SUPPLEMENTAL SITE CHARACTERIZATION WORK PLAN

Prior Plant #4 - ESP
310 SE Stephens St.
Portland, Oregon 97214

Oregon DEQ ECSI No. 1010

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1 INTRODUCTION

PNG Environmental, Inc. (PNG) has prepared this work plan for investigation of the former East Side Plating (ESP) Plant #4 property in Portland, Oregon (Figures 1 and 2). Multiple investigations were completed in 2022, 2023, and 2024 to provide a preliminary assessment of soil, groundwater, soil vapor, and indoor air quality at the facility. The former Plant #4 facility is conducting site characterization activities, at the direction of DEQ, as part of the DEQ Voluntary Cleanup Program (VCP). Following recent discussions with DEQ and their review of existing data, DEQ stated in a letter dated March 6, 2025, that further action is needed to address data gaps and assess the potential risks on the former Plant #4 facility prior to issuance of a No Further Action (NFA) determination. Specifically, DEQ is requesting additional characterization of soil gas and groundwater to evaluate potentially contaminated media at the site. These data will support delineation of the nature and extent of contamination at the site, support updating the conceptual site model, support development of a remedial action plan, and allow assessment of potential risks to human health and the environment.

2 BACKGROUND

2.1 FACILITY DESCRIPTION AND OPERATION

The 0.61-acre facility located at 310 SE Stephens Street contains one building (former Plant #4) comprised of three interconnected sub-buildings/structures (Figures 1, 2, and 3). The property is zoned IG1 General Industrial. All adjacent properties are also zoned General Industrial, within the Central Eastside Industrial District (CEID). The building occupancy is currently in flux, with periodic turnover of tenants. A detailed summary of site history is available in the Preliminary Assessment (Hahn 1995).

In the 1920s and 1930s, the site was occupied by several dwellings and two livestock liveries. Beginning in 1946, East Side Plating owned the facility until the recent property transfer in 2023. In the 1950s and 1960s, East Side Plating occupied only a portion of the building at 310 SE Stephens Street with other tenants, including The Peters Company Assembling Shop, occupying the remainder (AAI 2015). The parcel immediately south of the former Plant #4 building, located at 1988 SE 3rd Ave, was purchased by the Oregon Department of Transportation (ODOT) in 1963. The parcel purchased by ODOT was cleared of all structures in preparation for construction of the Mount Hood Freeway, which was never built. ODOT's purchase included modification of the lot lines and, subsequently, modifications of the former ESP building footprint. Between 1963 and 1969, the building (which previously extended onto the parcel to the south) was altered to coincide with the newly established lot lines. Coincident with building footprint changes, the previous tenant that was occupying the southern half of the building, The Peters Company, moved out and ESP expanded their occupancy to utilize the entire building.

The ESP facility operated six plating lines (a chrome plating line, two zinc barrel lines, a prototype dye and plating line, a hand-barrel plating line, and a hand zinc rack line), a strip line for reclaiming metals, and a polish shop. The polish shop, formerly located in the northeast corner of the building, included a parts degreaser that originally utilized 1,1,1-trichloroethane (TCA) and then transitioned to trichloroethene (TCE). According to discussions with the former owners, degreaser operations were moved to an alternate facility and no longer operated at the former Plant #4 by the mid to late 1980s.

ESP plating lines generated process wastewaters that were historically disposed directly to the city sanitary sewer. In 1980, the City of Portland billed ESP for the replacement of a 40-foot section of concrete sewer piping, located along SE Third Avenue near the intersection with SE Harrison Street, that had corroded. At that time, ESP constructed a wastewater treatment facility in the southern portion of the building and discontinued discharge of untreated process wastewater. The wastewater treatment system, constructed in 1980, processed approximately 1,880,000 gallons of wastewater per year and subsequently discharged to the sanitary sewer. Sludge was shipped off-site. Additional pollution control infrastructure (e.g., floor sumps, chrome treatment system, cyanide destruction system, holding tanks) were also installed between 1978 and 1981.

Despite the fact that an EPA Preliminary Assessment prepared in 1984 indicated that the city sewer line outside of former Plant #4 had been replaced at least four times between 1950 and 1980, the City of Portland records show the line was only replaced once (in 1980). This records review conclusion was also confirmed by the former owner (Hahn 1995). There is no record of any other sewer replacement projects in the vicinity of the facility related to former Plant #4 operations.

Prior to the property's transfer in 2023, the building was emptied of all equipment related to prior metal plating activities. Since 2024, the building has housed multiple tenants.

2.2 PHYSICAL SETTING AND GEOLOGY

The former Plant #4 facility is located within the Portland Basin, a structural basin in the Pacific Northwest filled with continental sedimentary rocks of late Miocene to Pleistocene age. The Portland Basin is a northwest-southeast trending basin covering southwest Washington and northwest Oregon, including Portland, and is about 20 miles wide and 45 miles long.

Soils in the vicinity of the ESP facility have been mapped as Channel facies (i.e., Pleistocene age). The channel facies are catastrophic Missoula flood deposits that are complexly interlayered with variable silts, sands, and gravels deposited in major floodways. The thickness of these flood deposits is approximately 100 feet.

Underlying these soils in the vicinity of the facility is the Troutdale sand and gravel aquifer, which consists of volcanoclastic conglomerates derived from the Cascade Range. The thickness of the Troutdale aquifer near the facility may be up to 200 feet. Beneath the Troutdale aquifer are Tertiary rocks generally consisting of volcanic basalts.

Soil borings were completed in 2022 and 2023 within the building footprint and adjacent to the north, west, and south (PNG 2022, PNG 2023a). During 2022 and 2023, soil borings were not completed due to an elevated roadway section constructed immediately adjacent to the east wall of the building, preventing drill rig access. Observed soils were predominately silts and silt with sand, transitioning to sandy gravel at approximately 10 to 13 feet below ground surface (bgs), followed by sand to the termination depth of 55 feet bgs.

2.3 HYDROGEOLOGY

The water table observed in the 2022 and 2023 soil borings was generally encountered between 45 to 50 feet bgs (PNG 2022, PNG 2023a). Similarly, historic water level measurements, obtained from the on-site industrial well, indicated groundwater at 53 feet bgs (Hahn 1995). A Phase II Environmental Site Assessment was completed at the property immediately adjacent to the south of the former Plant #4 building (Evren 2015). Groundwater was encountered during that assessment at 42 feet bgs.

In 2024, a network of eight monitoring wells were installed across the site. Depth-to-water measurements were collected from the entire monitoring well network (MW-1 through MW-8) during the July 2024 monitoring event. Water was measured at approximately 43 to 47 feet bgs (PNG 2025). Water level measurements were also collected in August 2024, November 2024, and May 2025, and confirmed the same westerly flow direction (Appendix A). Although groundwater flow direction remained consistent to the west, a slight seasonal variation in water table elevation of approximately two feet was noted across the four seasonal events.

Based on regional studies, groundwater flow is expected to be generally to the west/northwest, toward the Willamette River. The Willamette River is located approximately 1,100 feet (0.21 miles) to the east of the Former Plant #4 building. Groundwater elevations collected from the newly-installed monitoring wells in 2024 indicate groundwater flow is generally to the west across the facility, consistent with regional flow.

2.4 REGULATORY FRAMEWORK

Oregon's environmental cleanup rules (Oregon Administrative Rules [OAR] 340-122) establish the standards and procedures to be used to assure protection of the present and future public health, safety and welfare, and the environment in the event of a release or threat of a release of a hazardous substance. In the event of a release of a hazardous substance, remedial actions shall be implemented to achieve one of the following:

- Acceptable risk levels defined in OAR 340-122-0115, as demonstrated by a residual risk assessment.
- Numeric cleanup standards developed as part of an approved generic remedy identified or developed by the Department under OAR 340-122-0047, if applicable.
- For areas where hazardous substances occur naturally (e.g., metals, etc.), the background level of the hazardous substances, if higher than those levels specified above.

Acceptable risk levels may be evaluated through conducting a site-specific risk assessment that calculates exposure point concentrations (EPCs) for specific exposure-pathway receptor-scenarios, or responsible parties (RPs) may use generic for hazardous substances under DEQ's Risk-Based Decision Making (RBDM) guideline to streamline the risk assessment process. In terms of the latter, DEQ has compiled default risk-based screening reference levels (DEQ 2017) for common exposure-pathway receptor-scenarios that may be utilized in lieu of site-specific risk calculations (OAR 340-122-0115). In particular, the pre-calculated risk-based concentration (RBC) represents the concentration of a contaminant of interest (COI) in the impacted medium (e.g., soil, groundwater, or air) that potentially represents an unacceptable risk level.

2.4.1 DEQ Risk Based-Concentrations

DEQ first developed RBDM guidance in 2003 for comparing COI concentrations to default RBCs for applicable human health exposure scenarios. These RBCs eventually replaced Environmental Protection Agency (EPA) Preliminary Remediation Goals (PRGs) as screening criteria in human health risk assessments. Published RBC tables are updated periodically by DEQ; with the most recent update relevant to ESP published in 2018 (DEQ 2018).

In the 2009 revision to its RBC tables, DEQ included newly-developed soil gas and indoor air RBCs for residential, urban, and occupational settings. DEQ also published final guidance for vapor intrusion assessments (DEQ 2010) and issued air and soil vapor RBC values which have also been revised over time. In September 2017, DEQ updated their guidance as Risk-Based Decision Making for the Remediation of Contaminated Sites to reflect a broader spectrum of contaminated sites (DEQ 2017). The last DEQ RBC table revision was in May 2018 (DEQ 2018).

In June 2023, DEQ released a set of tables that provide new RBCs for vapor intrusion pathways. These updated RBCs for residential and commercial exposure scenarios are intended to be more consistent with EPA's Vapor Intrusion Screening Level (VISL) calculations and values. In March 2024, DEQ released a draft Guidance for Assessing and Remediating Vapor Intrusion into Buildings which incorporates the June 2023 RBCs (DEQ 2024). This draft guidance is intended to replace the previous 2010 guidance for vapor intrusion assessments.

The published RBCs represent a conservative default concentration of a chemical in an impacted medium (e.g., soil, groundwater, or air). When chemical concentrations on a site exceed the RBC, unacceptable human health impacts are possible. For carcinogens, the regulatory standard is represented by an excess cancer risk of one in one million (1x10 ^{6}); for non-carcinogens, this is represented by a Hazard Index of 1. RBC exceedances typically trigger further investigation and potentially a human health risk assessment. Therefore, RBCs can be applied at sites as generic, conservative cleanup standards and are routinely used by DEQ to determine if a site requires additional action. Site specific parameters used in the equations to develop the RBCs are often adjusted to match actual conditions in developing site-specific cleanup levels. As such, DEQ reserves the right to disallow the use of generic RBCs at sites that may not fit generic RBC default conditions, such as at sites with widespread contamination.

2.4.2 Previous Water Well Survey

A previous water well survey/inventory for the area surrounding the Former Plant #4 facility was conducted in the 1990s (Hahn 1995). The survey was based on well logs filed with Oregon Water Resources Department (OWRD) at the time. The scope of the well survey was limited based on hydrogeologic boundary conditions; specifically, the inventory area was bounded by the Willamette River on the west. It was assumed that the groundwater flow direction was to the west and towards the Willamette River. The study area was arbitrarily bounded to the north, east, and south by including the one-mile square section in which the site is located and the surrounding one-mile sections in each of those directions. There were 162 wells logs identified during the survey. Due to the large number of well logs identified, it was decided to limit the scope to a more detailed inventory based on wells that are downgradient of the ESP Plant #4 facility.

Ten water wells were identified in the vicinity of the Former Plant #4 facility. The identified wells include nine industrial wells and one well whose use was not specified. The owner of the well with unspecified use was determined to be the City of Portland. The depth of the ten water wells ranged from 40 to 350 feet bgs.

The Portland Water Bureau was contacted with the addresses of all properties with wells to determine if the properties have City-supplied water. Seven of the addresses that were indicated by OWRD were connected to city-supplied water. One of those seven wells was indicated as previously decommissioned. The remaining three addresses no longer exist. The previously mentioned well with an unspecified use was determined to be owned by the City of Portland at one of the no-longer existing addresses. The remaining two wells at no-longer existing addresses were drilled in 1928 and 1946. Hahn concluded that it is unlikely that the water from any of the downgradient wells identified is being used for drinking water purposes, although it may be used for industrial purposes.

The nearest suspected active water well to the Former Plant #4 building, other than ESP's on-site well, is located approximately 1,500 feet northwest of the facility. According to the water well log, the water obtained from this well is used for industrial purposes (truck washing).

2.4.3 Potential Receptors and Migration Pathways

There are several exposure pathways by which a receptor may be exposed to a chemical, including incidental ingestion, inhalation, and dermal contact with the affected medium. The current and reasonably anticipated future use of properties in the Locality of Facility (LOF) are the primary criterion for determining whether a certain exposure pathway is likely to be of concern.

The property is zoned IG1 General Industrial. Adjacent properties are also zoned General Industrial, within the Central Eastside Industrial District (CEID). The current and expected future land use is expected to remain industrial. The facility and surrounding properties are expected to continue to have access to City-supplied drinking water, therefore ingestion of groundwater is not reasonably likely to be a pathway for exposure.

The City of Portland supplies drinking water to all properties in the vicinity of the facility. Based on a previously conducted survey of water well logs filed with OWRD, groundwater near the former Plant #4 is used primarily for industrial purposes (Hahn 1995). Within the area of the facility, groundwater has generally been encountered at depths between 42 and 53 feet bgs. Investigation of the facility in August 2022 and February 2023 encountered groundwater between 45 and 50 feet bgs in eight borings. In 2024, a network of eight monitoring wells were installed across the site. Depth-to-water measurements were first collected from the entire monitoring well network (MW-1 through MW-8) in July 2024. Water was measured to approximately 43 to 47 feet bgs (PNG 2025). Water level measurements were also collected in August 2024, November 2024, and May 2025, and confirmed slight seasonal variation of approximately two feet across the four events with the same westerly flow direction (Appendix A). At these depths, excavation and construction workers are not reasonably likely to be exposed to groundwater.

2.5 PREVIOUS INVESTIGATIONS AT THE FORMER ESP PLANT #4

Multiple focused investigations were completed in 2022, 2023, and 2024. These investigations consisted of focused soil, groundwater, and soil vapor sampling. In addition, an ambient air (indoor and outdoor) sampling event was conducted in August 2023. These investigations were conducted to document environmental conditions at and adjacent to the facility. Sampling locations chosen were intended to provide overall coverage throughout the facility. The sampling locations were also based on a combination of building use (potentially worst-case areas such as in the vicinity of the former plating lines, wastewater treatment system, or solvent use areas) and adequate access for drilling equipment. Soil borings were not completed adjacent to the east, due to an elevated roadway section constructed immediately adjacent to the east wall of the building preventing drill rig access. Similarly, no monitoring wells have been installed on the eastern side of the property due to limited access and worker safety concerns.

Details of recent (2022-2024) investigation results are available in multiple technical memorandums and reports (PNG 2022, PNG2023a, PNG 2023b, PNG 2025). Sample locations are shown on Figure 2. Below is a summary of constituents detected during the sampling activities.

- Detections in soil include:
    - Volatile Organic Compounds – low levels of primarily Tetrachloroethene (PCE) and trichloroethene (TCE)
    - Metals – Arsenic, cadmium, chromium, copper, nickel, silver, zinc
    - Total Petroleum Hydrocarbons – diesel (DRO) and oil (RRO)
- Detections in groundwater include:
    - Volatile Organic Compounds – low levels of PCE, TCE, cis-1,2-dichloroethene (DCE), 1,1-DCE
    - Metals – Arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, thallium, zinc
    - Per and Polyfluoroalkyl Substances (PFAS) – Perfluorbutanesulfonic acid (PFBS), perfluorohexanoic acid (PFHxA), hexafluoropropylene oxide dimer acid (HFPO-DA), perfluoroheptanoic acid (PFHpA), perfluorohexanesulfonoic acid (PFHxS), perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS)

- Detections in soil gas include:
    - Total Petroleum Hydrocarbons – gasoline (GRO)
    - Volatile Organic Compounds – TCE, ethylbenzene, xylene, multiple other VOCs at low levels
- Detections in indoor/outdoor air include:
    - Volatile Organic Compounds – low levels of several VOCs including TCE, PCE, ethylbenzene, chloromethane, benzene, 1,2-dichloroethane (DCA).

DEQ has compiled default risk-based screening reference levels for common exposure-pathway receptor-scenarios that may be utilized in lieu of site-specific risk calculations. In particular, the pre-calculated risk-based concentration represents the concentration of a contaminant of interest in the impacted medium (e.g., soil, groundwater, or air) that potentially represents an unacceptable risk level. For screening purposes at the former Plant #4, DEQ's default commercial and occupational exposure scenario risk-based concentrations have been used. Additional details are discussed in Section 3.

Soil

Soils were analyzed for multiple constituents including metals, VOCs, and hydrocarbons.

Several metals (arsenic, cadmium, chromium, copper, nickel, silver, and zinc) were detected in soil from borings within the building footprint at concentrations that exceed Portland Basin regional default background concentrations established by DEQ. Conversely, in soil samples from borings completed outside of the building footprint, only two metals (cadmium and nickel) were detected at concentrations that exceed Portland Basin regional default background concentrations. Although metals have been detected in soils above Portland Basin regional default background levels both inside and outside of the building, none of the detected metals concentrations, except arsenic, exceed occupational risk-based concentration (RBC) screening levels established by DEQ. The RBC for arsenic in soil is lower than regional default background concentration.

Fifty of the 74 soil samples collected were analyzed for TPH. Where analyzed, gasoline (GRO) was not detected in any of the soil samples. Diesel (DRO) and oil (RRO) were only detected in two of the 50 samples (B-10 at 5 feet bgs and B-14 at 10 feet bgs). No TPH concentrations exceed the DEQ occupational or construction worker RBCs, except for the TPH RRO concentration detected in the soil sample from B-10 located in Stephens Street, offsite to the north of the former Plant #4 (5,040 mg/kg compared to the construction worker RBC of 4,600 mg/kg).

VOCs were not detected in the 37 soil samples analyzed, except for relatively low concentrations (generally part per billion levels) detected in eight samples: Boring B-12 from 15 feet bgs and three deep samples from below the groundwater table at about 50 feet bgs (boring locations B-12, 13, 14). No VOCs were detected at concentrations that exceeded an occupational RBC established by DEQ. As previously mentioned, the facility and all adjacent properties are zoned general industrial. This building is within the Central Eastside Industrial District and occupational use of the property is not expected to change in the future.

Groundwater

Various concentrations of total (unfiltered) metals (arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, and zinc) were detected in the groundwater grab samples collected from the temporary well points during the 2022 and 2023 sampling events. In July 2024, a network of eight newly installed, and developed, groundwater monitoring wells was sampled. Analytical results from groundwater collected from properly developed monitoring wells are more representative of formation conditions, however they are generally consistent with the prior grab sample results. For all sampling events, most metals were not detected above laboratory reporting limits. The push probe methodology for collecting screening-level groundwater samples will typically result in more turbid samples containing suspended and colloidal material that may contain naturally occurring metals (sourced from suspended soil in the water sample) and may not be representative of the true quality of groundwater. As such, dissolved (filtered) metals in groundwater samples were also collected. The results of filtered sample analysis only detected a small subset of the aforementioned metals (copper, nickel, arsenic, chromium, and thallium) and at much lower concentrations and frequency. Although groundwater is below depths likely to represent an excavation or construction worker related exposure (groundwater is consistently observed at depths greater than 40 feet bgs), none of these detected concentrations exceed applicable RBCs for groundwater in an excavation.

Groundwater samples from all wells were analyzed for gasoline (GRO), diesel (DRO), and residual range organics (RRO). GRO and RRO were not detected in any samples during the 2024 sampling event. DRO was only detected at one location, MW-1, at a relatively low concentration of 159 ug/L. None of the TPH concentrations detected in groundwater exceed the commercial RBC for vapor intrusion into buildings.

The groundwater grab samples and subsequent groundwater samples from monitoring wells were also analyzed for VOCs and PFAS compounds. Low part per billion concentrations of PCE and TCE were detected in nearly every groundwater sample collected. Consistent with previous grab sample results, PCE was detected in every groundwater sample collected in July 2024 at relatively low concentrations ranging from 1.4 to 3.0 ug/L, well below the commercial RBC for vapor intrusion into buildings (130 ug/L). Also consistent with previous results, TCE was detected in every July 2024 groundwater sample at concentrations ranging from 1.3 to 39 ug/L. The highest TCE concentrations were detected along SE Stephens Street north of the former Plant #4 building adjacent to the Glass Lab (MW-1 and MW-2), and at the northeast portion of the former Plant #4 building (MW-6). TCE concentrations at these three locations slightly exceed the commercial RBC for screening vapor intrusion into buildings (13 ug/L). No other VOCs exceed the commercial RBC for screening vapor intrusion into buildings. Some of the detected TCE concentrations in groundwater grab samples exceed DEQ's occupational RBC for ingestion/inhalation from tap water (3.3 ug/L). However, municipal drinking water is available in this City of Portland area, and ingestion/inhalation of tap water derived from groundwater in the vicinity of this facility is not considered reasonably likely. These results, showing relatively low levels detected throughout the site without a specific trend or source, suggest that groundwater quality results are representative of regional conditions within the industrial corridor.

Groundwater samples from all wells were analyzed for PFAS in 2024. Results were generally consistent with past results from grab samples in 2023, with seven compounds consistently detected at low part per trillion levels across the site. Similar to the VOC results above, the observation of these PFAS compounds at low levels in all groundwater samples collected to the north, west and south of Plant #4 suggests a more regional groundwater quality condition.

Soil Gas

In 2022 and 2023, soil gas was collected from shallow (5 ft bgs) soil borings located outside of the building footprint, as well as from 13 cross-slab vapor pins within the former Plant #4 building. More recently in May and June 2024, soil vapor grab samples were collected at 10 and 20 feet bgs from all recent monitoring well installation locations (MW-1 through MW-8). During 2024 investigation activities, the vapor pin network was expanded to include five new locations outside or at the outer edge of the building footprint (SG-14 through SG-18). During the 2024 investigation activities, four VOCs were detected in soil vapor at concentrations above the commercial RBC for vapor intrusion into buildings.

TPH as GRO was detected at several locations, both from soil borings and vapor pins. However, none of the detections exceed the commercial RBC for vapor intrusion into buildings.

Although benzene was detected at relatively low levels in many soil vapor samples, only one sample (98 ug/m^3 from MW-5 at 20 feet bgs) exceeded the applicable RBC of 52 ug/m^3. Ethylbenzene was similarly detected in a majority of samples at low levels, but was not detected above the commercial screening RBC for vapor intrusion into buildings in any of the samples collected during the 2024 investigation.

1,3-Butadiene was detected at relatively low levels in several deep soil gas samples, with five samples exceeding the commercial vapor intrusion screening RBC of 14 ug/m^3. The highest detection was 213 ug/m^3 from MW-5 at 20 feet bgs. 1,3-Butadiene was not detected in any sub-slab soil gas samples.

Chloroform was detected in many soil vapor samples during both the 2023 and 2024 investigations. Concentrations ranging from non-detect at laboratory reporting limits to 236 ug/m^3, with a majority of samples exceeding the commercial vapor intrusion screening RBC of 18 ug/m^3. The chloroform detections are located throughout the site and at all depths, without a clearly defined trend horizontally or vertically.

Consistent with results from the 2023 investigation activities, PCE and TCE were detected in every soil vapor sample collected during the 2024 investigation. PCE and TCE concentrations across the site exceed the commercial vapor intrusion screening RBCs of 1,600 ug/m^3 and 100 ug/m^3, respectively. The highest TCE concentrations were detected in the northeastern quadrant of the Former Plant #4 building at sub-slab vapor pins SG-6, SG-7, and SG-9. In general, soil vapor TCE concentrations in this area, such as at MW-6 and MW-7, decrease with depth. Outside of the building footprint, PCE and TCE concentrations in soil gas do not exceed the commercial vapor intrusion screening RBCs at a shallow depth immediately below the pavement/sidewalk, but do exceed at 10-20 feet bgs. The highest PCE and TCE concentrations outside of the Former Plant #4 building footprint are located to the north (MW-1 and MW-2).

Indoor Air

In August 2023, five indoor air quality samples were collected throughout the northeastern portion of the former Plant #4 facility. Sample locations were selected to represent areas of the building with generally greater VOC concentrations in previously collected sub-slab soil vapor samples. One outdoor air quality sample was collected in outdoor air simultaneous to the indoor air sampling event. Although seven VOCs were detected in indoor air during the August 2023 sampling event, all VOCs detected were reported at relatively low levels and none exceed DEQ's commercial RBCs for air. Similarly, only five VOCs were detected in outdoor air, and all detected concentrations were well below DEQ commercial RBCs for air. TCE, which was detected in every indoor sample at concentrations ranging from 0.26 to 1.2 ug/m^3, was not detected in the outdoor air sample.

2.5.1 MLK Boulevard – Grand Avenue Viaducts Project

In 2003 as part of the MLK-Grand Avenue Viaducts Project, Oregon Department of Transportation collected soil and groundwater data within the industrial eastside. In particular one groundwater sample (TB-09350-59), was collected along Martin Luther King Blvd immediately upgradient to the east of the Prior ESP Plant #4 building (Appendix B). PNG has been unable to collect groundwater in this area upgradient from the Prior ESP building due to limited access created by the retaining wall and elevated roadway (MLK Jr Blvd), constructed following the ODOT investigation in 2003, as well as worker safety concerns. The results of ODOT's groundwater sampling immediately upgradient of the Prior Plant #4 building had detections of several VOCs, including PCE at 5.2 ug/L and TCE at 22 ug/L (Sample 59). Two additional samples, Sample 55 and Sample 57, are located slightly further upgradient, and have PCE concentrations of 22.1 and 6.65 ug/L, respectively, and TCE concentrations of 3.76 and 1.75 ug/L, respectively. These concentrations are of similar magnitude to concentrations detected within and adjacent to the Prior ESP building during the 2022-2024 investigations and further suggest that groundwater quality results at the site are representative of regional conditions within the industrial corridor.

2.5.2 The Glass Lab

Adjacent and to the north of the Prior Plant #4 building, across SE Stephens Street, is The Glass Lab (formerly the Byrum W. Morehouse Building), located at 1805 SE Martin Luther King Jr. Boulevard (Figures 2 and 3). Historically, a brass foundry operated at the site beginning in the 1920s. By 1960, the current building had been developed, replacing the foundry. The building was occupied by Morehouse Glass Company from approximately 1960 to 1981, followed by City Antiques, Inc. and Oak Merchants, Inc. in 1995, Classic HM Design and Build, Inc. in 2010, and Eastside Distilling LLC in 2014 (Farallon 2018a and Farallon 2018b).

In preparation for the sale and redevelopment of The Glass Lab property, Phase I and Phase II Environmental Site Assessments were completed (Farallon 2018a and Farallon 2018b). In November 2017, limited subsurface investigations were performed at the property for environmental due diligence purposes. During that investigation, TCE and PCE were detected in soil gas samples from the property at concentrations up to 9,600 and 9,500 ug/m^3, respectively. The source of the contamination is not known, and no source has been identified. These and subsequent TCE and PCE concentrations in soil gas samples collected at the site exceed the occupational/commercial RBCs for vapor intrusion into buildings.

As part of a building renovation, DEQ required the design and construction of a sub-slab depressurization system (SSDS). This system, outlined in the Focused Remedial Action Plan (Farallon 2018c), mitigates vapor intrusion risks to future occupants/tenants. Installation of the SSDS and sealing of the concrete slab floor was completed in 2019 (Farallon 2020). Sampling and laboratory analysis of soil exposed in trenches completed for installation of SSDS piping detected TCE in shallow soil beneath the building floor. The system consists of a vacuum blower with a manifold connected to nine horizontal SSDS wells (a total of approximately 600 feet of slotted piping installed in 18-inch-wide trenches), and an exhaust stack extended to the roof. Following construction of the SSDS, trenches were backfilled, and the concrete slab was restored. The system was initially operated in active depressurization mode with the vacuum blower on, but was later switched to passive ventilation mode (blower off) in 2023. Ongoing monitoring has been conducted by Geoengineers.

2.5.3 Vacant Lot at 1988 SE 3rd Ave

Adjacent and immediately to the south of the Prior Plant #4 building is a vacant lot currently owned by the City of Portland. The current address assigned to this lot is 1933 SE 3rd Ave (Figures 2 and 3). Historically, this property was a small triangular portion of a larger lot (the same lot that the Prior Plant #4 building currently occupies). The larger lot was undeveloped prior to the early 1900s when three residences were built on it. In the 1950s and 1960s, East Side Plating occupied only a portion of the building at 310 SE Stephens Street with other tenants, including The Peters Company Assembling Shop, occupying the remainder (AAI 2015). The southern triangular parcel was purchased by the Oregon Department of Transportation (ODOT) in 1963. The parcel purchased by ODOT was cleared of all structures in preparation for construction of the Mount Hood Freeway, which was never built. ODOT's purchase included modification of the lot lines and, subsequently, modifications of the former ESP building footprint. Between 1963 and 1969, the building which previously extended onto the parcel to the south, was altered to coincide with the newly established lot lines. Coincident with building footprint changes The Peters company vacated the southern half the building. Subsequently, ESP expanded their occupancy to utilize the entire building by 1969. Since ODOT's purchase in 1963, neither ODOT nor the City of Portland has improved the property and it remains vacant at this time.

Several investigations have been conducted at this lot for the City of Portland (Evren 2015, Evren 2016, Farallon 2019) as the property was briefly considered for a possible Right to Dream too (R2DToo) development. A geophysical survey identified buried pipes and a former building foundation; however, no underground storage tanks were identified. The investigations assessed soil, groundwater, and soil vapor quality.

- Soil: Soil samples were analyzed for VOCs, TPH, RCRA 8 metals, hexavalent chromium, PCBs, PAHs, and cyanide.
  - VOCs, TPH, PAHs, and PCBs were not detected above RBCs in any of the samples analyzed.
  - Several metals were detected across the property, but concentrations were generally in the range of DEQ's published background levels or did not exceed RBCs with a couple of exceptions. Arsenic was detected that exceeds residential and occupational RBCs. These RBCs are less than DEQ's background concentration for soil. The detected arsenic concentration was only slightly higher than DEQ's background concentration, and less than arsenic RBCs for construction worker and excavation worker receptors. However, the hexavalent chromium concentration at one of the 10 samples analyzed, located on the east end of the site, was 3.39 mg/kg at a depth of 0.5-1 foot, which exceeds the residential and urban residential RBCs but does not exceed occupational or construction worker/excavation worker RBCs. The absence of detectable hexavalent chromium in nine other soil samples (including a sample deeper in the same boring) suggests its occurrence is not widespread. Arsenic, cadmium, copper, and nickel were detected at concentrations exceeding clean fill criteria.
  - An Environmental Media Management Plan (EMMP) was prepared in 2019 to establish procedures for identifying, handling, characterizing, and

disposing of contaminated soil, if encountered at the property during future construction activities (Farallon 2019).

- Groundwater: Groundwater was encountered a depth of 42 feet and two reconnaissance grab samples were collected (one in 2015 and one in 2018).
  - The majority of investigation activities at this property were not deep enough to encounter groundwater so no additional groundwater samples were collected.
  - The groundwater grab sample results indicated no detections of PCBs, cyanide, PAHs, and petroleum hydrocarbons. Chloroform and naphthalene were the only VOCs detected in groundwater. Some metals, including arsenic, barium, trivalent chromium, and lead were detected in groundwater. No analytes were detected at concentrations exceeding screening levels for volatilization to outdoor air, vapor intrusion into buildings, or groundwater in excavation for construction and excavation workers.
- Soil Vapor: Two soil vapor samples were collected on this property. Both samples were collected from the northern part of the property (adjacent to the former ESP Plant #4) at a depth of five feet bgs.
  - Although several VOCs were detected in soil gas, only TCE was detected at a concentration that exceeds the residential and occupational RBCs for vapor intrusion. The highest concentration of TCE detected was 3,300 ug/m^3 in the northwest corner of the property; this location, adjacent and slightly south of the southwest corner of the Plant #4 building, was identified for vapor monitoring as part of this work plan.

3 OBJECTIVES

Initial investigations were completed in 2022 and 2023 to provide a preliminary assessment of soil, groundwater, soil vapor, and indoor air quality at the facility. After the review of preliminary data, DEQ required investigation in 2024 to further characterize the nature and extent of contamination at the site. The 2024 investigation activities included additional groundwater and soil vapor characterization at the facility. DEQ reviewed the results of these previous investigations and requested additional characterization to address data gaps in a letter dated March 6, 2025. The objectives of the DEQ-requested investigation activities are as follows:

- Confirm groundwater flow direction through seasonal measurement of groundwater elevations.
- Further characterize groundwater quality at the site. In particular, characterize groundwater downgradient from the historically replaced section of sewer on the western side of SE 3rd Ave.
- Further characterize soil vapor quality under and adjacent to the prior ESP Plant #4 building. In particular, characterize areas of current and previous operations that involved the use of chemicals such as metals, paints, and solvents. Also, characterize vapor quality across SE 3rd Ave (west of the Prior Plant #4 building) and on the northern portion of the lot at 1988 SE 3rd Ave (south of and adjacent to the prior ESP Plant #4 building).
- Gather information to complete the conceptual site model (CSM), such as;
    - Identification of contaminated media
    - Identification of potential human and ecological receptors
    - Identification of potential pathways between identified contamination and receptors
- Gather information to support evaluation of potential current and future risk to human health receptors.

4 INVESTIGATION PLAN

The investigation activities described in this work plan are designed to address the data gaps identified by DEQ and the objectives outlined in Section 3.

Investigation activities will involve expansion and sampling of a soil gas monitoring network, soil vapor extraction testing, and cross-slab differential pressure monitoring to assess risk associated with potential vapor intrusion. This data will also be used to support a focused, streamlined evaluation of remedial actions and remedial action plan to address the soil vapor "hot spot" identified during previous characterization activities (PNG 2025).

Additional investigation activities will include the installation, development, and sampling of two monitoring wells, and site-wide groundwater monitoring to assess seasonal variation in groundwater quality and groundwater flow direction. These activities will address data gaps downgradient of the sewer section replaced in 1980 and downgradient of the Glass Lab building, as well as assess potential impacts of seasonal variation on groundwater flow and groundwater quality across the site. Any modifications to the planned characterizations below will be completed in consultation with DEQ as described in Section 5.

4.1 PRE-INVESTIGATION ACTIVITIES

Prior to beginning any on-site work, the following tasks will be completed.

Health and Safety Plan

PNG will review the site-specific Health and Safety Plan (HASP), and update it if necessary. The HASP is developed in accordance with rules established by the Occupational Safety and Health Administration (OSHA). The purpose of this written plan is to establish procedures and practices for PNG employees, as well as subcontractors, aimed at minimizing potential exposure, accidents, and physical injuries that may occur during onsite activities. The HASP will specifically address known or suspected hazards at the site. The HASP will also provide contingency arrangements for emergency situations.

Underground Utilities

In preparation for subsurface activities, underground utilities in the vicinity will be researched in advance. In particular, PNG will research details of the sanitary sewer segment (diameter, depth, etc.) on SE Third Avenue adjacent to the facility that was replaced in 1980. The newly proposed monitoring well MW-9 will be in the vicinity of this historically replaced sewer segment.

Underground utilities will be located in the vicinity of proposed vapor pins and monitoring wells. Underground utilities will be located through a combination of one-call and private utility locate subcontractors. Utilities that run across planned installation locations will be identified. If one of the proposed vapor pins or monitoring well locations is too close to an existing underground utility for that feature to be safely installed, the vapor pin or well location will be modified as necessary. Once all proposed locations have been cleared for utilities, installation locations can be finalized.

4.2 INVESTIGATION ACTIVITIES

4.2.1 Groundwater Characterization

As requested by DEQ in their March 6, 2025 letter, PNG conducted a spring groundwater monitoring event in May 2025. Depth-to-water measurements were collected from all wells prior to sampling to allow for the characterization of groundwater flow in the vicinity of Plant #4 and, in combination with groundwater elevation data collected in 2024, allow for the evaluation of seasonal variation. Nine groundwater samples were collected (one from each monitoring well plus one duplicate sample) and analyzed for total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), total and dissolved priority pollutant metals, and PFAS compounds. This activity was completed consistent with the Site Characterization Work Plan (PNG 2024) and the associated 2024 groundwater sampling event. This work was already completed prior to the preparation of this work plan to ensure the data was collected during the spring season.

As a component of the DEQ-requested 2025 characterization activities, PNG plans to install two additional groundwater monitoring wells, MW-9 and MW-10 (Figure 3). The proposed groundwater monitoring well locations were selected to characterize groundwater quality downgradient (to the west) from the sewer segment replaced in 1980 along SE 3rd Ave and downgradient from the Glass Lab building. Continuous soil cores will be screened in the field (e.g., odor, color, and PID readings). These groundwater monitoring wells will be constructed with 15-foot, 2-inch diameter, 0.010-inch slotted, pre-packed schedule 40 PVC well screens to a depth of approximately 55 feet, consistent with OWRD standards and depth-to-water observations in previously completed soil borings and monitoring wells. The wells will be fitted with a locking cap and finished with a flush-mount surface monument. Wells will be developed and sampled, consistent with previously installed monitoring wells at the site.

Following development, groundwater from MW-9 and MW-10 will be sampled consistent with methods and laboratory analytical methods used for the other wells on site. Groundwater from MW-9 and MW-10 will be analyzed for gasoline and diesel-extended range total petroleum hydrocarbons (TPH) by NW Methods TPH-Gx and TPH-Dx, volatile organic compounds (VOCs) by EPA Method 8260D, and total and dissolved priority pollutant metals by EPA Methods 6010/7470/7471. Groundwater samples will also be analyzed for PFAS compounds by EPA Method 1633.

A licensed surveyor will establish elevations for the MW-9 and MW-10 monuments and well casings. Elevations will be recorded to within an accuracy of 0.01 feet vertically and 0.1 feet horizontally. Relevant physical features (e.g., building corners, catch basins, etc.) will also be surveyed in order to compile an accurate map of the site as deemed appropriate. However, legal property boundaries will not be surveyed.

Permitting

Installing monitoring wells in the public right-of-way (the sidewalk adjacent to SE 3rd Ave) requires a series of permits with the City of Portland, including a monitoring well permit and a temporary street use permit. A city-approved traffic control plan will be required as a component of the temporary street use permit. Monitoring wells in the right-of-way also require a performance bond prior to installation. PNG will coordinate with the City to ensure all permits and bonds are completed prior to commencing field activities in the right-of-way downgradient from Prior Plant #4.

4.2.2 Vapor Characterization

In order to address a data gap and to further characterize the distribution of VOCs in soil vapor, PNG proposes installation of twelve vapor wells on or adjacent to the Prior Plant #4 property (Figure 3). This will include nine vapor wells within the building footprint and one vapor well immediately adjacent to the former office space in the parking area. In addition, one vapor well will be installed to the south of the building on the adjacent vacant lot. Lastly, one vapor well will be installed along the western side of SE 3rd Ave toward the building at 1919 SE 3rd Ave. A direct-push drill rig will be used to install the vapor wells. Continuous soil cores will be screened in the field (e.g., odor, color, and PID readings). The vapor well screens will be installed within the sandy/gravel zone observed at depths of generally 10 to 15 feet bgs in other soil borings completed at the site. All vapor wells will be constructed with 5-foot, 2-inch diameter, 0.010-inch slotted, pre-packed schedule 40 PVC well screens to a target depth of approximately 12-15 feet based on observed soil characteristics.

In addition, PNG proposes to expand the existing semi-permanent soil gas vapor pin sampling network by installing a vapor pin (SG-19) adjacent to the aforementioned downgradient vapor monitoring well location (VW-12). The vapor pin will allow for sampling of shallow sub-slab soil vapor. Together, these deep and shallow soil vapor samples are intended to further characterize the soil vapor quality both laterally and vertically.

Installation of a vapor well in the right-of-way (i.e., the sidewalk) will require the same permitting with the City of Portland as the groundwater monitoring wells mentioned above. PNG will coordinate with the City to ensure all permits and bonds are completed prior to commencing the groundwater and vapor monitoring well installations downgradient from Prior Plant #4.

One vapor well, VW-1, is located within the soil vapor “hot spot” in the northeast quadrant of the building and will be used as a soil vapor extraction point during pilot testing, described below. The rest of the vapor wells (VW-2 through VW-12) will be used for monitoring the influence of soil vapor extraction testing within the more permeable soil zone at approximately 10-15 feet bgs.

Soil Gas Sampling

As requested by DEQ, PNG proposes conducting a soil gas sampling event of the existing soil gas vapor pin network (SG-1 through SG-18) and the newly installed vapor wells (VW-1 though VW-12) and pin (SG-19) (Figure 3). The site-wide soil gas sampling event will be conducted prior to SVE testing. Sampling and laboratory analytical methodology will be consistent with 2024 sub-slab soil gas sampling activities. However, prior to sampling, PNG will inspect the entire vapor pin network. As a result of damage and/or theft, PNG is aware of at least three vapor pins that will need to be repaired or replaced/reinstalled. Vapor pins are multi-functional, and are used for sub-slab soil gas sampling as well as cross-slab differential pressure monitoring.

All soil gas samples will be analyzed for VOCs by U.S. Environmental Protection Agency (EPA) Method TO-15. All soil gas analysis will be completed on a normal turnaround basis.

Soil gas samples are collected consistent with PNG’s SOPs (Appendix C) and DEQ’s draft Guidance for Assessing and Remediating Vapor Intrusion into Buildings (DEQ 2024).

4.2.3 Soil Vapor Extraction Testing

In order to support a focused, streamlined evaluation of remedial actions and a remedial action plan to address the soil vapor "hot spot" identified during previous characterization activities, PNG proposes conducting soil vapor extraction (SVE) testing. This testing will utilize the vapor characterization infrastructure including a network of vapor wells for monitoring and extraction, and a network of shallow sub-slab vapor suction points.

SVE Test Equipment and Procedure

An SVE step test will be conducted to evaluate the relationship between the applied vacuum at the extraction well VW-1 and the associated vacuum radius of influence (ROI). During each test, vacuum will be measured at the remaining eleven vapor monitoring wells using a magnehelic gauge. In addition, PNG will conduct a direct measurement of cross-slab differential pressure during the SVE test. The cross-slab differential pressure data collection will utilize CLK-Zephyr II+ data logging micro-monometers at five vapor pin locations, consistent with 2024 cross-slab differential pressure monitoring. The micro-manometer is auto-zeroing and has a pressure differential sensitivity to 0.001 inches of water. The auto-zeroing feature allows for highly accurate differential pressure logging over time. Cross-slab differential pressure data will be electronically recorded at one-minute intervals throughout the collection time. The meters will be installed at vapor pins SG-5, -6, -9, -10, and -13. The differential pressure meters will be installed at least 24 before the SVE test begins and left in place for the duration of the SVE test.

The SVE test equipment will consist of a portable skid-mounted motor and blower attached to VW-1 using a temporary flexible hose. The SVE unit will be staged outside, adjacent to the building in the parking lot to minimize noise disturbance to existing tenants. The blower will be rated at a minimum of 5 horsepower (hp). Gauges will be installed to measure effluent air pressure and flow rate. The extracted air will be discharged to ambient air via a stack at or above the building's roof line. A sampling port along the discharge pipe will allow for collection of air samples during the SVE test. Off-gas from the SVE test will be managed in accordance with DEQ's Guidance for Managing Hazardous Substance Air Discharges from Remedial Systems (DEQ 2024, Appendix E). This guidance is applicable to remediation and mitigation systems that emit effluent vapor containing hazardous substances at environmental cleanup sites. Per the guidance, DEQ requires projects submit an evaluation of implementation risks before full-scale remediation or vapor intrusion mitigation begins. The results of this proposed short-term SVE test will help inform full-scale remedial design and will be used to conduct screening to determine if off-gas treatment prior to discharge would be necessary for a future full-scale system. PNG will work with DEQ to evaluate if there is a need for treatment of off-gas during the short-term SVE test at the prior Plant #4 facility.

During the SVE test, vacuum will be applied at vapor well VW-1, only. The applied vacuum will be increased incrementally until the observed vacuum in the monitoring wells reaches a maximum and plateaus. The vacuum will then be maintained at a constant rate for approximately five days to observe the radius of influence. Throughout the test, PNG will record the applied vacuum, extraction flow rate at VW-1, and observed vacuum in the vapor monitoring wells (VW-2 through VW-12) and select vapor pins. In addition, PNG will note the VOC concentration of the extracted vapor before discharge using a photoionization detector (PID). Four air samples, including a duplicate, will be collected from the discharge pipe for laboratory analysis on the first, third, and fifth days of the constant rate portion of the SVE test. Effluent air samples will be sent for laboratory analysis of VOCs by EPA Method TO-15.

4.3 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance and Quality Control (QA/QC) for the work to be performed under this work plan will be conducted as necessary to provide confidence in the characterization for the site. QA/QC samples will include field duplicate and trip blank samples as appropriate. Field and trip blank results may indicate possible contamination introduced by field or laboratory procedures, and field duplicates indicate overall precision in both field and laboratory procedures. QA/QC samples will be collected as part of the soil and groundwater sampling, in accordance with PNG's SOP (Appendix C).

Field duplicates will not be identified as duplicates on the sample labels or chain-of-custody forms, but will be identified as duplicates on the field forms and sample logs. The field duplicate will be analyzed for the same parameters as the investigative sample. At a minimum, one field duplicate for each sample matrix will be sampled and analyzed for every 20 samples collected.

Trip blanks are water samples prepared by the laboratory by filling a water sample container with laboratory grade distilled, deionized water. Trip blanks will accompany the sample containers to and from the event, but at no time will they be opened or exposed to the atmosphere. One trip blank will be transported for each sampling event.

Analytical results from the blanks and duplicates will facilitate data quality control checks. A data validation evaluation will be conducted to verify the accuracy and precision of the resultant chemical data. The evaluation includes a check of the following:

- Data completeness
- Holding times and preservation
- Blanks
- System monitoring compounds (surrogates)
- Laboratory control samples
- Matrix spike/matrix spike duplicates

Based on the results of this data validation evaluation, a more detailed evaluation of other data in the context of the project objectives may be warranted. Additional data validation may be conducted, as appropriate, to ensure data is of an acceptable quality for the intended site characterization purposes.

4.4 INVESTIGATIVE DERIVED WASTE DISPOSAL

All soil and groundwater investigative-derived waste (IDW) media will be containerized in suitable containment and secured on-site for future disposal. It is estimated that two 55-gallon drums of IDW soil and two 55-gallon drums of IDW water will be generated to support monitoring well installation, development, and sampling. All IDW soil and groundwater will be characterized and managed in accordance with applicable rules based on characterization analytical testing results.

4.5 FIELD PROCEDURES AND PNG STANDARD OPERATING PROCEDURES

Field procedures for soil gas sampling, groundwater monitoring well installation, and vapor pin installation will be completed in accordance with the attached standard operating procedures (SOPs) (Appendix C).

5 WORK PLAN ADDENDUM PROCEDURE

If additional work activities beyond the scope of this Work Plan are necessary, they will be described in addendum form and submitted to DEQ for approval prior to initiation. Some modifications or optimization of the field investigation activities described in this work plan may need to be made while in the field in consultation with DEQ. In most cases, modifications will be made in consultation with DEQ and are anticipated to be managed via telephone communication and documented in a follow-up summary electronic mail.

6 REPORTING

A detailed investigation report will be prepared to document all soil, groundwater, and soil gas sampling, and investigative-derived waste management. The report will include a brief description of the site work activities and any variations from the work plan, and interpretation and significance of the results. In addition, the report will discuss the conceptual model, current and future land use, current and future beneficial use of water, and potential migration pathways and receptors. The results of all data collected will be provided in tabular format with figures depicting sample locations and analytical testing results. Laboratory analytical testing reports and IDW disposal documentation will be included in appendices.

7 PROJECT SCHEDULE

At this time work is anticipated to be initiated within thirty (30) days following DEQ approval of this work plan. Contingent on contractor and vendor availability, the activities outlined in this work plan are estimated to require four to six months to complete.

8 LIMITATIONS

PNG has prepared this work plan for use by Plant 4, LLC and Farhad Ghafarzade. This work plan may be made available to future property owners and to regulatory agencies. This work plan is not intended for use by others and the information contained herein is not applicable to other sites.

Our interpretation of subsurface conditions is based on field observations and chemical analytical data. Areas with contamination may exist in portions of the site that were not explored or analyzed.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices and laws, rules, and regulations at the time that the report was prepared. No other conditions, express or implied, should be understood.

PNG ENVIRONMENTAL, INC.

Samantha Biles, P.E.
Environmental Engineer

Brad Berggren, P.E., R.G.
Senior Engineer

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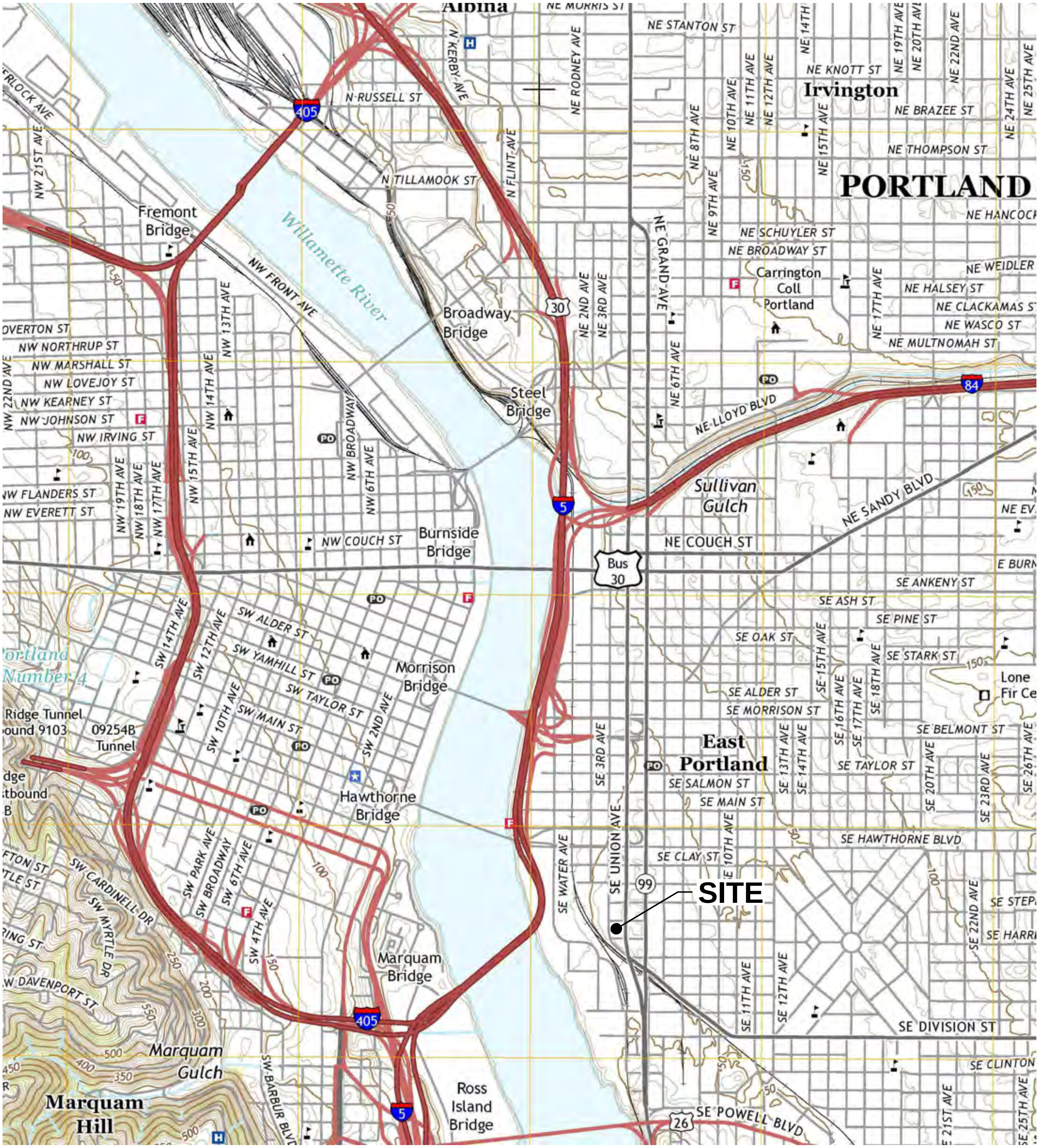
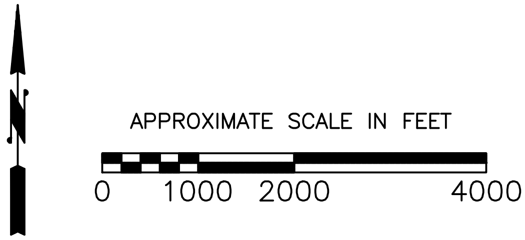
FIGURES





NOTE: USGS, PORTLAND QUADRANGLE
OREGON-WASHINGTON
7.5 MINUTE SERIES (TOPOGRAPHIC)

PNG ENVIRONMENTAL, INC.
6665 SW Hampton St., Ste. 101 TEL (503) 620-2387
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DATE: 2-25-24
FILE NAME: 1257-01
DRAWN BY: JJT
APPROVED BY: SV

PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

VICINITY MAP

Project No. 1257-01
Figure No. 1

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LEGEND

⌖ Monitoring Well Location
● Soil Boring Location
▲ Vapor Pin Location
⧗ Air Sample Location

APPROXIMATE SCALE IN FEET

0 40 80

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PNG ENVIRONMENTAL, INC.
6665 SW Hampton St., Ste. 101
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DATE: 6-2-25
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PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

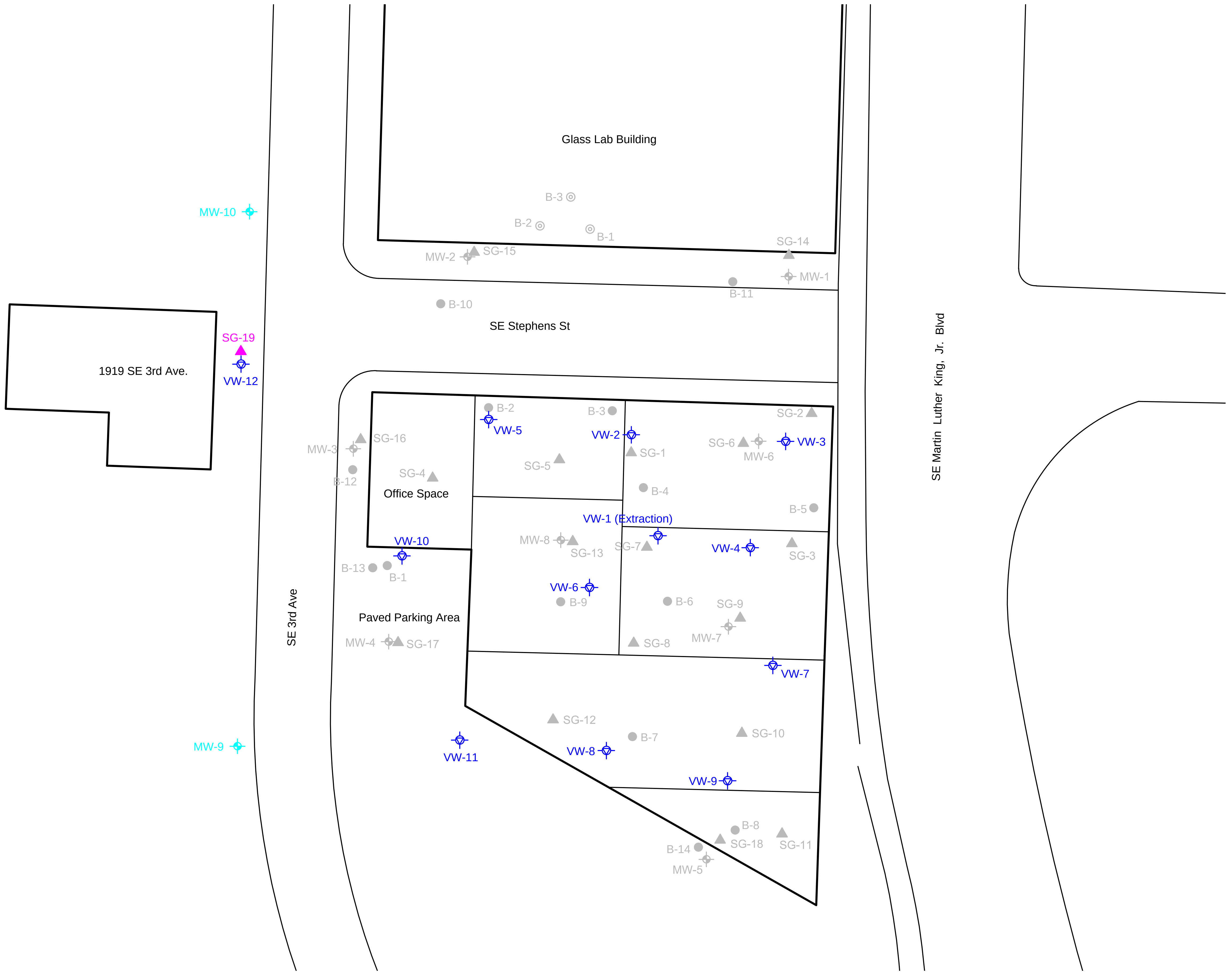
SITE FEATURES

Project No.
1257-01

Figure No.
2

LEGEND

- ⌖ Monitoring Well Location
- ● Soil Boring Location
- ▲ Vapor Pin Location
- ⌖ Proposed Monitoring Well
- ⌖ Proposed Vapor Well
- ▲ Proposed Vapor Pin



APPROXIMATE SCALE IN FEET

0 40 80

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PNG ENVIRONMENTAL, INC.

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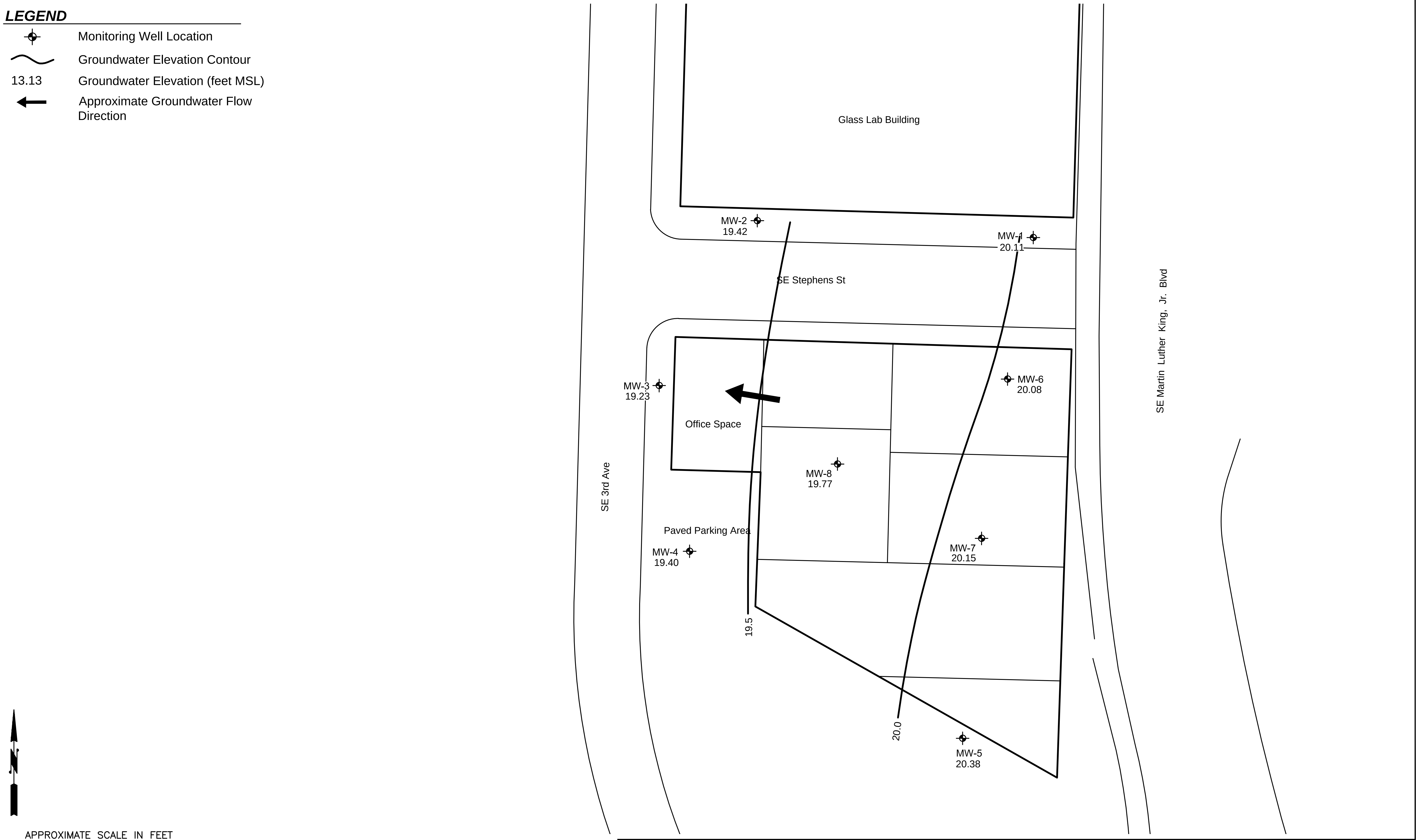
PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

PROPOSED MONITORING LOCATIONS

Project No.
1257-01

Figure No.
3

APPENDIX A
Groundwater Elevation Contours



PNG ENVIRONMENTAL, INC.
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DATE: 8-6-24
FILE NAME: 1257-01
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PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

GROUNDWATER ELEVATION CONTOURS
JULY 23, 2024

Project No.
1257-01
Figure No.
9

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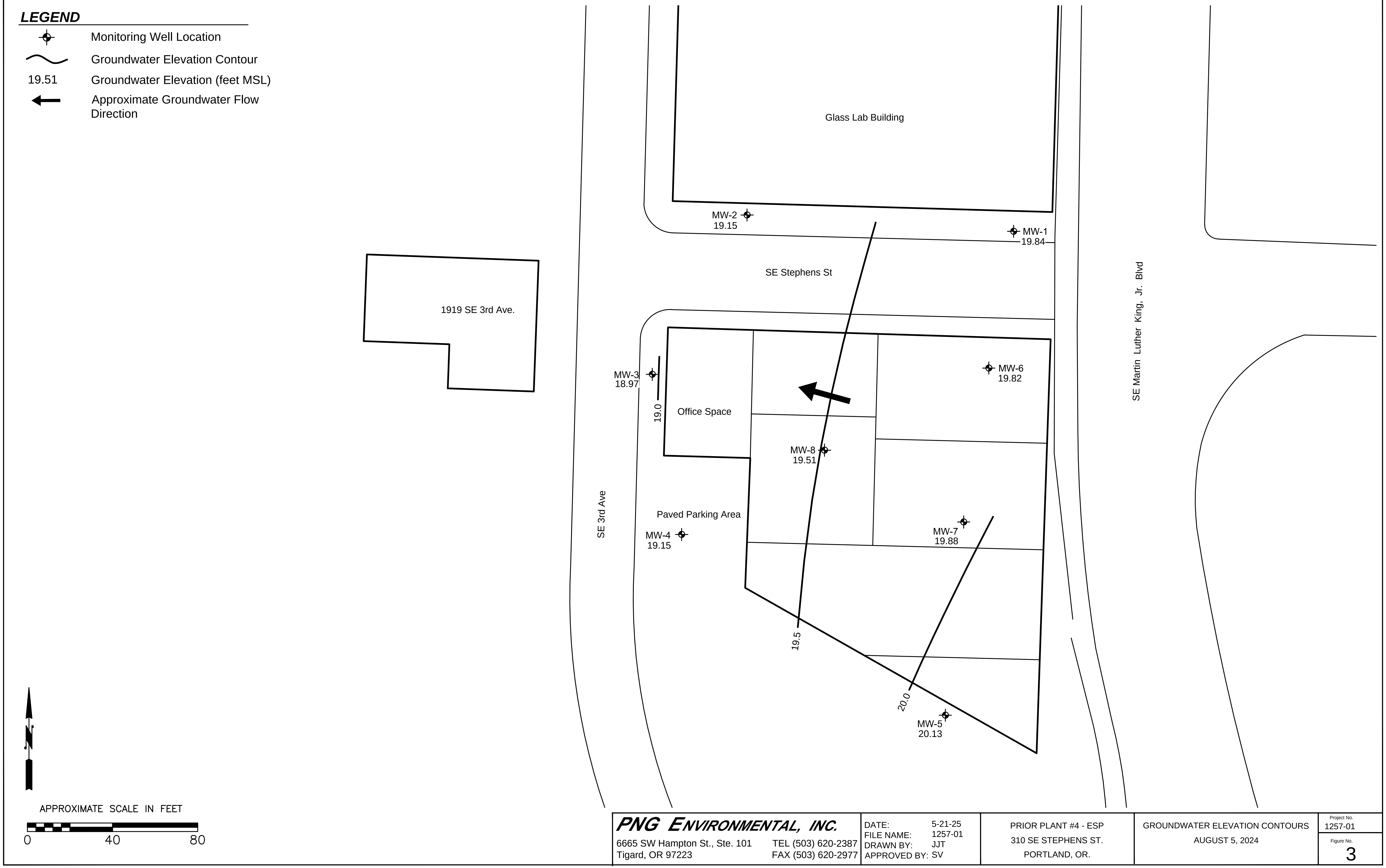

PNG ENVIRONMENTAL, INC.

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DATE:	5-21-25
FILE NAME:	1257-01
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PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

GROUNDWATER ELEVATION CONTOURS
AUGUST 5, 2024

Project No.
1257-01

Figure No.
3

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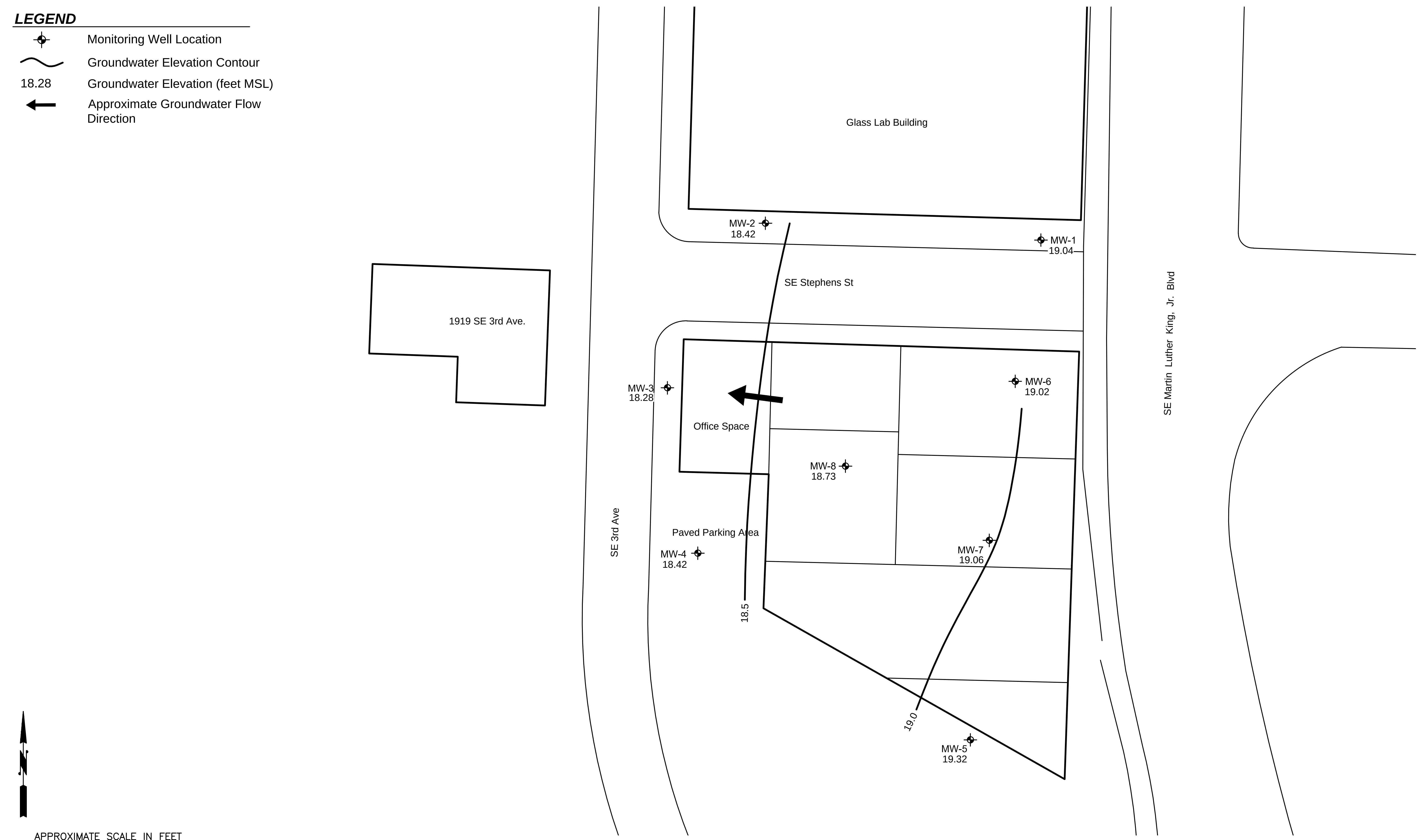

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FILE NAME: 1257-01
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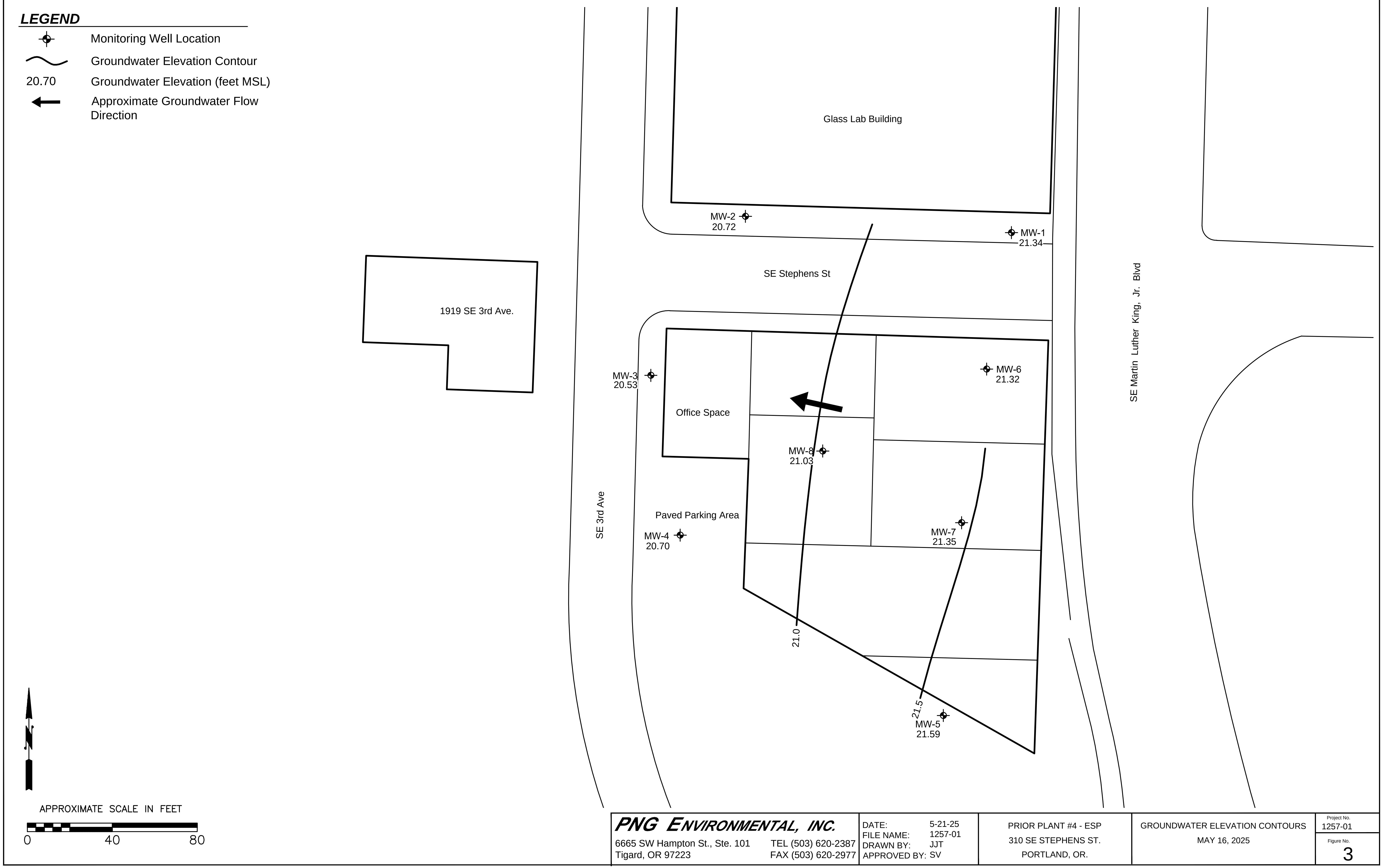
PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

GROUNDWATER ELEVATION CONTOURS
NOVEMBER 12, 2024

Project No.
1257-01

Figure No.
3



PNG ENVIRONMENTAL, INC.

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DATE: 5-21-25
FILE NAME: 1257-01
DRAWN BY: JJT
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PRIOR PLANT #4 - ESP
310 SE STEPHENS ST.
PORTLAND, OR.

GROUNDWATER ELEVATION CONTOURS
MAY 16, 2025

Project No.
1257-01

Figure No.
3

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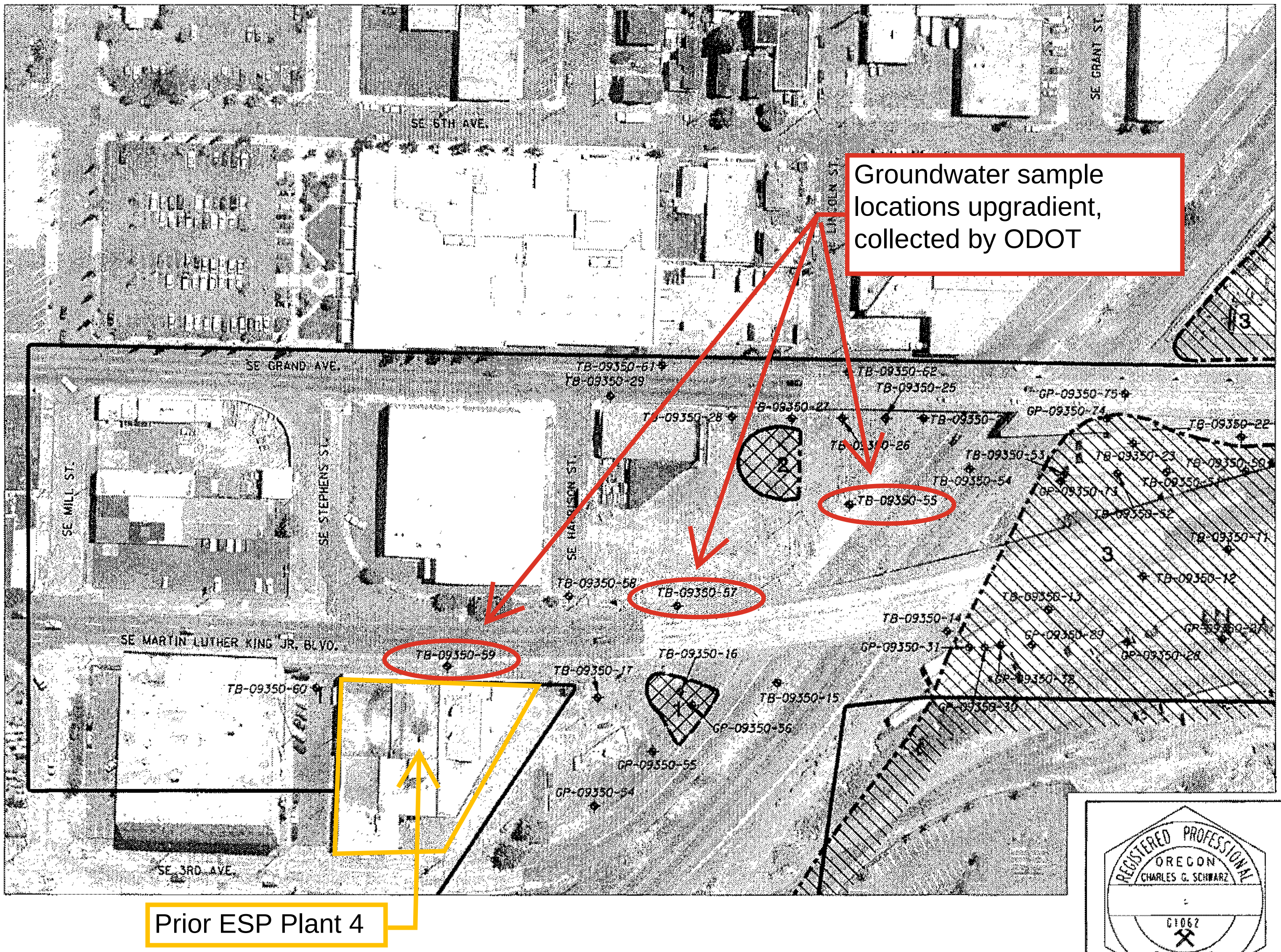
APPENDIX B
ODOT MLK-Grand Ave Viaducts Project Corridor Investigation

Table D2 - Groundwater Analytical Results, Dissolved VOCs
MLK - Grand Avenue Viaducts

Sample ID (TB09350-)	Date Collected	EPA Method 8260B VOCs (ug/l)														
		PCE	TCE	1,1-DCA	1,1-DCE	1,2,4-TMB	1,3,5-TMB	Naphthalene	2-Butanone	sec-Butylbenzene	n-Propylbenzene	Benzene	Xylenes	Acetone	p-Isopropyltoluene	Toluene
8-W	9/15/1999	<0.5		<0.5	<0.5				<25			<0.5	<0.5	<25		<0.5
30-W	4/12/2003	<1	<1	<1	<1	<1	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
31-W	3/17/2003	<1	<1	<1	<1	<1	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
33-W	3/19/2003	<1	<1	**2.83**	**3.1**	**1.32**	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
39-W	3/24/2003	<1	<1	<1	<1	<1	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
43-W	3/21/2003	<1	<1	<1	<1	**2.06**	<1	**20.3**	<10	<1	<1	<1	<3	<25	<2	<1
46-W	3/26/2003	<1	<1	<1	<1	<1	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
47-W	3/25/2003	<1	<1	<1	<1	**21.2**	**5.99**	<2	<10	**1.27**	**2.34**	<1	**1.15**	<25	<2	<1
48-W	4/3/2003	<1	<1	<1	<1	**1.35**	<1	**88.5**	<10	<1	<1	<1	<3	<25	**11.4**	**5.59**
50-W	3/27/2003	<1	<1	<1	<1	**2.35**	<1	**6.98**	<10	<1	<1	<1	<3	**44.1**	**66**	**6.05**
52-W	3/28/2003	<1	<1	<1	<1	**16.1**	**3.46**	**2.22**	<10	<1	<1	<1	<3	<25	<2	**1.41**
55-W	3/28/2003	**22.1**	**3.76**	<1	<1	**4.54**	**1.22**	<2	<10	<1	<1	<1	<3	<25	<2	<1
56-W	8/20/2003	**3.43**	**1.77**	<1	<1	<1	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
57-W	3/28/2003	**6.65**	**1.75**	<1	<1	<1	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
59-W	4/18/2003	**5.2**	**22**	<1	<1	**11.7**	**3.2**	<2	<10	**1.63**	**3.3**	<1	**1.25**	<25	<2	<1
61-W	4/1/2003	**1.39**	**33.8**	<1	<1	<1	<1	<2	<10	<1	<1	<1	<3	<25	<2	<1
63-W	6/20/2005	<1	<1	<1	<1	<1	<1	<2	**18.5**	<1	<1	**1.17**	<3	**92.4**	<2	**1.15**
Const./Exc. Worker RBC		240	130		41,000	1,300	1,400	680			>S	1,700	22,000			78,000
BES Discharge Limit		300	200	2,300	5			2,700				0.14				1,400

Sample 56-W was collected from a monitoring well.

Note: Highlighted samples are located upgradient from Prior ESP Plant 4 facility. Sample 59 is located closest to Prior Plant 4, adjacent and immediately upgradient of the facility along MLK Jr Blvd.



39V-53

N

SCALE
1:1250

LEGEND

- ✦ = Drill Holes
- TB = Test Boring
- GP = Push Probe
- ╱ = Approximate Boundary Of Hazmat Survey
- ▨ = Area Where Woodwaste Is Present
- ▩ = Area Where Contaminated Soil Is Present

Woodwaste And Contaminated Soil Sites

1 Lead Contaminated Soil At Ground Surface. See ODOT Report Titled, "Soil Investigation At North Swale Site."

2 Lead Contaminated Soil At Ground Surface. See ODOT Report Titled, "Soil Investigation At Former Commercial Iron Works Site."

3 Woodwaste Fill At Elevations Ranging From 5.7m To 13.4m. See Geotechnical Data Sheets GB-5 To GB-15.

Notes:

1. Data Shown On This Drawing Are A Consolidation Of Information From Several Different Investigations And Samples Collected From Multiple Borings. Contractor Shall Refer To Referenced Reports And Boring Logs For More Specific Information Regarding Subsurface Conditions.
2. All Dimensions Are Shown In Meters (m) Unless Otherwise Noted.

CHARLES G. SCHWARZ
G1062
EXPIRES: 05/31/2006

OREGON DEPARTMENT OF TRANSPORTATION
REGION 1 GEO/HYDRO UNIT

OR99E: DIVISION ST -
ROSS ISLAND BRIDGE (PORTLAND)
PACIFIC HIGHWAY EAST
MULTNOMAH COUNTY

Reviewed By - Charles Schwarz
Drafted By - Charlotte Gerken

LOCATIONS OF WOODWASTE AND CONTAMINATED SOIL

SHEET NO.
GL

F:\ODOT.DATA\Projects\09350_MLK_Grand_m\09350_Haz\09350_aerial_Haz.dgn 3/22/2006 1:20:35 PM tab081

1:1250 - 1

APPENDIX C
PNG SOPs

STANDARD OPERATING PROCEDURE
SONIC DRILLING
SOP 107

This standard operating procedure (SOP) describes procedures for sonic drilling soil borings, soil sampling, and monitoring well installation. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present.

This SOP is intended as an overview and description of techniques for field personnel overseeing sonic drilling projects, and is not intended to guide subcontract drilling personnel in specific drilling techniques.

SONIC DRILLING OVERVIEW

Sonic drilling consists of a dual-cased system that uses high frequency mechanical vibration to collect intact, minimally disturbed continuous core soil samples, and to advance drill casing into the ground for well construction. The sonic drilling system may also utilize low speed rotational motion along with down-pressure to advance the drill bit. Sonic drilling is also referred to as Rotasonic, Rotosonic, Sonicore, Vibratory, and Resonantsonic drilling.

Advantage of using sonic drilling are that it provides a unique combination of low disturbance, large diameter continuous cores, high soil sample quality, and relatively fast drilling rates in deep gravel conditions. The outer casing prevents cross-contamination when drilling through contaminated zones or multiple aquifers. Sonic drilling also generates as much as 50% less investigation-derived waste soil cuttings compared to other common drilling methods.

The core barrel and drill rods are equipped with right hand threads and are rotated in a clockwise direction. The outer casing is equipped with left hand threads and is rotated in a counter-clockwise direction during drilling. In this manner, the core barrel and drill rods are not unscrewed as the outer casing is advanced.

Sonic Drilling Procedures

Down-hole drill tools and samplers will be steam-cleaned prior to arrival onsite and between each borehole location to minimize the potential for cross-contamination between borehole. Either a temporary decontamination pad will be constructed or a self-contained steam cleaning trailer will be used for steam cleaning the drilling tools and downhole equipment. All IDW generated during drilling, sampling, and decontamination will be containerized until characterized for disposal.

During drilling, the inner drill rods and core barrel may be advanced ahead of the outer casing to obtain a relatively undisturbed core sample. While drilling fluids (air or water) are occasionally used with sonic drilling, for environmental applications it is generally preferable not to add drilling fluids to the formation.

Soil samples are be collected and logged on a continuous basis during drilling as described below. Drill cuttings will be observed by the field geologist and each borehole will be logged in general accordance with ASTM D 2488, as described in the soil logging SOP (SOP 1).

In general, soil samples are recovered if possible using a ten-foot long, four-inch diameter core barrel advanced during drilling to yield a continuous core. The sample core may be extruded directly from the core barrel into a plastic sleeve, or onto a sampling table for observation. Samples may be collected with clear plastic or stainless steel liners placed inside the core barrel. Each ten-foot long core section will typically be subdivided into shorter sections placed in new clear plastic bags, and laid out in sequence for logging. A geologist will visually inspect all recovered samples, and perform any required field screening and sample collection.

Upon drilling completion, the boring will be abandoned by pumping full of bentonite grout, with an asphalt or concrete surface patch placed at the surface. Refer to the sampling and analysis plan (SAP) and Work Plan for details of the soil boring, including sample depth, boring total depth, and media analytical testing.

Telescoped Drilling

In order to isolate any potentially contaminated shallow groundwater, an oversized steel transmission casing can be installed from the ground surface, penetrating five to ten feet (or another appropriate distance) into the water table. A bentonite seal can be placed inside the base of the casing, and drilling continued using smaller-diameter steel casing. The temporary steel transmission casings can then be removed during monitoring well construction. This “telescoping” method is an industry standard protection for drilling through contaminated or potentially-contaminated aquifers. Once drilling reaches the desired depth, the drill bit is removed from the boring, the conductor casing backed out of the hole approximately two feet, and high density bentonite grout is placed in the bottom of the borehole and mechanically pushed into the borehole, forcing it laterally into the surrounding soil formation and outside the conductor casing annulus. Then a smaller diameter drill casing is used to drill the deeper borehole. As the monitoring well is constructed, the drill string is backed out of the hole and sealed above the well’s screened interval using pressurized bentonite grout below the water table. If no monitoring well is to be installed in the boring, the boring will be pumped full of bentonite grout as describe above.

Typical Well Installation Procedures

Wells are typically constructed as described below:

- Depending on the well location and depth, the sand filter pack will be installed by manually pouring sand from the ground surface as described below. The sand level will be measured with a stainless steel weighted tape during placement to detect bridging.
- The well casing will be surged and/or bailed with a clean surge block, stainless steel bailer, or submersible pump during placement of the sand pack and prior to the placement of bentonite in order to settle the sand pack. Sand pack settlement will be monitored by sounding until no further settlement is observed. Sand will be placed to one foot above the screen to prevent bentonite migration into the screen.
- After surging and confirming that the top of the sand pack reaches one foot above the top of the screen, bentonite will be installed to a depth of approximately one-foot below ground surface (bgs).
- The top of the well casing will be cut uniform and flat such that it is at a depth just below grade. A file will be used to cut a “reference mark” on the outside of the well casing.
- A protective monument will be installed flush to grade and the well casing will be furnished with a locking cap.
- Upon completion, the total depth of the well will be sounded such that construction details can be recorded to 0.01-foot accuracy. Total depth (length) of well, sump interval, screen intervals, and top of well below grade will be calculated and recorded. The top of the flush monument will represent ground datum unless a monument is set next to the well completion.

- Well logs and drilling reports will be furnished to the appropriate regulatory agency as required under state law.
- All information regarding soil conditions encountered in the boreholes and well construction details will be recorded on the Soil Borehole Log Form as described in SOP 1 (Logging of Soil Boreholes).

STANDARD OPERATING PROCEDURE
FIELD MEASUREMENT OF TEMPERATURE, PH AND ELECTRICAL CONDUCTIVITY FOR GROUNDWATER
SOP 201

This standard operating procedure (SOP) describes general methods for collecting field measurements of temperature, pH, and electrical conductivity (EC) (field parameters) during groundwater sampling. These measurements are collected during well purging prior to sampling to evaluate the representativeness of the water being tested. The procedures outlined in this SOP are suitable for most commercially available instruments.

PROCEDURE

Purge the well until three continuous readings of the field parameters differ within the range shown below or a minimum of three well casing volumes. The well casing volume is calculated using the *Groundwater Sampling Form.* Field parameters should be collected continuously during purging of the third or last well casing volume.

- Rinse a 250- or 500-ml plastic beaker with small portions of sample water three times.
- Rinse electrodes with sample water.
- Fill beaker and measure sample temperature to nearest 1°C using NBS-calibrated mercury thermometer or similar.
- Adjust pH meter temperature compensator to sample temperature.
- Immerse electrodes in sample while swirling the sample, if needed, to provide thorough mixing. Turn on temperature meter, allow temperature to stabilize and record value on sampling form. Turn on pH meter, allow the meter to stabilize and record on sampling form. Turn on Conductance meter, allow the meter to stabilize and record on sampling form. Note any problems such as unusual drift of meter.
- Following temperature, pH, and conductance measurements, measure oxidation-reduction potential (ORP) using the pre-calibrated ORP meter. Lastly measure dissolved oxygen (DO) using pre-calibrated DO meter.
- Repeat procedure for a total of at least three measurements with three to five minutes between each measurement.
- The groundwater is considered stabilized if the following criteria are met with three consecutive measurements:

Temperature	± 3 percent of reading (minimum of ± 0.2 C)
pH	± 0.1 units, minimum
Conductance	± 3 percent of reading
Dissolved Oxygen	± 10 percent of reading
Redox (ORP)	± 10 mV
Turbidity	± 10 percent NTU or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation)

INSTRUMENT CALIBRATION

Calibrate pH meter in the field laboratory at the beginning of any day of fieldwork or field laboratory work when field parameters will be measured, then recalibrate each time and at a minimum of every ten samples analyzed. Meters will be calibrated according to manufactures instructions.

MAINTENANCE

- Store meters in the field laboratory, with pH electrodes immersed in a Paraffin-covered beaker of tap water.
- Inspect electrodes weekly.
- Check batteries each time meter is used. Carry a spare battery pack and a screwdriver into the field.

STANDARD OPERATING PROCEDURE
WELL DEVELOPMENT
SOP 202

BACKGROUND

This standard operating procedure (SOP) describes procedures for well development and completion which were adopted from regulatory guidance for well completion found in the Resource Conservation and Recovery Act (RCRA) Ground Water Monitoring Technical Enforcement Guidance Document (EPA, 1986), and the Environmental Protection Agency (EPA) Handbook (EPA, 1991).

All well drilling and installation procedures create a skin, or filter cake, on the borehole wall. During well development, the fine particulate matter is removed from the well or saturated formation near the screen. A secondary function of development is to settle the annular fill to a stable position.

The following factors influence the success of well development:

- The drilling method employed in the well construction.
- The design and completion of the well.
- The type and gradation of geologic material surrounding the screen.

Because of the small size of weathering products from the volcanic tuff, in some of the alluvial canyon aquifers in the region, it is virtually impossible to eliminate turbidity while developing the well.

Well Development Methods

There are various techniques that may be effective in developing wells depending on the hydrogeologic conditions encountered in the aquifer, drilling method used, and well design. Since hydrogeologic conditions may be complex and unpredictable, a single SOP cannot be developed that will apply to all possible situations. Rather, the methods discussed briefly below are intended to be used as alternatives or as a series of steps to achieve acceptable well development results. Refer to site-specific work plan for more information on the scope of work activities for determining the most appropriate method to be used for existing conditions.

- Wire-Brush Method - Running a tight-fitting wire brush up and down the interior of the well casing, screen, and sump serves to remove sediment and debris particles and clears the screen openings. Use of the wire-brush method followed by bailing is an effective primary development scheme preliminary to surging or pumping.
- Bailing Method - Bailing involves inserting and withdrawing of a bailer or length of pipe with an end cap on the bottom. Bailing serves to remove turbid water and exerts a surging action as the bailer passes the screen. After wire brushing of the well interior has been performed, the well is bailed to remove sediment and debris. The bailing method is also used as an alternative when the formation or

water-producing zone fails to supply water at sufficient rates to sustain development by pumping.

- Mechanical Surging - Surging involves raising and lowering a surge block inside the well to force water to flow into and out of a screen and through the filter pack. The seals on the surge block are the same diameter as the inside of the well casing or one-half inch smaller if surging is conducted inside the screened interval. Turbid water must frequently be bailed from the well so that fines are not forced into the formatting and to prevent sand from locking up the surge block.

- Swabbing Method - A swab is a mechanical surging device that is pulled upward through the water column in a well. Swabbing may be done with single- or double-swab flanges and with or without water-bypass vents. Water may be injected into the well to the formation through the swabbing tool. In this method, water flows into one part of the screen, through the filter pack and adjacent formation, and out in another part of the screen. Swabbing is an aggressive development method that may be suitable if the introduction of water is acceptable. Swabbing is not recommended for wells with plastic casing or screens.

- High-Velocity Jetting - Jetting, or forcing water through the screen from nozzles on a pipe assembly, can clear screen openings. The jetting method is not always advisable as it forces the fines back into the filter pack and formation and adds large volumes of water to the system.

- Overpumping - A simple method of removing fines from a water-bearing formation is by overpumping. This method involves alternately pumping the well at a rate that will force it to become dry and allowing it to recover. The overpumping method is not always effective, particularly in unconsolidated formations, and may result in a formation that is partially developed.

- Pump Development - Pump development is commonly used as the final phase of well development for ER Project monitor wells after wire brushing and bailing methods have been performed. A submersible pump and packer assembly, if applicable, is installed and pumping at a sustainable rate is conducted until the water attains acceptable criteria to complete well development.

PROCEDURE

Preoperation Activities

Decontaminate all equipment that will enter the well or come into contact with the development water before developing each well.

Well development may begin as soon as is practical after the well is installed, but typically no sooner than 24-hours after grouting is completed. Do not use any dispersing agents, acids, or disinfectants to enhance the development of the well unless otherwise specified.

Well Development Activities

Open the surface protective lid and remove the well cap (if applicable). Monitor air quality at the top of the casing and in the breathing zone using a PID or other suitable field monitoring instrument.

Measure and record depth to water and total depth of the well. A minimum of three depth to water measurements should be taken with adequate time between measurements to ensure water table elevation is stable prior to development.

Begin bailing to remove turbid water from the well and sediment from the sump. Measure and record initial field chemical parameters (pH, electrical conductivity, and temperature) and turbidity. Periodically measure field parameters as specified in the site-specific work plan. Note and record volumes of water produced as bailing proceeds.

Begin pump-development procedures. For wells with multiple completions, each water-bearing zone is isolated using inflatable packers above and below the screen. The following general steps are taken to develop each screen individually and in succession:

- The drilling contractor installs a submersible pump-and-packer assembly across the first screen to be developed. Pumping is initiated at a sustainable rate that will not induce excessive drawdown.
- A transducer and/or a bubble piezometer may be installed in the well to measure water levels during the pump-development phase.
- When the pump has been turned on, collect a sample of the development water to measure and record initial field chemical parameters and turbidity. Note the initial color, clarity, and any obvious odor of the water. Periodically monitor water quality parameters throughout the pump-development phase as prescribed in the work plan. Likewise, note and record flow measurements (flow rate and volume produced) as indicated by an in-line flow meter. Continue to record measurements until the screen interval has been fully developed.

In general, well development procedures will continue for each screen interval until (1) the development water becomes free of suspended sediment, (2) an appropriate volume of water has been purged, and (3) field parameters have stabilized. Criteria for completing well development are described as follows:

- Turbidity Criteria - Well development shall continue until the turbidity readings stabilize or cannot be improved. If the well is not free of sediment after the required volume of water has been removed, continue pumping until twice that volume has been purged.
- Purge Volume Criteria - For wells where borehole drilling was conducted without the use of drilling fluid (water, mud, or additives), purge a minimum of five casing volumes of water before stopping well development. In situations where the groundwater flow from the screen interval is exceeded by the development pumping rate, the well may temporarily dry up.

- Field Parameter Criteria - This criterion for well development has been met when field parameters (temperature, pH, turbidity, dissolved oxygen, ORP) have stabilized over a minimum of three continuous monitoring measurements.

Documentation

Complete the appropriate data entry requirements on the Borehole/Well Completion information form to document well development.

STANDARD OPERATING PROCEDURE
LOW-FLOW PERISTALTIC PUMP GROUNDWATER SAMPLING
SOP 207

This standard operating procedure (SOP) is designed to assist the user in taking representative groundwater samples from wells. Groundwater samples will be collected using low-flow (minimal drawdown) purging and sampling methods as discussed in U.S. EPA, Ground Water Issue, Publication Number EPA/540/S-95/504, July 1996 by Puls, R.W. and M.J. Barcelona - “Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells.”

The field sampler’s objective is to purge and sample the well so that the water that is discharged from the pump, and subsequently collected, is representative of the formation water from the aquifer’s identified zone of interest.

This SOP is applied when the wells to be sampled are not equipped with dedicated down well equipment.

INITIAL PUMP FLOW TEST PROCEDURES

Measure and record the Static Water Level (SWL) on field data sheet following the procedures outlined in SOP 10.

If possible, the optimum flow rate for each well will be established during well development/redevelopment or in advance of the actual sampling event. The appropriate tubing type (Teflon, HDPE, PVC, polyethylene, etc…) should be preselected based on the analytes of interest.

The mid-point of the saturated screen length is used by convention as the location of the tubing intake (i.e. if total well depth is 30 ft below grade surface (bgs) and well is screened from 20-30 ft with a SWL of less than 20 ft., base of tubing should be lowered to 25 ft.). If the head in the well is within the screened interval tubing intake should be placed at ½ of the static well head (i.e. for previous example SWL is at 22 ft. bgs, tubing intake should be placed at 26 ft bgs as 30-22 = 8ft of head in well, 30 – (8*½) = 26 ft.).

Site specific work plans may change the location of sample intake depth in order to sample from the highest yielding zone within the screened interval. In wells with a fully saturated screen length over 10 feet, testing should be performed if possible during development to determine highest water yielding zone within screened interval.

After tubing installation and confirmation that the SWL has returned to its original level (as determined prior to tubing installation), the peristaltic pump should be started at a discharge rate less than 0.5 liters per minute (0.13 gal/min) without any In-Line Flow Cell connected. The water level in the well casing must be monitored continuously for any change from the original measurement. If significant drawdown is observed, the pump’s flow rate should be incrementally reduced until the SWL drawdown ceases and stabilizes. Total drawdown from the initial (static) water level should not exceed 0.3 feet. In any case, the water level in the well should not be lowered below the top of the screen/intake zone of the well.

Once the specific well’s optimum flow rate, without an In-Line Flow Cell connected, has been determined and documented, connect the In-Line Flow Cell system (if available) to be used to the well discharge and determine the control settings required to achieve the well’s determined optimum flow rate with the In-Line Flow Cell connected (due to the system’s back-pressure, the flow rate will be decreased by ten to 20 percent).

PURGE AND SAMPLING EVENTS

Prior to the initiation of purging a well, the Static Water Level will be measured and documented. The peristaltic pump will be started utilizing its documented control settings and its flow rate will be confirmed by volumetric discharge measurement with the In-Line Flow Cell connected. If necessary, any minor modifications to the control settings to achieve the well's optimum flow rate will be documented on the gauging sheet. When the optimum pump flow rate has been established, the SWL drawdown has stabilized within the required range, and at least one pump system volume (down well extraction tubing, pump head tubing, and discharge tubing volume) has been purged, begin taking field measurements for pH, temperature (T), conductivity (Ec), oxygen reduction potential (ORP), dissolved oxygen (DO), and turbidity (TU) using an in-line flow cell or if unavailable individual water quality meters. All water chemistry field measurements will be documented on the gauging sheet. Measurements should be taken every three to five minutes until stabilization has been achieved. Stabilization is achieved after all parameters have stabilized for three consecutive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or dissolved oxygen. Three consecutive measurements indicating stability should be within:

Temperature	± 3 percent of reading (minimum of ± 0.2 C).
pH	± 0.1 units, minimum.
Conductance	± 3 percent of reading.
Dissolved Oxygen	± 10 percent of reading.
Redox (ORP)	± 10 mV.
Turbidity	± 10 percent NTU or < 10 NTU (Turbidity is not a water chemistry indicator parameter but is useful as an indicator of pumping stress on the formation).

When water quality parameters have stabilized, and there has been no change in the stabilized SWL (i.e., no continuous drawdown), sampling collection may begin.

EQUIPMENT LIST

The following equipment is needed to conduct low flow purging and sampling:

- Portable peristaltic pump equipped with a flow controller set to operate at the specific well's documented optimum flow rate.
- Disposable down well sampling tubing of sufficient length to intake groundwater at the target sampling depth for each well.
- In-Line Flow Cell and meter(s) with connection fittings and tubing to measure water quality.
- Water quality meters as backup in-case of in-line flow cell malfunction.
- Water Level Probe or installed dedicated water level measurement system.
- Photoionization detector (PID).
- Sample containers appropriate for the analytical requirements.
- Field measurement documentation forms.
- 300 to 500 milliliter graduated cylinder or measuring cup.
- Five gallon bucket(s) for containerizing purge water.
- Wristwatch with second hand or stopwatch.
- Sufficient cleaning and decontamination supplies if portable Water Level Probe is utilized.

PROCEDURE

- Calibrate all field instruments at the start of each day's deployment per the instrument manufacturer's instructions. Record calibration data.
- Drive to the first well scheduled to be sampled (typically the least contaminated). Make notes in the field log book describing the well condition and activity in the vicinity of the well. Decontaminate the portable water gauging probe by washing with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Remove the wellhead cover and take a measurement of the well vapor space with a PID. Record the measurement on the gauging and sampling sheet.
- Measure the depth to water from the surveyed reference mark on the wellhead and record the measurement on the gauging and sampling sheet. Lock the water level meter in place so that the level can be monitored during purging and sampling. When placing the probe in the well, take precautions to not disturb or agitate the water.
- Insert a sufficient length of disposable sampling tubing into the well casing to insure that the tip of the tubing is located within the appropriate sampling depth within the well screen.
- Insert a new length of flexible silicone tubing into the peristaltic pump head fixture.
- Connect the down well sampling tubing to the silicone tubing in the peristaltic pump head fixture.
- Connect a new length of disposable pump discharge tubing to the silicone tubing in the peristaltic pump head fixture and secure to drain the flow-rate test purge water into the purge water collection container.
- Start the peristaltic pump. Set the pump controller settings to the documented settings for the specific well. Confirm the flow rate is equal to the well's established optimum flow rate. Modify as necessary (documenting any required modifications).
- Monitor the water level and confirm that the SWL drawdown has stabilized within the well's allowable limits.
- Remove the pump discharge tubing.
- Connect the pump discharge tubing to the In-Line flow cells "IN" fitting.
- Connect the Flow Cell's "OUT" line and secure to drain the purge water into the purge water collection container.
- After a single pump-system's volume (down well sampling tubing, pump head silicone tubing, and discharge tubing volume) has been adequately purged, read, and record water quality field measurements every three to five minutes until all parameters have stabilized within their allowable ranges for at least three consecutive measurements. When stabilization has been achieved, sample collection may begin.
- Disconnect the flow cell, and it's tubing, from the pump discharge line before collecting samples. Decrease the pump rate to 100 milliliters per minute or less by lowering the pump controller's setting prior to collecting samples for volatiles. Refer to the task instructions for the correct order and procedures for filling sample containers. Place the samples in a cooler with enough ice to keep them at 4 degrees Centigrade.
- Once samples for volatiles have been collected, re-establish pump flow rate to the original purge flow rate by inputting the documented controller settings for the well without the In-Line Flow Cell connected, and collect remaining samples.

- When all sample containers have been filled, make a final measurement of the well's Static Water Level and record the measurement on the gauging and sampling sheet. Measure the Total Depth of the well and record the measurement, as well.
- Measure and record total purge volume collected. Consolidate generated purge water.
- Remove and decontaminate the Portable Water Level Probe with phosphate-free detergent, rinsing with potable water and rinsing with deionized water.
- Disconnect and dispose of each length of down well sampling tubing, silicone pump head tubing, and pump discharge tubing.
- Secure the peristaltic pump in the portable pump carrying case.
- Secure the wellhead cover and secure with its lock. Move equipment to next well to be sampled.
- At the end of each day, post calibrate all field instruments and record the measurements.
- Clean and decontaminate the In-Line Flow Cell with phosphate-free detergent, rinsing with potable water, and rinsing with deionized water.
- Photocopies of all completed forms should be made each day. The copies should be retained on site. The original forms will be kept in the PNG Environmental project file.

GROUNDWATER
SAMPLE COLLECTION FORM

Well ID no________________________ Project name________________________
Sample no.________________________ Project no.________________________
Date_____/___/__________________ Collector________________________

Well Information
Monument condition ☐ Good ☐ Needs repair____________________
Well cap condition ☐ Good ☐ Locked ☐ Replaced ☐ Needs replacement
Headspace reading ☐ Not measured ______ ppm ☐ Odor__________
Elevation mark ☐ Yes ☐ Added ☐ Other ____________________
Well diameter ☐ 2-inch ☐ 4-inch ☐ 6-inch ☐ Other __________

Purge Data
Total well depth____________ft ☐ Clean bottom ☐ Muddy bottom ☐ Not measured
Depth to product____________ft Pump/Tubing Intake Depth____________ft
Depth to water____________ft
Casing volume ____________ft (H_2O) X __________gpf = _______ X 3 = ____________
Casing volumes 3/4”=0.02 gpf 1”=0.04 gpf 2”=0.16 gpf 4”=0.65 gpf 6”= 1.47 gpf
Bladder Pumps: ¼” Tubing purge: 5.3mL/ft + 100mL; ⅜” Tubing purge: 9.5 mL/ft + 500mL

Purge Method
Pump type ☐ Peristaltic ☐ Bladder ☐ Submersible ☐ Other__________
Purge tubing ☐ New LDPE ☐ New HDPE ☐ New Teflon ☐ New Tygon ☐ Other _____
Bailer type ☐ Disposable ☐ Teflon ☐ Stainless ☐ PVC ☐ Other _____
Purge start time____________Purge stop time____________Purge rate____________
Refill Timer Setting_____ Discharge Timer Setting _____ Pressure Setting_____ Flow Rate .

Field Parameters
Meter used ☐ HYDAC Ξ QED Flow Cell ☐ Hanna ☐ Other__________

Gallons / mL	pH	Temp (F)	Conductivity	ORP	DO mg/L	Turbidity	Comments

Sampling Device
Bailer ☐ Disposable ☐ Stainless ☐ Teflon ☐ Other ________________
Filter Type________ Size_______ (micron) Bailer cord used ☐ Monofillament

Bottles Filled Time________
NumberType Preservative Filtration
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No
___☐ VOA ☐ Amber ☐ Poly ☐ HCL ☐ Nitric ☐ Sulfuric ☐ None ☐ Other__ ☐Yes ☐No
Comments:

Sampler’s Signature____________________________________Date_________/___/_________

STANDARD OPERATING PROCEDURE
SUB-SLAB VAPOR SAMPLE COLLECTION
SOP 300

This Standard Operating Procedure (SOP) describes the method for sub-slab vapor sample collection from both temporary and permanently installed soil vapor probes (implants). Soil gas probe installation/construction methods are detailed in SOP 21. Because each site is unique, these procedures should be viewed as guidelines and will likely require modification based on site and subsurface conditions present. In certain instances where specific chemicals of concern (e.g. diesel or semi-volatile organic compounds) are being investigated or lower method reporting limits are desired, an alternate sampling methodology (EPA TO-17) may be utilized. In these instances installation of the sampling point will follow the same procedure as described in this SOP but alternate sampling media (adsorbent tubes) will be required as specified in the alternate sampling methodology section of this SOP.

Personnel performing the soil gas monitoring and sampling will follow site safety procedures as specified in the site-specific Health and Safety Plan.

EQUIPMENT/MATERIALS

- Tubing: ⅛-inch or ¼-inch outer diameter (OD) inert, impermeable tubing such as nylon (Nylaflow®), Teflon® tubing, or stainless steel.
- Sample Containers: Stainless steel Summa canisters (one-liter Summa canisters are preferred; however, the site specific work plan may justify another appropriate size), syringe, or tedlar bag.
- Monitoring and sampling equipment may include the following: Certified flow controllers (if flow controllers are used, ensure flow controllers are dedicated to the canister/sample location), stainless steel t-fitting, stainless-steel particulate filter, photoionization detector (PID), low flow vacuum pump, vacuum gauge, portable weather station, and/or barometric pressure data loggers. In the event that EPA TO-17 sampling methodology is required adsorbent tubes, low flow rate pumps or high flow rate pumps with low flow adapters and constant pressure controllers will be substituted (see alternate sampling methodology section of this SOP).
- Leak check equipment using helium or other pre-approved non-reactive tracer gas may include: helium tank, piping, and valve, leak check enclosure (shroud), helium detector, paper towels or rags, and nitrile gloves. Tracer gas should be laboratory grade and the grade noted on the sample form (e.g. 100% pure helium by volume).

COLLECTION PROTOCOL

Since sub-slab sampling is from very shallow depths (typically two to six-inches below surface), minimum purge volumes and low volume samples are preferred to minimize potential breakthrough from the surface. Regardless of sample depth, a 30 minute flow controller (minimum) should be used. Tracer/leak gas (helium is preferred) will be used to ensure breakthrough does not occur. Note that if sub-slab and deeper subsurface soil gas samples are to be collected, they should be collected from separate boring locations in order to maintain a proper seal. Constructing nested sampling points is possible, but breakthrough is more likely and nested construction is not preferred. If possible, shallow samples should be collected prior to deeper samples to ensure surface seal.

Syringe Grab Samples

If only syringe samples are to be collected, connect syringe to probe tubing using the T-valve. If the syringe is connected directly to the probe implant, no purging is required. If a connecting tube is used between the syringe and the implant, purge out one to two dead-volumes of the connecting tubing (approximately one cubic centimeter per foot (cc/ft) for ⅛-inch OD tubing and five cc/ft for ¼-inch OD tubing). Leave syringe connected to implant the tubing. Sample by extracting soil gas via the syringe plunger.

Summa Canisters

Inspect the laboratory-provided Summa canister for damage prior to use. Do not use a canister that has visible damage.

Using a wrench, remove the brass cap above the valve on the top of the Summa canister. Measure and record the initial vacuum of Summa canister. If using an external vacuum gauge, cap the gauge and attach it to the canister using a wrench. Open the canister valve only after verifying the gauge is properly capped.

Verify that the vacuum pressure of the canister is equal to that indicated on the laboratory supplied tag. If the vacuum does not match, the canister has likely leaked and should not be used. Record the vacuum pressure on the sample collection form.

The canister will then be fitted with the laboratory-provided steel filter. The sampling train (steel-filter, flow-controller (if used), and Summa canister) will be attached to a T-connector with an in-line vacuum gauge and vacuum tight flow valves at each end. All valves should be closed on the T connector at this time. The valve connected to the sampling train is referred to as the sampling valve. The vacuum pump (truck-mounted or otherwise) is then attached to the second end of the T with the valve closed (referred to as the purge valve).

Lastly, the sample tubing is threaded through the leak-check shroud and connected to the sub-slab sampling point and the third closed valve on the T-connector. The leak-check shroud should then be sealed against the slab surface (see “Leak Check – Probe Point Surface Seal” below).

Leaking Checking - Apparatus

The method described below shall be used to check for leaks in the lines and fittings of the above ground sampling apparatus:

- After the sampling system is set up, double check all valves are closed.
- Open the purge valve (the valve connecting the purge pump to the apparatus, all other valves remain closed), turn on the purge pump, and apply approximately ten inches of vacuum into the T-connector and valves. Close the purge valve and check to verify that there is no loss of vacuum within the sampling apparatus (T-connector and valves) over a one minute period of time. If there is a loss of vacuum, this indicates a leak in the purge/sample system train that must be remedied.
- If necessary, recheck the system to verify that there is no leakage as described above.
- Document the date and time the leak check(s) were performed on the sampling form. Ensure all valves remain closed.

Leaking Checking – Probe Point Surface Seal

In addition checking for leaks in the apparatus, the probe point surface seal also needs to be checked for leakage. The preferred method uses helium gas as a tracer and permits checking for and correcting potential leaks in the field prior to sampling. Other tracer gases may be used but approval of their use should be verified prior to the start of the work. The helium tracer gas method is listed in ITRC's "Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline" dated January 2007 (ITRC 2007), and as described below. The ITRC guidance from which the text below is derived is consistent with California Environmental Protection Agency and Oregon Department of Environmental Quality guidance (CalEPA 2005 and 2010; DEQ 2010).

Helium Leak Check Method

- Insert sample tubing through the leak check enclosure (also referred to as a shroud) and complete sample tubing connections to the other apparatus (previously described above).
- Place the enclosure shroud flush with the ground surface, placing hydrated bentonite around the shroud to seal the shroud around the sample point.
- Attach helium tubing from the helium tank regulator to the enclosure (the "helium in" tubing).
- Attach the exhaust tubing ("helium out") to the enclosure and locate the discharge end of the tubing as far as possible from the helium detector.
- Attach the helium detector on the exhaust line from the sample pump.
- Make sure the sample valve (from the sampling probe point) is closed.
- Open the helium tank valve and set the flow at 200 milliliter per minute (ml/min) or less; let it flow for about one minute to fill the leak check enclosure.
- Do an initial check to make sure the helium detector is not detecting any helium.
- Begin purging of soil gas as described in the section on purging below. During purging, continue monitoring helium detector, record readings. If helium is detected at over 5%, this indicates leakage; check/tighten all seals and fittings and repeat procedure. The helium exhaust line should also be monitored so that additional helium can be added to the shroud during sampling if needed.
- Close valves from the probe sampling point and purge pump lines, and turn pump off.
- If the helium detector reading is less than 5%, the system is considered leak free and sampling can be performed (see sampling section below).
- If the helium detector reading continues to be above 5%, leakage is indicated and the sub-slab abandoned.
- Record helium monitoring measurements in field notes.

Soil Gas Purging Procedures

Purging and sampling will be accomplished at a low flow rate (100 to 200 ml/min) to minimize the potential for inducing leakage. Flow rates should not exceed 200 ml/min. Purge vapors will be monitored using a PID for the presence of volatile organic compounds.

Slowly open the vacuum pump purge valve and purge three volumes of vapor from the dead space (volume of tubing and sand pack combined), then close the purge valve. Tubing volume can be estimated at 44 milliliters per foot (mm/ft) of 0.25-inch inner diameter (ID) tubing. For the sand pack volume calculation it is important to note that 1 cubic inch is equivalent to 16.387 milliliters. The sand pack volume can be calculated as shown:

Sand pack volume = $(\Phi*\pi*r_1^2*L_1) - (\pi*r_2^2*L_2)$

Where Φ = sand pack porosity, typically estimated at 30%

r_1 = radius of sand pack

L_1 = length of sand pack

r_2 = outer radius of tubing (half of outer diameter)

L_2 = length of tubing within the sand pack

Care will be taken not to purge an excessive volume, or at an excessive rate, so as to minimize the chances of inducing leakage from the surface. The pump will also be monitored for signs that it is laboring, a possible indication of a clogged probe or tubing.

During purging, check for leaks as described in the section on leak checks above. Record PID measurements of purge vapors on the field form. At the conclusion of purging, immediately close the purge valve and then shut off the purge pump.

Soil Gas Sample Collection Procedures - Grab Sampling

Atmospheric conditions (barometric pressure, temperature, wind speed and direction) will be recorded prior to and after sampling. A portable weather station equipped with a data logger is preferred to log site-specific conditions over the duration of sampling. However, if a weather station cannot be set-up on site, record atmospheric data from the closest weather station.

After leak testing and soil gas purging, soil gas sampling may be performed.

After purging, the purge valve will be closed prior to opening the sampling valve. The sample valve will then be opened followed by slowly opening the Summa canister valve. The canister's valve should be closed when the vacuum gauge shows a vacuum of 5 inches of mercury (in Hg) (pressure of -5 in Hg). The sample valve should then be closed.

Ensure the canister valve is tightly closed. The sample train should be immediately disassembled by removing the steel particulate filter, and the Summa canister. Immediately cap the Summa canister fitting. The final vacuum reading from the canister should be recorded on the chain of custody, sample collection form, and canister identification tag. If the final canister vacuum is less than 0.1 in Hg (more than -0.1 in Hg of pressure, or is a positive pressure), then the sample should be disregarded and a new sample collected.

Soil vapor samples will be shipped to a certified laboratory for analysis.

Sampling Procedures using a flow controller

The sampling procedure is the same as above except that a laboratory certified in-line flow controller for a pre-specified sampling time (i.e. 30 minutes) will be used. The flow controller fits between the laboratory provided steel particulate filter and the Summa canister. The entire sample train (laboratory-provided steel particulate filter, flow-controller, and summa canister) should be pre-assembled prior to connecting to the sampling valve.

Other Collection Notes

For larger canisters (greater than one liter), sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize potential for vacuum extraction of contaminants from the soil phase. If large volume canisters are used (three or more liters) without a flow controller to ensure the flow rate remains below 200 ml/min, a purge volume test may be required to ensure sample dilution from other zones is not occurring.

FIELD RECORDS

The field technician maintains a log sheet summarizing:

- Sample Location.
- Sample Identification.
- Date and time of sample collection.
- Sampling depth.
- Tubing type, length, and volume.
- Purge Data (i.e. pump used, volume, PID screening information, purge start and stop time, purge vacuum reading).
- Weather conditions.
- Sampling methods and devices.
- Volume of sampling device.
- Sampling start and end date/time.
- Vacuum of canisters before and after samples collected.
- Apparent moisture content (dry, moist, or saturated, etc.) of the sampling zone.
- Chain of custody protocols and records used to track samples from sampling point to analysis.
- Other notes as applicable to site specific observations, sampling issues and mitigation of problems encountered.

ALTERNATIVE EPA METHOD TO-17 SAMPLING PROCEDURE

This alternate sampling methodology is consistent with EPA Compendium Method TO-17: *Determination of Volatile Organic Compounds in Ambient Air using Active Sampling onto Sorbent Tubes* (EPA 1999) and the established protocols of the PNG preferred laboratory (Air Toxics Ltd.) for the collection and analysis of samples by this method. This method replaces earlier sorbent-based EPA Methods TO-1 and TO-2 and provides an alternative to canister-based EPA Method TO-15 discussed in the Collection Protocol above. The target compound list is the same as TO-15 (i.e. subsets of the 97 VOCs listed as hazardous air pollutants in the Clean Air Act Amendments of 1990). However, TO-17 can collect VOCs over a wider volatility range than TO-15, by using a tube with multiple sorbents packed in increasing sorbent strength. Both single and multi-bed sorbent tubes are described in TO-17. Tube selection and the number and type of sorbents that will be packed into the tubes and conditioned by the laboratory are dependent on the COCs and desired reporting limit. Although the EPA Method TO-17 suggests replicate or distributed pair samples with sampling volumes of one and four liters, there is considerable mention of calculating a safe sampling volume (SSV). The SSV will minimize the potential for breakthrough on the sorbent tube and support the generation of valid analytical results. The sampling volume that is selected should include consideration of both the desired final reporting limit and the SSV of the sorbent being used. Further, when applied to the circumstances presented in this SOP, the methodology must be further modified to account for the greater concentrations of target COCs in soil gas than ambient air. In addition, because soil gas samples are typically for characterization purposes, the replicate or distributed pair sampling methodology should only be applied where field QA/QC samples are considered necessary.

SORBENT TUBE SELECTION

The approach to sorbent tube selection considering both reporting limits and sorbent SSVs is described in the following steps. This evaluation should be discussed with the analytical laboratory prior to ordering sorbent tubes for a given site investigation or sampling event.

- **Determine the Final Reporting Limit of the Target Compound –** This will be dependent on the COCs that are being investigated and their respective risk-based concentrations (RBCs) or preliminary remediation goals (PRGs) that are applicable at the site.
- **Determine the Method Reporting Limit –** The analytical laboratory will provide the mass value for each of the COCs that are being investigated based on the analytical method selected and the sensitivity of the instrumentation. The method reporting limit may vary for each of the target COCs.
- **Calculate the Sampling Volume –** The target sampling volume must be calculated to determine the volume of soil gas that must be drawn through the sorbent tube in order to achieve the desired final reporting limit for the target COCs. The target sampling volume is calculated by dividing the laboratory provided reporting limit for the target COC by the RBC or PRG of the COC then multiplying by 1000 liters. For example if the target COC was benzene at a residential site. The laboratory provided method reporting limit is 0.01 micrograms (ug) and the residential soil gas RBC in Oregon is 62 ug/m^3. Dividing 0.01 by 62 and multiplying by 1000 L/m^3 yields 0.16 L for a minimum sampling volume to achieve the target final reporting limit.
- **Calculate Minimum Flow Rate –** The minimum flow rate for the sampling pump and sorbent tube must be calculated to determine the sampling velocity for a specified time interval. Using the example above, if a minimum sampling volume of 0.16 L is required and the specified sampling interval is 5 minutes, the minimum flow rate would be determined by dividing 0.16 L by 5 minutes. This would yield a minimum flow rate of approximately 0.032 L/minute.
- **Compare the Sampling Volume to the SSV –** To determine whether or not sorbent tube breakthrough is likely for the target COC it is necessary to compare the minimum sampling volume calculated for the target COC with the SSV for the selected sorbent tube for the target COC. The SSVs for target COCs and suitable sorbents for those COCs are presented in Appendix 1 of the EPA Compendium Method TO-17 (EPA 1999). For example TO-17 Appendix 1 indicates that for benzene a SSV of up to 26 L can be collected using a Type 3 (CarboTrap 300) multi-sorbent tube. The target sampling volume determined above (0.16 L) could therefore be accommodated by the SSV of the tube and no breakthrough would be expected at the target sampling volume for a method reporting limit concentration.
- **Calculate if Overloading of Sorbent Tube is Possible –** Having determined if breakthrough is possible due to sampling volume, the likely concentration of the target COC in the soil gas sample must also be considered. For the target sampling volume desired, the maximum concentration of the target COC that could be accommodated by the SSV of the tube must also be evaluated. Again using the above example, if a minimum sampling volume of 0.16 L is required in order to achieve a final reporting limit lower than the RBC (62 ug/m^3), a tube which has an SSV of 26 L could contain a sample with a concentration equivalent to the SSV (26 L) divided by the minimum sampling volume (0.16 L) and multiplied by the RBC (62 ug/m^3) which would equate to 10,075 ug/m^3. Samples collected with sorbent tubes in known source areas would therefore require lower target sampling volumes (achieved through lower flow rates for the same duration or the same flow rate for a shorter duration) because it would not be necessary to achieve the lower reporting

limit but quantification of the concentration without saturation of the sorbent tube is desired.

SORBENT TUBE SAMPLING PROCEDURE

This approach to sorbent tube sampling assumes that sub-slab sampling point installation was performed in accordance with SOP-21 and leak checking and purging as described in the Collection Protocol above has been completed prior to the initiation of the following steps:

- **Pre-Sampling Flow Calibration –** Prior to sorbent tube sample collection the sampling pump that will be used during sample collection must be calibrated. In order to calibrate the pump connect a "set-up" tube provided by the lab to the Tygon tubing connected to the pump. If using a higher flow pump a low flow holder and constant pressure controller may be necessary to lower the flow rate. Adjust pump settings or restrict the flow using the low flow holder to the desired flow rate and record it on the field data sheet.
- **Sorbent Tube Connection –** After pump calibration, replace the "set-up" tube with the sample tube. Remove the sorbent tube from the laboratory provided sample container; then remove the foil wrapping, and both end plugs from the tube. Again using the Tygon tubing, connect the sampling pump to the outlet of the sample tube/low flow holder. Attach the sorbent tube inlet to the union fitting using a Swagelok nut. In the same manner attach the union to the Swagelok nut on the tubing from the sub-slab sampling point.
- **Sample Collection –** To begin sample collection start the sample pump and record the start time. After the desired duration, stop the pump and record the end time.
- **Sorbent Tube Removal –** Disconnect the sorbent tube from the Tygon tubing and union fitting and replace the end plugs on both ends of the sample tube. Record the sample ID, the tube ID, the collection date and time on the field data sheet and the laboratory chain-of-custody form. Wrap the tube in foil then replace in the laboratory provided sample container. Place the sample container in a cooler with blue ice.
- **Post Sampling Flow Calibration –** When completed with sample collection, reattach the "set-up" tube to the pump/low flow holder and measure the post sampling flow rate. Record the post-sampling flow rate on the field data sheet. The post-sampling flow rate should be within 10% of the pre-sampling flow rate.
- **Calculate Sampling Volume –** Calculate the average of the pre- and post-sampling flow rates then determine the total sampling volume by multiplying the average flow rate by the sample collection time duration. Record the sampling volume on the field data sheet and the laboratory chain-of-custody form.

REFERENCES

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