication No. 10-09-057. June 2016.

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Tables

Table 1: Monitoring and Multi-Purpose Well Construction Details

Monitoring Well ID	Date Installed	Well Diameter (inches)	Screened Interval (feet bgs)	Total Depth in 2006 (feet btoc)	Total Depth in 2016 (feet btoc)	Top of Casing Elevation (feet amsl)
MW-1	09/11/89	2	5.5-22.2	abandoned	abandoned	--
MW-2	09/11/89	2	5.5-20.9	20.9	20.90	69.79
MW-3	09/12/89	2	7.5-22.9	abandoned	abandoned	--
MW-4	09/12/89	2	4-18.8	17.9	17.90	63.62
MW-5	09/12/89	2	7-27.4	abandoned	abandoned	--
MW-6	10/02/89	2	5-20.4	20.43	20.33	63.13
MW-7	10/02/89	2	5-20.2	20.49	20.20	62.66
MW-8	10/03/89	2	5-20.3	19.45	19.40	63.59
MW-9	10/03/89	2	5-21.2	20.35	20.23	64.30
MW-10	10/03/89	2	5-20.4	20.47	20.22	62.86
MW-11	10/04/89	2	5-20.0	20.31	20.00	63.59
MW-12	10/04/89	2	5-20.3	abandoned	abandoned	--
MW-13	12/20/89	2	4-19.0	18.81	18.65	65.08
MW-14	12/20/89	2	4-19.3	18.87	15.50	63.30
MW-15	12/21/89	2	4-18.7	16.81	16.75	64.18
MW-16	12/21/89	2	4-19.2	18.94	--	64.00
MW-17	08/01/16	2	4.0-19.0	--	20.0	65.98
MW-18	08/01/16	2	5.0-15.0	--	20.0	66.73
MW-19	09/23/16	2	5.0-20.0	--	20.0	66.36
MW-20	09/23/16	4	5.0-20.0	--	21.0	66.17
MW-21	09/23/16	4	5.0-20.0	--	20.0	65.89
RW-1	02/07/17	4	5.5-21.5	--	21.5	--
RW-2	02/09/17	4	5.0-20.0	--	21.5	--
RW-3	02/09/17	4	5.0-20.0	--	21.5	--
RW-4	02/08/17	4	5.0-20.0	--	21.5	--
RW-5	02/08/17	4	5.0-20.0	--	21.5	--
RW-6	02/10/17	4	5.0-20.0	--	21.5	--
RW-7	02/07/17	4	5.0-20.0	--	21.5	--

Note:

Top of casing elevations surveyed to City of Seattle Benchmark SNV-2541 located at the northeast quadrant of the intersection of East Boston Street and 24th Avenue.

Abbreviations and Symbols

"- -" denotes not measured, not available, or not applicable.
bgs = below ground surface
btoc = below top of casing
amsl = above mean sea level

Figures

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Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors,

Legend

Site Location

N

0 200 400

Scale: Feet

Note:

1. All locations are approximate.

Kennedy Jenks

Former Circle K Site
Seattle, Washington

Site Location and Vicinity Map

K/J 2196008*00

Figure 1

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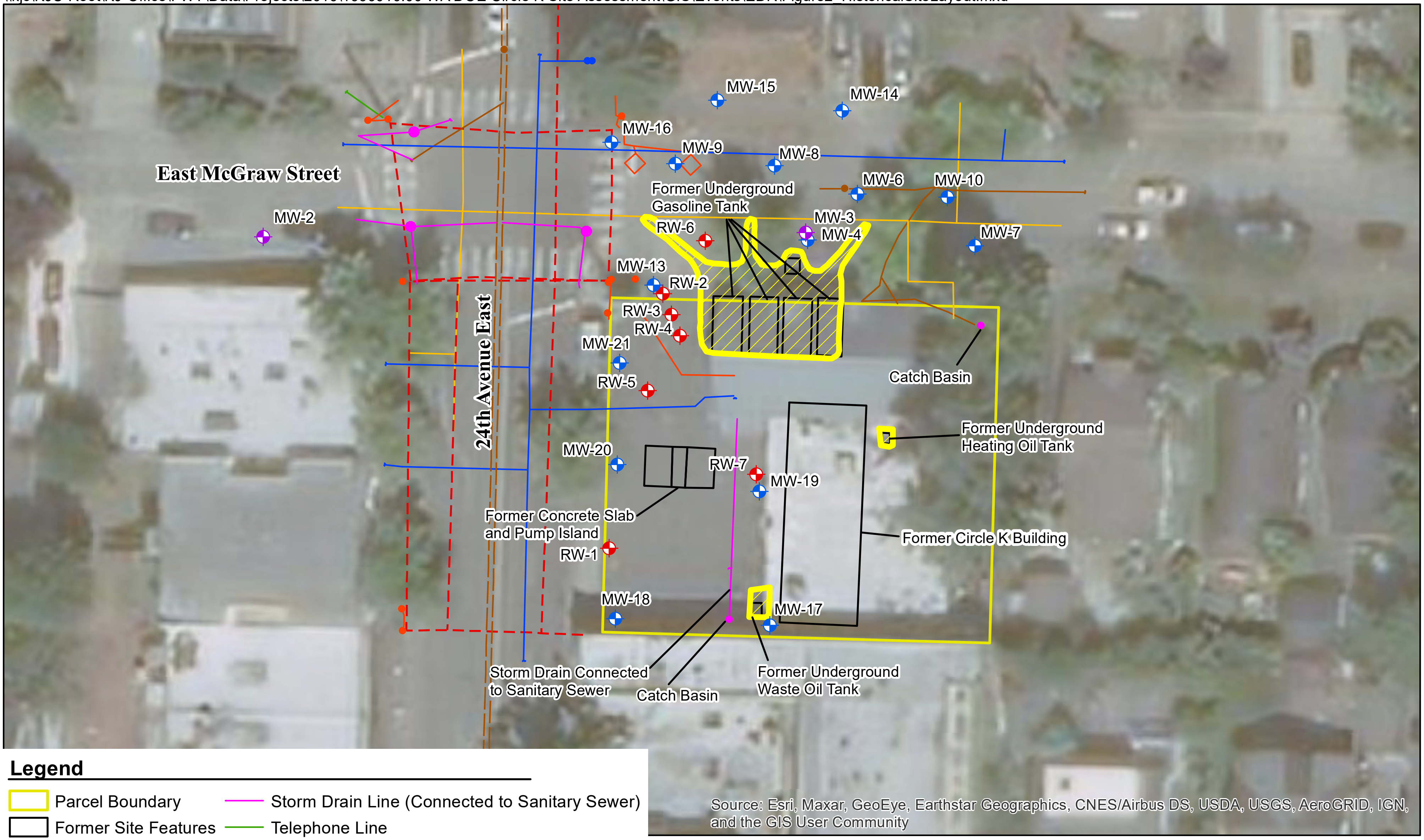

Notes:
1. All locations are approximate.
2. Sewer and water line locations are based on available site information and not appropriate for construction purposes.
3. Former feature locations georeferenced from *Report of Geotechnical Services Subsurface Contamination Study and Remedial Action Monitoring Circle K Facility 1461 Seattle, Washington*, dated 6 March 1990 by GeoEngineers.

N

0 20 40

Scale: Feet

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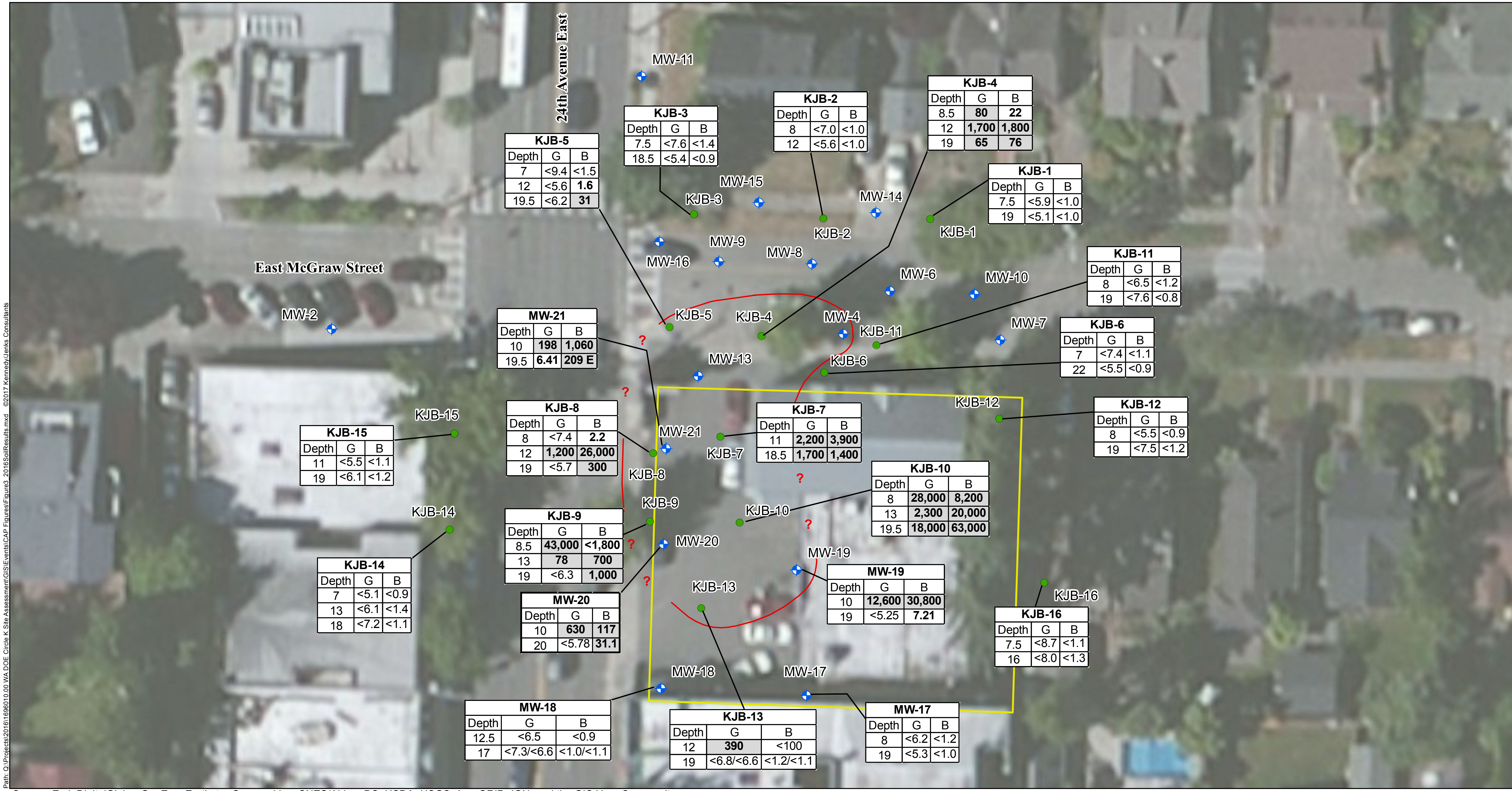
Former Circle K Site
Seattle, Washington

Historical Site Features, Monitoring Wells and Soil Boring Locations

K/J 2196008*00

Figure 2



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Legend

- Monitoring Well
- Soil Boring
- Parcel Boundary
- Approximate Extent of Gasoline-Range Organics/Benzene in Soil above MTCA Method A Cleanup Levels

Boring ID →
Sample Depth in feet →

MW-17		
Depth	G	B
8	<6.2	<1.2
19	<5.3	<1.0

← All concentrations in mg/kg. Concentrations are bolded where detected. Shaded concentrations are above the MTCA Method A cleanup level.

Notes:
1. All locations are approximate.
2. mg/kg = milligrams per kilogram.
3. G = gasoline-range organics.
4. B = benzene.

N

0 15 30

Scale: Feet

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Former Circle K Site
Seattle, Washington

2016 Soil Boring
Soil Sample Results

K/J 2196008*00

Figure 3

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Monitoring Well
- Landau Well
- Extent of GRO and/or BTEX concentrations exceeding MTCA Method A CULs in Groundwater
- Parcel Boundary

Notes:
1. All locations are approximate.
2. Groundwater samples were collected 7-8 December 2016 from monitoring wells.
3. NS = not sampled.
4. µg/L = micrograms per liter.
5. GRO = Gasoline-Range Organics.
6. BTEX = Benzene, Toluene, Ethylbenzene, Total Xylenes.

N

0 15 30

Scale: Feet

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Former Circle K Site
Seattle, Washington

Estimated Extent of GRO and BTEX Contamination December 2016

K/J 2196008*00

Figure 4

Plot Date: 12/7/2021 4:38 PM

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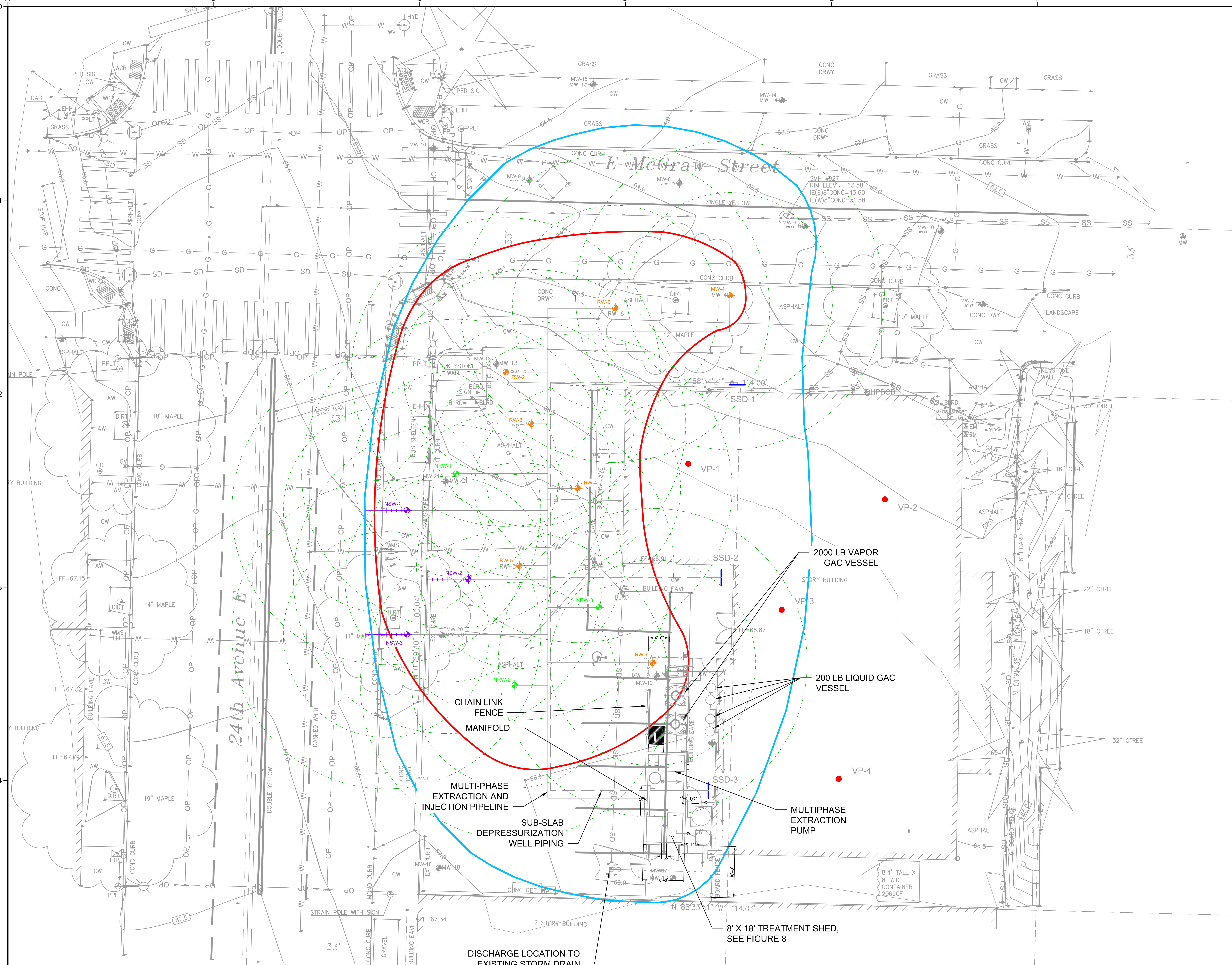

LEGEND

- EXISTING WELL TO BE USED FOR EXTRACTION/INJECTION
- EXISTING WELL NOT USED FOR EXTRACTION/INJECTION
- NEW EXTRACTION/INJECTION WELL
- NEW SLANT WELL
- VAPOR RADIUS OF INFLUENCE (20 FT)
- GROUNDWATER RADIUS OF INFLUENCE (30 FT)
- EXTENT OF GRO AND BTEX IN GROUNDWATER
- EXTENT OF GRO AND BTEX IN SOIL
- EXTRACTION AND INJECTION PIPING
- SUB-SLAB DEPRESSURIZATION PIPING
- SUB-SLAB DEPRESSURIZATION WELL
- VAPOR MONITORING PIN

NOTES:

1. WELL TERMINOLOGY:
   1A. GREY MW = EXISTING MONITORING WELL NOT USED AS PART OF SYSTEM
   1B. ORANGE MW = EXISTING MONITORING WELL TO BE USED AS PART OF SYSTEM
   1B. RW = EXISTING REMEDIATION WELL
   1C. NRW = NEW REMEDIATION WELL TO BE INSTALLED
   1D. NSW = NEW SLANT WELL TO BE INSTALLED
2. SLANT WELLS TO BE INSTALLED AT 30 DEGREES TO A DEPTH OF 10 FEET. HORIZONTAL EXTENT (APPROXIMATELY 8 FEET) SHOWN ON PLAN VIEW. RADIUS OF INFLUENCE OF SLANT WELLS CENTERED OVER MIDPOINT OF WELL CASING SHOWN.

0 10' 20'
1"=10'-0"

File: C:\bms\kjce-pw\d0181576\C-01-SYSTEM-LAYOUT.DWG

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BELLEVUE, WASHINGTON

FORMER CIRCLE K SITE 1461 CLEANUP
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CONCEPTUAL SYSTEM LAYOUT

SCALE	1"=10'
JOB NO	2196008.00
DATE	DECEMBER 2021
SHEET --- OF ---	**Figure 5**

LEGEND

- EXISTING WELL TO BE USED FOR EXTRACTION/INJECTION
- EXISTING WELL NOT USED FOR EXTRACTION/INJECTION
- NEW EXTRACTION/INJECTION WELL
- NEW SLANT WELL
- VAPOR RADIUS OF INFLUENCE (20 FT)
- GROUNDWATER RADIUS OF INFLUENCE (30 FT)
- EXTENT OF GRO AND BTEX IN GROUNDWATER
- EXTENT OF GRO AND BTEX IN SOIL
- EXTRACTION AND INJECTION PIPING
- SUB-SLAB DEPRESSURIZATION PIPING
- SUB-SLAB DEPRESSURIZATION WELL
- VAPOR MONITORING PIN

NOTES:

1. WELL TERMINOLOGY:
   1A. GREY MW = EXISTING MONITORING WELL NOT USED AS PART OF SYSTEM
   1B. ORANGE MW = EXISTING MONITORING WELL TO BE USED AS PART OF SYSTEM
   1B. RW = EXISTING REMEDIATION WELL
   1C. NRW = NEW REMEDIATION WELL TO BE INSTALLED
   1D. NSW = NEW SLANT WELL TO BE INSTALLED
2. SLANT WELLS TO BE INSTALLED AT 30 DEGREES TO A DEPTH OF 10 FEET. HORIZONTAL EXTENT (APPROXIMATELY 8 FEET) SHOWN ON PLAN VIEW. RADIUS OF INFLUENCE OF SLANT WELLS CENTERED OVER MIDPOINT OF WELL CASING SHOWN.

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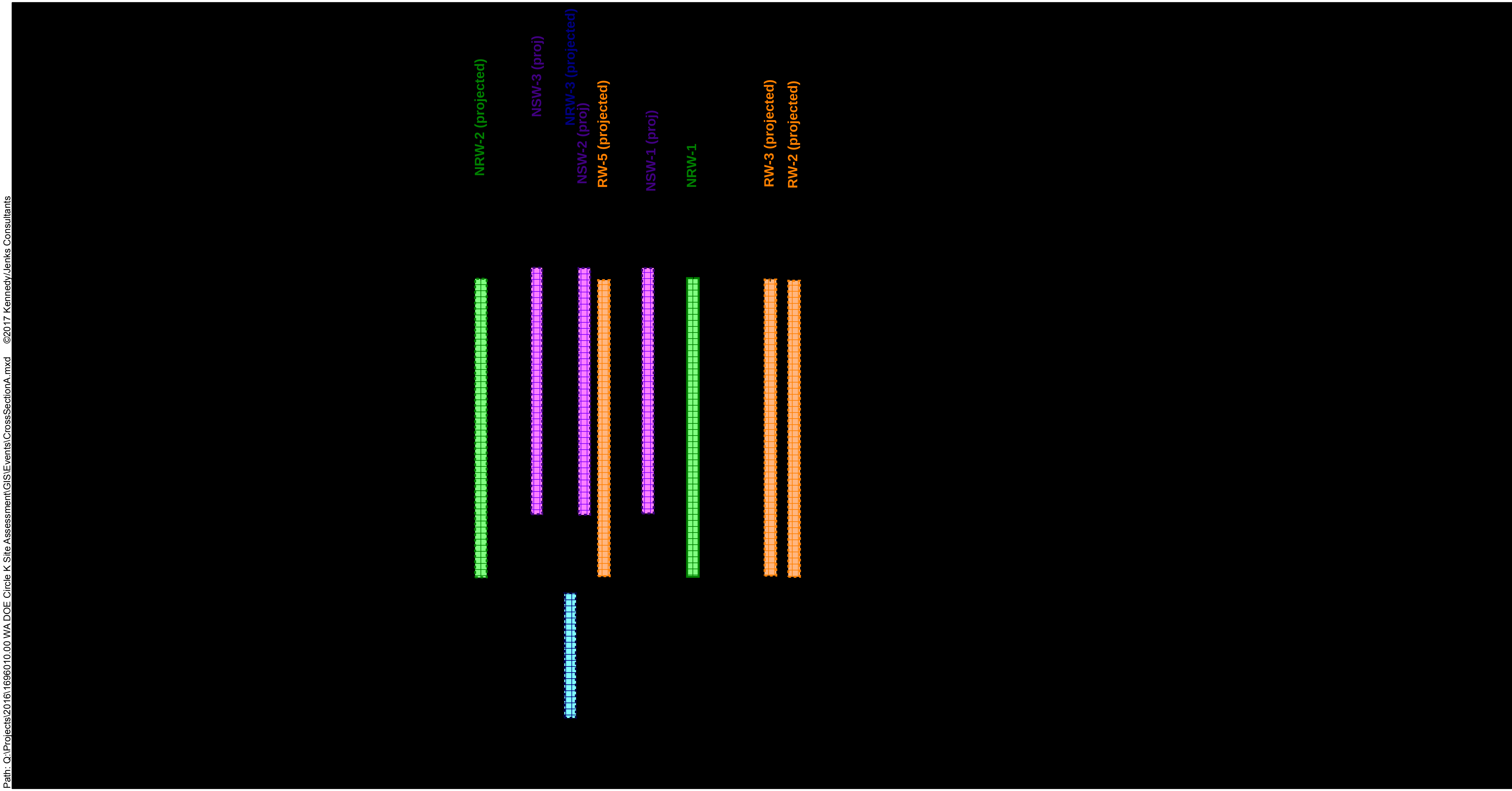
CROSS-SECTION PLAN VIEW

SCALE: 1"=10'
JOB NO: 2196008.00
DATE: DECEMBER 2021
SHEET --- OF ---
Figure 6



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Legend

- Water Table in December 2016
- GRO and/or Benzene Concentration in Groundwater less than CUL
- GRO and/or Benzene Concentration in Groundwater exceeds CUL
- Sand with silt
- Sandy silt/silty sand
- Silt with sand lenses
- Approximate Extent of GRO and/or Benzene in Soil that exceeds the CUL

MW-16 — Groundwater Monitoring Well

Screened Interval

GRO and/or Benzene Concentration in Soil is less than CUL or Not Detected

GRO and/or Benzene Concentration in Soil is greater than CUL

Notes:

1. All locations and depths are approximate.
2. BGS = below ground surface.
3. CUL = MTCA Method A Cleanup Level.
4. GRO = Gasoline Range Organics.
5. RWs screened approximately 5 - 20 ft bgs except NRW-3, which is screened from 23-28 ft bgs. SWs screened approximately 5 - 17 ft bgs

Feet: 0, 2.5, 5

0, 10, 20 Feet

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Former Circle K Site
Seattle, WA

Interpretive Geologic Cross-Section A - A'

K/J 1696010*00

Figure 7

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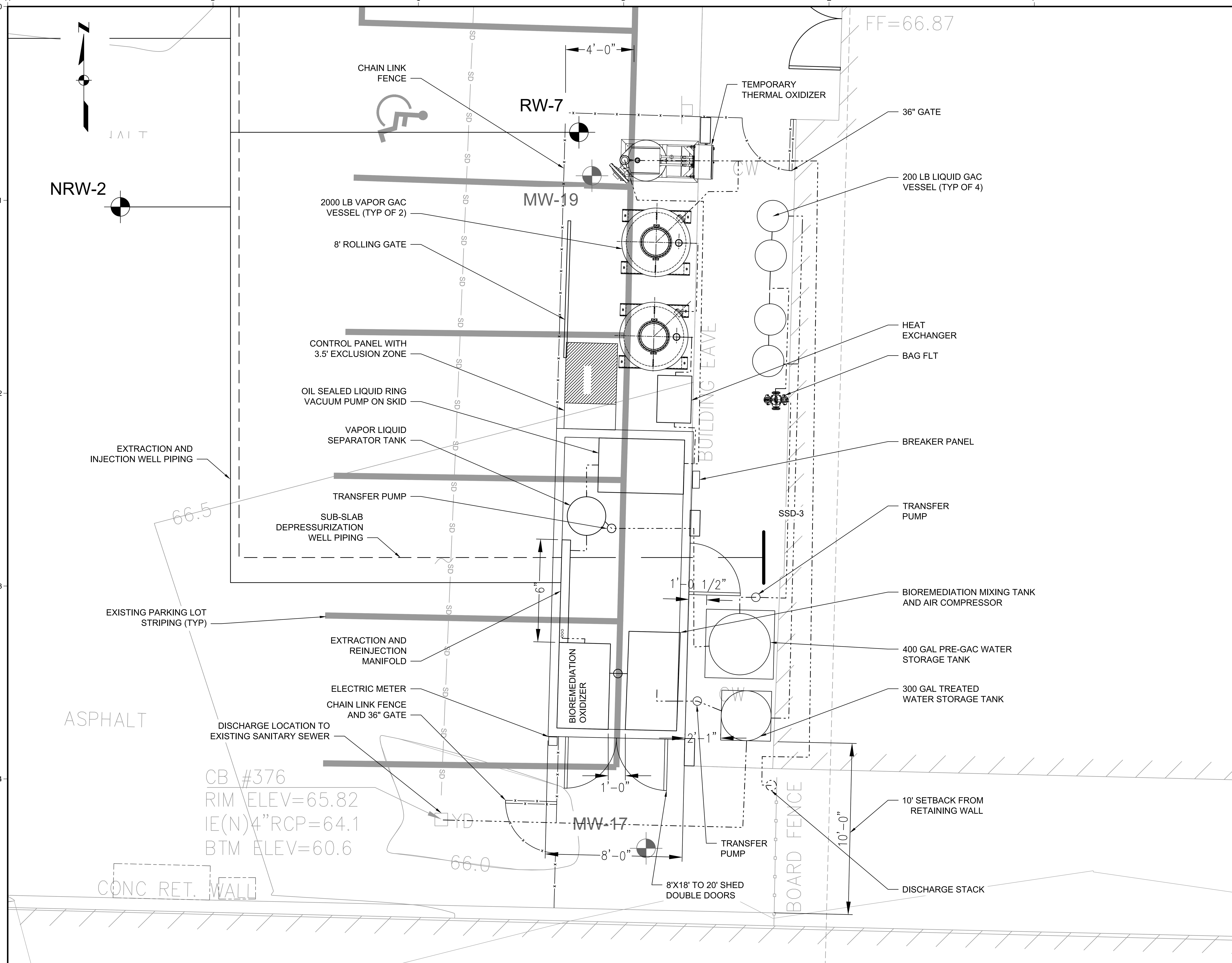

GENERAL SHEET NOTES

1. WELL TERMINOLOGY:
   1A. MW = EXISTING MONITORING WELL
   1B. RW = EXISTING REMEDIATION WELL
   1C. NRW = NEW REMEDIATION WELL TO BE INSTALLED
2. ALL MANIFOLDS EQUIPPED WITH GATE VALVE, SAMPLE PORTS, AND 1/4" TAP FOR FLOW INSERTION.
3. EXTRACTION AND REINJECTION MANIFOLDS EQUIPPED WITH CONTROL VALVES AND ELECTRONIC FLOW METER FOR EACH WELL.
4. PIPING AND VALVES STACKED VERTICALLY ALONG EQUIPMENT ENCLOSURE WALL FOR ACCESS TO FLOW PATH AND MEASUREMENTS.

LEGEND

- EXTRACTION AND INJECTION PIPING
- SUB-SLAB DEPRESSURIZATION WELL PIPING
- TREATMENT SYSTEM PROCESS PIPING
- CHAIN LINK FENCE
- SUB-SLAB DEPRESSURIZATION WELL
- VAPOR MONITORING PIN
- WELL TO BE USED FOR EXTRACTION/INJECTION (NEW AND EXISTING, SEE NOTE 1)
- EXISTING WELL NOT USED FOR EXTRACTION/INJECTION

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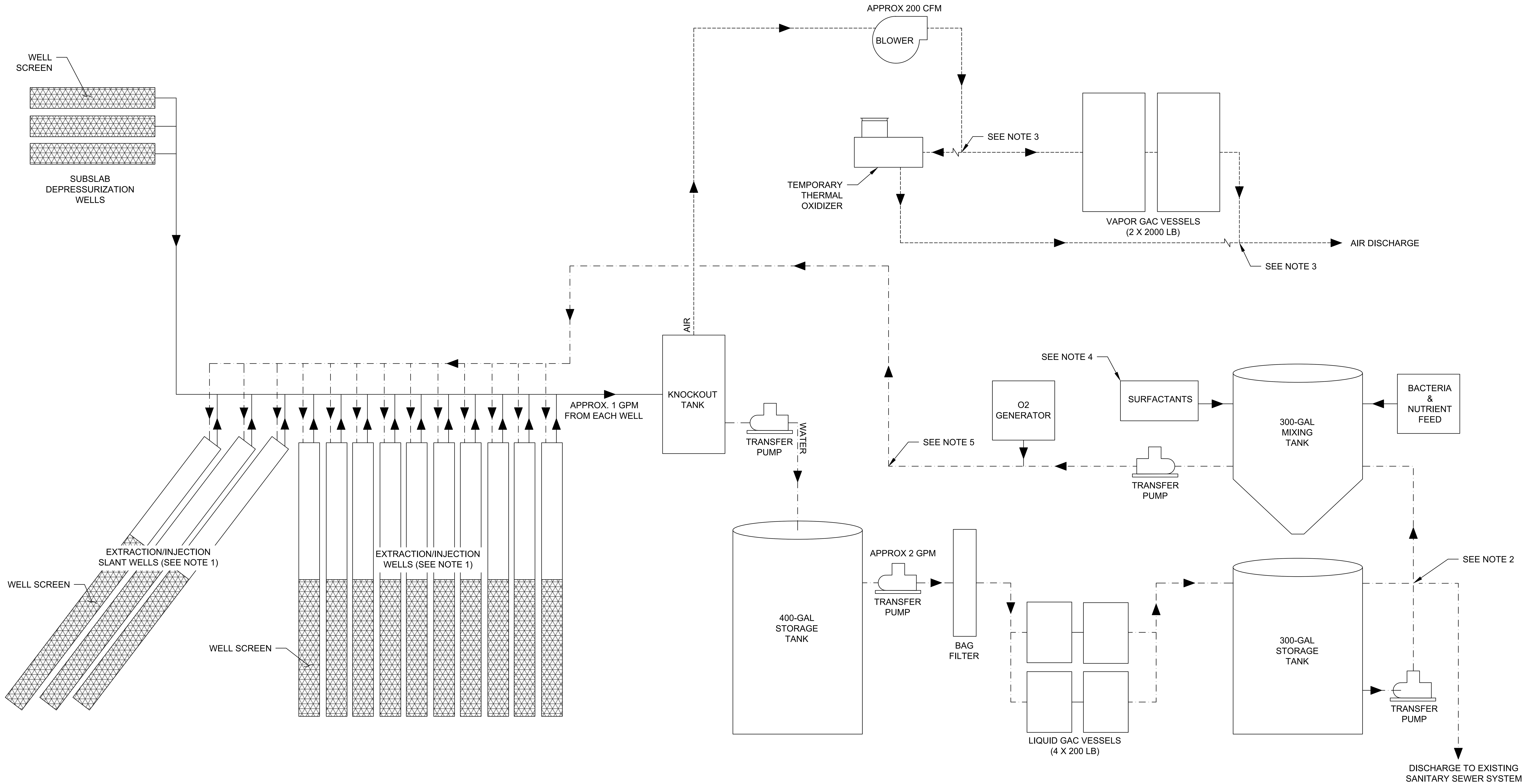
CONCEPTUAL SYSTEM LAYOUT, TREATMENT SYSTEM DETAILS

SCALE	1"=10'
JOB NO	2196008.00
DATE	DECEMBER 2021
SHEET	--- OF ---

Figure 8



NOTES:

1. SYSTEM WILL BE OPERATED TO ALLOW WELLS USED FOR EXTRACTION TO ALSO BE USED FOR REINJECTION AND VICE VERSA. OPERATION OF WELLS FOR EXTRACTION OR REINJECTION WILL BE BASED ON SITE CONDITIONS, WELL LOCATIONS, CONCENTRATIONS OF THE CONTAMINANTS OF CONCERN, AND THE OVERALL REMEDIATION PROGRESS.
2. GROUNDWATER INITIALLY EXTRACTED FROM THE SYSTEM IS EXPECTED TO BE DISCHARGED TO THE SANITARY SEWER VIA GRAVITY. ONCE GROUNDWATER CONCENTRATIONS ARE AMENABLE TO BIOREMEDIATION VIA REINJECTION, WATER WILL BE TRANSFERRED TO MIXING TANK FOR AMENDMENT PRIOR TO REINJECTION. EXCESS WATER WILL GRAVITY FLOW TO THE SANITARY SEWER. VOLUMES AND FLOW RATES WILL BE DETERMINED DURING OPERATION.
3. VAPOR WILL BE DIRECTED THROUGH THE TEMPORARY THERMAL OXIDIZER FOR THE FIRST SEVERAL MONTHS OF OPERATION UNTIL CONCENTRATIONS OF THE CONTAMINANTS OF CONCERN HAVE DECREASED TO A LEVEL SUITABLE FOR TREATMENT VIA THE VAPOR GAC VESSELS. THE THERMAL OXIDIZER WILL THEN BE REMOVED AND VAPOR WILL BE DIRECTED THROUGH THE GAC VESSELS PRIOR TO DISCHARGE
4. SURFACTANTS WILL BE ADDED FIRST TO THE WATER PRIOR TO REINJECTION TO RELEASE ADDITIONAL HYDROCARBONS FROM THE SOIL. THEN BACTERIA AND NUTRIENT FEED WILL BE ADDED TO THE WATER PRIOR TO REINJECTION TO CREATE A MICROBIAL POPULATION TO DEGRADE THE HYDROCARBONS IN SITU.
5. PIPING WILL BE COMPRISED OF A FLEXIBLE THERMOPLASTIC COMPATIBLE WITH HYDROCARBONS.

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SCALES
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DEPARTMENT OF ECOLOGY State of Washington

WASHINGTON STATE DEPARTMENT OF ECOLOGY
BELLEVUE, WASHINGTON

FORMER CIRCLE K SITE 1461 CLEANUP
SEATTLE, WASHINGTON

Kennedy Jenks

PROCESS FLOW DIAGRAM

SCALE
JOB NO 2196008.00
DATE DECEMBER 2021
SHEET OF ---

Figure 9

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