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Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

Memorandum

To: Sam Meng, Washington State Department of Ecology

Copies: Lisa Hendriksen, Port of Longview

From: Nathan Schachtman and Gabe Cisneros, Floyd|Snider

Date: November 22, 2024

Project ID: POL-TPH

Re: Pre-Design Investigation Work Plan

This Pre-Design Investigation (PDI) Work Plan has been prepared on behalf of the Port of Longview (Port) Total Petroleum Hydrocarbons (TPH) Site (Site) and Potentially Liable Parties (PLP) Group for the Site. The Site is located in Longview, Washington, on the north side of the Columbia River, directly east of the Lewis and Clark Bridge (Figure 1). This PDI Work Plan presents proposed additional data collection to inform the design of the cleanup action for the Site. The PDI activities outlined in this work plan were requested by the Washington State Department of Ecology (Ecology) during the Remedial Investigation (RI) phase but were not necessary for moving forward with the Feasibility Study (FS); therefore, Ecology agreed to conduct these activities as a PDI. Ecology requested that the results of the PDI described herein be summarized in a memorandum to be submitted prior to preparing and submitting the Engineering Design Report (EDR). The PDI results will be used to finalize the design for the cleanup action and will be included in the EDR in accordance with Agreed Order # DE 15907.

BACKGROUND

The Site is currently zoned as heavy industrial and is used for Port operations and marine cargo operations, which includes a rail-dependent bulk export facility. The Site contains a ship berth, active railyard, and associated warehouse and transit shed buildings to accommodate the marine cargo. Since the early 1900s, the Port has been operating at this location. During that time, other entities (and their predecessors), including Chevron U.S.A. Inc. (Chevron),[1] Georgia-Pacific LLC (Georgia-Pacific),[2] Wilson Oil, Inc. (Wilson),[3] and Smurfit Westrock LLC (WestRock),[4] have

[1] Standard Oil Company of California is Chevron U.S.A. Inc.'s predecessor. Chevron Environmental Management Company manages environmental matters for the Chevron family of companies.

[2] James River Corporation and Crown Zellerbach are corporate predecessors of Georgia-Pacific.

[3] Wilson is doing business as Wilcox & Flegel Oil Company.

[4] WestRock Longview, Longview Fibre Paper and Packaging, Inc., Longview Fibre Company, and KapStone Kraft Paper Corporation are predecessors to WestRock.

operated facilities at the Site. These facilities and years each entity operated them are summarized in the Remedial Investigation/Feasibility Study (Floyd|Snider 2024).

The Site is designated Ecology Facility Site ID No. 42978181 and is officially referred to as the Port of Longview TPH Site. It includes portions of four tax parcels and a section of the Port Way right-of-way including the following:

- Parcels owned and operated by the Port (Cowlitz County Parcels 10171 and 10183)
- A small parcel owned by the Port and/or BNSF Railway Company that contains rail lines that the Port operates (Cowlitz County Parcel 90293)
- A portion of the Washington State Department of Transportation (WSDOT) property on the west side of Port Way (Cowlitz County Parcel 61634)
- A segment of the City of Longview's right-of-way beneath Port Way located adjacent to/between the parcels identified above.

The Site is almost entirely paved, except for areas of rail track infrastructure and a material storage area within the former Calloway Ross parcel and the WSDOT property (Figures 2 and 3). The Site will have similar land use in the future. A log export facility owned by Weyerhaeuser NR Company and an active bulk fuel facility owned by Wilson are located northwest- and northeast-adjacent to the Site, respectively. The Columbia River and Port property border the Site to the southwest and southeast, respectively. The Jones Stevedoring Company borders a small portion of the Site to the northwest. The rail lines are operated by the Port and owned by either the Port and/or BNSF Railway Company.

PURPOSE

This PDI Work Plan was developed to provide additional soil and groundwater data that will be used to inform the engineering design of the cleanup action prior to implementation. The following additional data collection have been identified and are detailed in this PDI Work Plan:

- **Monitoring well decommissioning:** Existing monitoring wells MW-04 and MW-30, located on the WSDOT property, will be decommissioned and replaced (locations shown as replacement wells MW-04R and MW-30R on Figure 3).
- **Monitoring well installation and sampling:** Seven new monitoring wells (including the MW-04 and MW-30 replacements) will be installed to help fill groundwater quality data gaps in the perched zone and alluvial aquifer as detailed in the RI/FS and draft Cleanup Action Plan (Floyd|Snider 2024a, 2024b). Limited soil sampling during monitoring well installation will occur at select locations to support the PDI.
- **Field testing on soil containing residual light non-aqueous phase liquid (LNAPL) near MW-09:** Surfactant injection and extraction activities are part of the selected remedy to eliminate the residual LNAPL in MW-09. Therefore, hydrocarbon saturated soil will be collected from a direct-push boring near MW-09 and mixed with a surfactant

solution (PetroCleanze) to confirm that the surfactant will be effective at LNAPL removal by liberating hydrocarbons adsorbed to soil.

- **Limited former Longview Pipeline inspection:** The purpose of the pipeline inspection is to identify whether residual product is present within the former pipeline structure. Pipeline inspection activities will include excavating overlying soil to expose the pipeline(s) at two separate locations, cutting into the pipeline structure to observe whether product is present, resealing the pipeline, and backfilling with excavated soil that has been tested to confirm it is suitable as backfill. The operational history and background of the pipeline structures are summarized in the Agreed Order under the Findings of Fact Section and in the RI/FS (Floyd|Snider 2024a).

The additional data collection proposed above and in this PDI Work Plan will be conducted in accordance with the Sampling and Analysis and Quality Assurance Project Plan (SAP/QAPP) provided as Appendix F of the RI Work Plan and the Floyd|Snider standard guidelines provided in Attachment 1 (Floyd|Snider 2015a, 2015b, 2019a, 2019b, 2022, 2023). The SAP/QAPP provides details regarding sampling and analysis methods and field procedures as well as quality assurance and quality control procedures for field and laboratory activities developed for the Site.

MONITORING WELL DECOMMISSIONING

Existing perched zone monitoring wells MW-04 and MW-30, located west of Port Way on the WSDOT property, will be decommissioned by a licensed driller in accordance with WAC 173-160-381. MW-04 will be decommissioned because it has extremely low yield and not able to be sampled most of the year. MW-30 will be decommissioned because it is intended to be a perched zone monitoring location, but the well screen extends through both the perched zone and alluvial aquifer. Additionally, groundwater in MW-30 is initially very turbid when sampling, and typically, a large quantity of water needs to be evacuated prior to a sample being collected. This high initial turbidity is potentially indicative of a broken or partially fractured well screen and sand pack.

After decommissioning MW-04 and MW-30, replacement wells MW-04R and MW-30R will be installed in approximately the same locations. Details on the installation and construction of replacement monitoring wells are presented in the following section.

MONITORING WELL INSTALLATION, DEVELOPMENT, AND SAMPLING

Seven new monitoring wells will be installed to fill data gaps pertaining to the extent of the dissolved phase plumes within the perched zone and alluvial aquifer and/or to replace existing monitoring locations MW-04 and MW-30. It is anticipated that select new monitoring wells will also serve as part of the long-term compliance monitoring network once the selected remedy has been implemented. Proposed PDI monitoring well installation locations are shown in

Figures 3 and 4, and a rationale and general summary of new/replacement monitoring well is provided below:

- **MW-04R:** Perched zone monitoring location installed to replace the decommissioned MW-04 on the WSDOT property, which is frequently dry and likely is not screened deep enough into the saturated part of the perched zone. Therefore, MW-04R will be screened deeper than the existing well, which is screened from 7.5 to 17.5 feet below ground surface (bgs). The bottom of the MW-04R well screen will be placed in the upper foot of the low-permeability silt that separates the perched zone from the alluvial aquifer to maximize potential yield for sampling. The final well screen interval is contingent on field observations but anticipated to be from approximately 10 to 20 feet bgs.
- **MW-30R:** Perched zone monitoring location installed to replace the decommissioned MW-30 on the WSDOT property, which currently is inferred to collect groundwater from both the perched zone and alluvial aquifer. Therefore, MW-30R will be screened shallower than the existing well, which is screened from 9 to 26 feet bgs. Consistent with other perched zone monitoring locations, the bottom of the MW-30R well screen will be placed in the upper foot of the low-permeability silt that separates the perched zone from the alluvial aquifer. The final well screen interval is contingent on field observations but anticipated to be from approximately 10 to 20 feet bgs.
- **MW-41:** Perched zone monitoring location installed east of Port Way along the western border of Port property. MW-41 will provide additional information about the southern extent of the northern perched zone plume and is also intended to be part of the long-term compliance monitoring network after the remedy is implemented. Consistent with other perched zone monitoring locations, the bottom of the MW-41 well screen will be placed in the upper foot of the low-permeability silt that separates the perched zone from the alluvial aquifer. The final well screen interval is contingent on field observations but anticipated to be from approximately 5 to 15 feet bgs, based on the screen intervals of nearby perched zone monitoring location MW-02.
- **MW-42:** Perched zone monitoring location installed east of Port Way along the western border of Port property. MW-42 will provide additional information on the northern extent of the southern perched zone plume and, similar to MW-41, is intended to be part of the long-term compliance monitoring network after the remedy is implemented. Consistent with other perched zone monitoring locations, the bottom of the MW-42 well screen will be placed in the upper foot of the low-permeability silt that separates the perched zone from the alluvial aquifer. The final well screen interval is contingent on field observations but anticipated to be from approximately 10 to 20 feet bgs, based on the screen intervals of nearby perched zone monitoring locations MW-28 and MW-35.
- **MW-43:** Alluvial monitoring location installed east of Port Way along the western border of Port property, in the southwest corner of the former Calloway Ross parcel.

MW-43 will help delineate the northeastern extent of the alluvial aquifer plume centered around MW-09 and serve as part of the long-term compliance monitoring network after the remedy is implemented. Consistent with other alluvial aquifer monitoring wells, the top of the MW-43 well screen will be placed directly below the low-permeability silt that separates the perched zone and alluvial aquifer. The final well screen interval is contingent on field observations but anticipated to be from approximately 15 to 25 feet bgs, based on the screen intervals of nearby perched zone monitoring locations MW-05 and MW-08.

- **MW-44:** Alluvial monitoring location installed east of Port Way along the western border of Port property, directly west of direct push location GP-2. MW-44 will help delineate the western extent of the alluvial aquifer plume centered around MW-09 and serve as part of the long-term compliance monitoring network after the remedy is implemented. Consistent with other alluvial aquifer monitoring wells, the top of the MW-44 well screen will be placed directly below the low-permeability silt that separates the perched zone and alluvial aquifer. The final well screen interval is contingent on field observations but anticipated to be from approximately 15 to 25 feet bgs, based on the screen intervals of nearby perched zone monitoring locations MW-33 and MW-40.
- **MW-45:** Alluvial monitoring location installed west of Port Way within the WSDOT property, directly west of MW-05. MW-45 was requested by Ecology to determine whether dissolved phase hydrocarbon impacts are migrating off-property and whether an environmental covenant is needed for the WSDOT property. MW-45 will help delineate the western edge of the alluvial aquifer plume centered around MW-09. Consistent with other alluvial aquifer monitoring wells, the top of the MW-45 well screen will be placed directly below the low-permeability silt that separates the perched zone and alluvial aquifer. The final well screen interval is contingent on field observations but anticipated to be from approximately 15 to 25 feet bgs, based on the screen intervals of nearby perched zone monitoring locations MW-03 and MW-05.

Limited Soil Sampling

Limited soil sampling will occur at MW-43, MW-44, and GP-39 to assess the potential for the injection remedy to mobilize metals within the soil. Two soil samples will be collected from saturated, representative lithologies within each boring: one sample from within the perched zone and another sample from within the alluvial aquifer. Soil samples will represent approximately 1-foot intervals of soil and be collected in accordance with Floyd|Snider standard guidelines provided in Attachment 1.

Soil samples will be submitted to the laboratory for analysis of U.S. Environmental Protection Agency (USEPA) Priority Pollutant metals (arsenic, cadmium, chromium, lead, mercury [inorganic], selenium, silver, antimony, beryllium, copper, thallium, nickel, zinc) by USEPA 6020.

Monitoring Well Construction and Development

Monitoring well construction and development will be performed in accordance with Floyd|Snider standard guidelines provided in Attachment 1. A 2-inch-diameter polyvinyl chloride well with a 10-foot screen will be installed at each location using the direct push drilling method unless the field geologist indicates otherwise based on the material encountered in the subsurface. Wells will be completed with flush-mounted, traffic-rated stainless steel monuments. Following installation, monitoring wells will be developed to remove fine-grained material by purging with a submersible pump and surging with the pump or a surge block to move water through the sand pack and surrounding soil formation. Wells will be developed until the purge water achieves visual clarity.

Groundwater Sample Collection

One round of groundwater samples will be collected from the seven new monitoring wells a minimum of 1 month after development to establish baseline groundwater quality conditions at each new well prior to remedy implementation. Monitoring wells will be sampled using low-flow methodology in accordance with Floyd|Snider standard guidelines provided in Attachment 1. Groundwater samples will be collected at each of the seven locations and submitted for laboratory analysis of the following constituents:

- Gasoline-range organics (GRO) by NWTPH-Gx
- Diesel and oil-range organics (DRO and ORO) by NWTPH-Dx with and without silica gel cleanup
- Benzene, toluene, ethylbenzene, and xylenes (BTEX) by USEPA 8260

FIELD TESTING ON SOIL CONTAINING RESIDUAL LNAPL NEAR MW-09

Soil will be collected from a direct-push boring within the vicinity of MW-09 to support an evaluation of the effectiveness of the PetroCleanze surfactant in removing LNAPL from the soil. Surfactant injection and extraction activities in the vicinity of MW-09 are part of the selected remedy to eliminate the residual LNAPL in MW-09.

To support field testing of the surfactant product, one soil boring (GP-39) will be advanced to approximately 15 feet bgs in the vicinity of MW-09 as shown on Figure 3. As GP-39 is in close vicinity to the rail lines and in an area with significant subsurface utilities, this boring may be relocated up to 20 feet in any direction based on the results of a utility locate prior to drilling. A minimum of three subsurface soil intervals spanning approximately 1 foot each will be collected from GP-39. Soil will be collected from the three-most impacted intervals identified by field observations (i.e., visual and olfactory, sheen tests, photoionization detector measurements). Based on soil analytical results from MW-09 and OIP data from adjacent locations, the most-impacted soil is expected to be present between 7 and 14 feet bgs.

Field testing consists of three steps. The first step is to conduct a sheen test by placing a small amount of soil into a disposable or decontaminated stainless steel bowl, spraying it with tap water or deionized water, and observing whether a sheen appears on the water. If there is a sheen, the second step will be to use Cheiron Resources Ltd.'s OilScreenSoil (Sudan IV) dye field kits to identify and confirm the presence of residually trapped hydrocarbons adsorbed to the soil. The field kits come ready to use by adding soil and water to the laboratory-provided jars. The jar is lightly shaken after soil and water have been added. The red, blue, or fluorescent dye in the field kit stains petroleum product and provides a visual contrast for the presence of LNAPL in soil samples but does not distinguish the product type or concentration. Concentrations between 500 and 2,500 parts per million can be observed when the bead in the field kit turns pink, indigo blue, or fluorescent. The brochure containing guidelines for use from the manufacturer, Cheiron Resources Ltd., is included in Attachment 1 (n.d.).

Once residual LNAPL is observed and confirmed by doing the sheen test and using the Sudan IV field kits, soil from the same depth interval will be tested in accordance with Regenesis' procedures, which were provided by their research and development team in an email. Ecology requested that we perform field tests on Regenesis' surfactant product at different concentrations to identify the most effective concentration. Regenesis' procedures for performing field tests at various concentrations of 1%, 2%, and 5% include the following steps:

- **1% solution:** Add 10 grams Part A to the 1 liter of room temperature water (room temperature or slightly warmer is important, due to solubility). After the Part A is 100% solubilized:
    - Add 10 grams of Part B and mix into solution.
    - Add the RegenOx (Parts A + B) solution to the prepared soil.
        - NOTE: it is important to add RegenOx solution to the soil, not the other way around.
    - Add sufficient RegenOx solution to cover the soil with about a 1-inch layer of the 1% RegenOx solution and gently mix the RegenOx solution and soil.
        - It may be necessary to allow the soil to stand for 7 to 10 days or until the emulsion becomes suitably visible.
- **2% solution:** Add 20 grams of Part A to the 1 liter of room temperature water (room temperature or slightly warmer is important, due to solubility). After the Part A is 100% solubilized:
    - Add 20 grams of Part B mix into solution.
    - Add the RegenOx (Parts A + B) solution to the prepared soil.
        - NOTE: it is important to add RegenOx solution to the soil, not the other way around.

    - Add sufficient RegenOx solution to cover the soil with about 1-inch layer of the 2% RegenOx solution and gently mix the RegenOx solution and soil.
        - It may be necessary to allow the soil to stand for 7 to 10 days or until the emulsion becomes suitably visible.
- **5% solution:** Add 50 grams of Part A to the 1 liter of room temperature water (room temperature or slightly warmer is important, due to solubility). After the Part A is 100% solubilized:
    - Add 50 grams of Part B mix into solution.
    - Add the RegenOx (Parts A + B) solution to the prepared soil; NOTE: it is important to add RegenOx solution to the soil, not the other way around.
    - Add sufficient RegenOx solution to cover the soil with about 1-inch layer of the 5% RegenOx solution and gently mix the RegenOx solution and soil.
        - It may be necessary to allow the soil to stand for 7 to 10 days or until the emulsion becomes suitably visible.

A concentration is deemed successful if, after allowing enough time to stand, a layer of LNAPL forms on the surface of the liquid in the glass jar, indicating that the surfactant was successful in separating out residual LNAPL. The results of this test will be documented via photographs and a measurement of the thickness of any LNAPL that separates. The concentration that is the most successful at liberating adsorbed hydrocarbons from the soil will be recommended in the EDR.

LIMITED FORMER LONGVIEW PIPELINE INSPECTION

A limited inspection of the former Longview Pipeline, which runs from approximately the former 80,000-barrel aboveground storage tank (AST) to Berth 2, to determine the presence/absence of remaining product will be conducted as part of the PDI scope (Figure 2). In addition, the former pre-1970 Standard Pipeline ran immediately adjacent to and parallel with the former Longview Pipeline in the southern portion of the Site (Figures 3 and 4). If this pipeline, or others, are encountered during the excavation activities the contents of the pipelines, not just the former Longview Pipeline, will be inspected. Historical investigations in the southern portion of the Site indicate that a few isolated areas of impacted soil immediately adjacent to the pipelines are present. Groundwater data indicate that TPH-impacted soil within the saturated zone has low solubility and does not impact groundwater. However, little is known about the current contents of the pipelines; therefore, to better understand the risks of a potential release and to inform the cleanup activities needed to address these risks, an inspection will be performed. The limited inspection will occur in two different locations along the pipeline(s) and involve the following components that a selected environmental subcontractor will implement:

- Prior to excavation activities, a localized ground-penetrating radar survey will be conducted in the vicinity of the proposed excavation to identify the exact location of the pipeline(s) as well as any other subsurface utilities that may be present.

- The pipeline inspection will occur in two locations along the pipeline transect, as shown on Figure 2:
  - Location No. 1 is in the northern portion of the property. Excavation of approximately 125 cubic feet (5-foot by 5-foot by 5-foot excavation) of surface soil overlying the pipeline(s) just east of the existing rail lines and southwest of the former 80,000-barrel AST (as shown on Figure 2), where the pipelines are known to lie at a shallow depth of approximately 5 feet bgs (Golder 1994).
  - Location No. 2 is in the southern portion of the Site, north of Transit Shed 2 and south of the Cowlitz Diking Improvement District #1 right-of-way easement as shown on Figure 2. The pipelines are estimated to be approximately 10 to 15 feet bgs and safety measures, such as using a trench box, will be taken to prevent collapse during exposure.
- Once the pipeline(s) is exposed in each location, spill response measures and air monitoring will be executed in and around the excavation. Spill response measures include surrounding the excavation with absorbent booms, having additional absorbents on hand, and having a vacuum truck on-site in case a spill occurs. Absorbent booms or composite waddles and berms will be placed around the excavation to prevent stormwater from entering the excavation.
- First, a small hole will be drilled, using a non-sparking bit, into the pipeline(s) to determine if any and how much residual product is contained within the pipeline at each location. If old product is present, the thickness of product in the pipe at each location will be visually estimated as well as gauged using a ruler or similar measuring device. If there is a substantial volume of product, a sample of the product will be collected from the drill hole, and the hole will be resealed using a threaded plug if the hole has a 2-inch diameter or less; a larger opening will not be attempted to prevent incidental leakage. If deemed necessary to prevent leaking and if the hole is larger, the pipeline will be made inert, and an overlapping plate will be welded to the pipeline using appropriate and safe procedures. If the pipeline is empty or contains some product, the exposed top of the pipeline will be cut open using a saw to make a larger incision; then, the interior of the pipeline will be initially inspected visually for remaining product. If product is identified within the pipeline, observations—including approximate volume, color, odor, viscosity, and any other notable characteristics—will be noted. A sample of any product identified within the pipeline will be submitted to the laboratory for semivolatiles by Method 8270D, volatile organic compounds by Method 8260, polychlorinated biphenyls by Method 8082, total metals by Method 6020, hydrocarbon identification (HCID) Method, and product characteristics such as viscosity, solubility, and flash point. Additionally, if product is observed in the pipeline, the contents will be compared to the content observed in the Longview Pipeline (Line E in the Interim Action Completion Report; Floyd|Snider 2019c) during the pipeline removal activities under the pier, and laboratory results will be compared for consistency.

- If the pipeline is empty or has a small amount of product visible (i.e., which would facilitate a camera inspection), an inspection camera will be inserted into the cut opening on top of the pipeline. The inspection camera will be inserted into the opening on top of the pipeline and advanced as far as practical in both directions along the pipeline to further investigate the contents and condition of the pipeline. The type of camera used for the inspection will depend on field conditions, including the pipe diameter and condition as well as the amount and nature of any residual product present. Use of a sewer cable camera, sewer crawler, or similar device may be necessary. The field crew will come prepared with a variety of camera options and will deploy the camera that will achieve the greatest possible inspection length with the best visual resolution.
- After the inspection, the pipeline will be properly resealed by welding an overlapping plate back over the window, if field and vapor readings indicate this is safe.
- As a part of this investigation, it is important to identify all pipelines that are encountered during the excavation, especially at Location No. 1; therefore, a private locator will be on-site during the excavation activities. Prior to backfilling the excavation, the locator will place a signal on all pipelines that are encountered and trace their paths away from the excavation. This will help determine which pipeline was connected to the former AST, which will help to assign the observations to a pipeline.
- Excavated soil will be stockpiled in a secure area with erosion control measures in place. Erosion control measures include stockpiling soil on an impermeable liner (e.g., Visqueen), covering the stockpile with an impermeable liner, and surrounding the stockpile with an ecology block, straw bale, or other berm placed under the liner to prevent erosion. Stockpiled soil will be sampled and analyzed for DRO, ORO, GRO, BTEX, and PAHs to determine whether it can be used as suitable backfill. The number of soil samples will depend on the total volume of soil excavated according to Table 6.9 of Ecology’s Guidance for Remediation of Petroleum Contaminated Sites (2016). If analytical results from soil stockpile sampling show that analyte concentrations are less than their respective Model Toxics Control Act (MTCA) Method A Cleanup Levels (CULs), the excavated soil will be used to backfill the excavation. If analytical results are greater than MTCA Method A CULs, then clean fill will be imported to backfill the excavation.

If product is present and mobile within a pipeline, the current conceptual site model for potential pipeline releases will be revised and further developed to provide a more detailed basis for evaluating necessary cleanup actions. Potential next steps and options will be assessed, in coordination with Ecology.

SCHEDULE AND REPORTING

PDI Work Plan implementation will begin within 90 days of Ecology's approval of the Work Plan. PDI results, including a description of all work performed, field observations, and analytical results will be summarized in a Draft PDI Results Summary Memorandum that will be submitted to Ecology for review within 60 days of receipt of final validated laboratory data. A final PDI Results Summary Memorandum will be submitted to Ecology within 30 days of receipt of Ecology's comment on the draft.

REFERENCES

Cheiron Resources Ltd. n.d. *OilScreenSoil: Cost Effective "Instant" and Disposable Tests for Field Screening of Petroleum Hydrocarbons and Chlorinated Solvents in Soil*.

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_____. 2019b. *F|S Standard Guideline: Soil Logging*. October.

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Golder Associates (Golder). 1993. *Phase III Characterization Report Bunker C and Diesel Fuel Investigation, Port of Longview, Longview, Washington*. 13 August.

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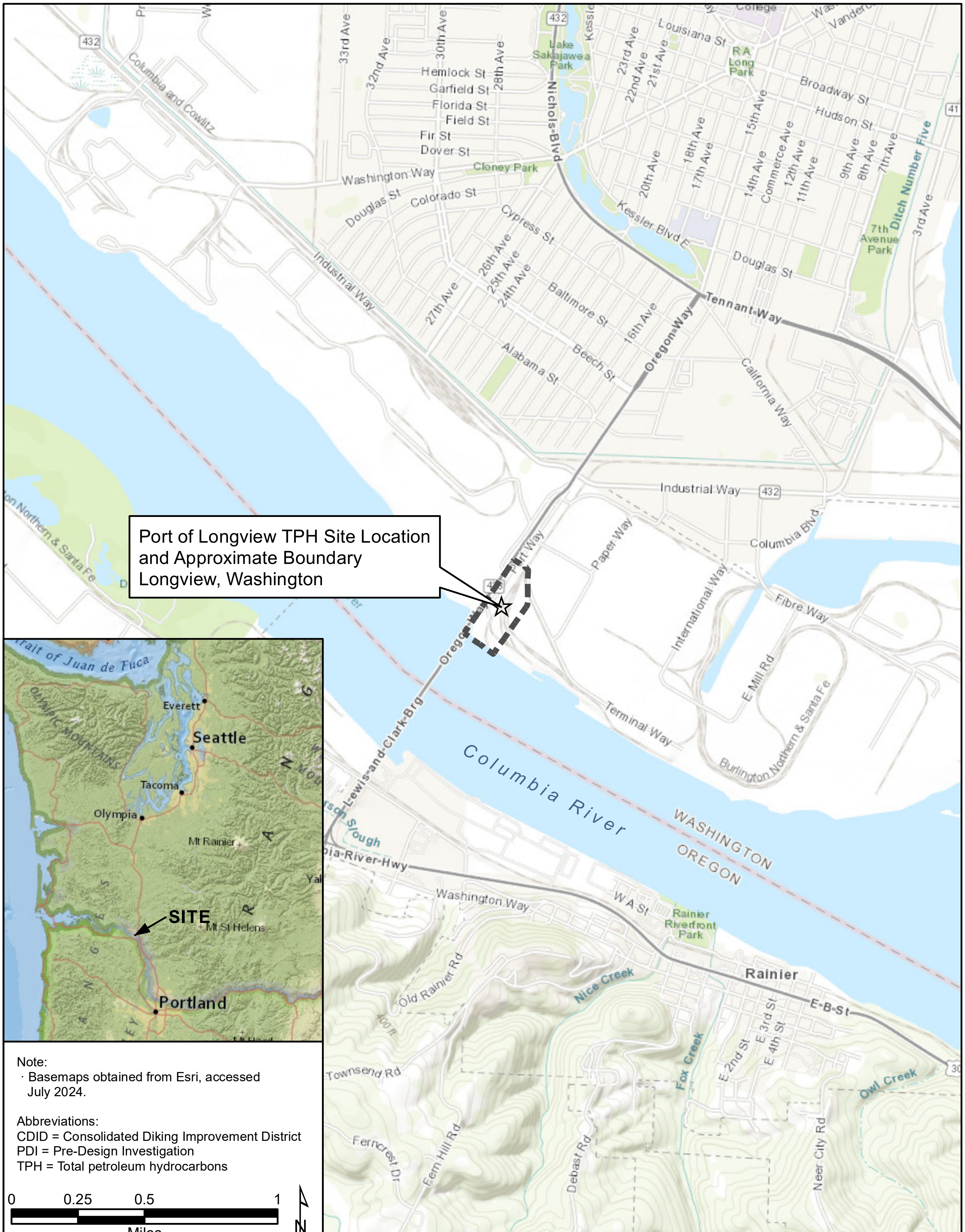
Washington State Department of Ecology (Ecology). 2016. *Guidance for Remediation of Petroleum Contaminated Sites*. Publication No. 10-09-057. Toxics Cleanup Program. Originally published November 2010. Revised June 2016.

LIST OF ATTACHMENTS

Figure 1	Site Vicinity Map
Figure 2	Site Map and Vicinity Property Ownership
Figure 3	Proposed PDI Locations (Perched Zone)
Figure 4	Proposed PDI Locations (Alluvial Aquifer)
Attachment 1	Standard Field and OilScreenSoil Guidelines

Figures



Note:
· Basemaps obtained from Esri, accessed July 2024.

Abbreviations:
CDID = Consolidated Diking Improvement District
PDI = Pre-Design Investigation
TPH = Total petroleum hydrocarbons

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PDI Work Plan
Port of Longview TPH Site
Longview, Washington

Figure 1
Vicinity Map

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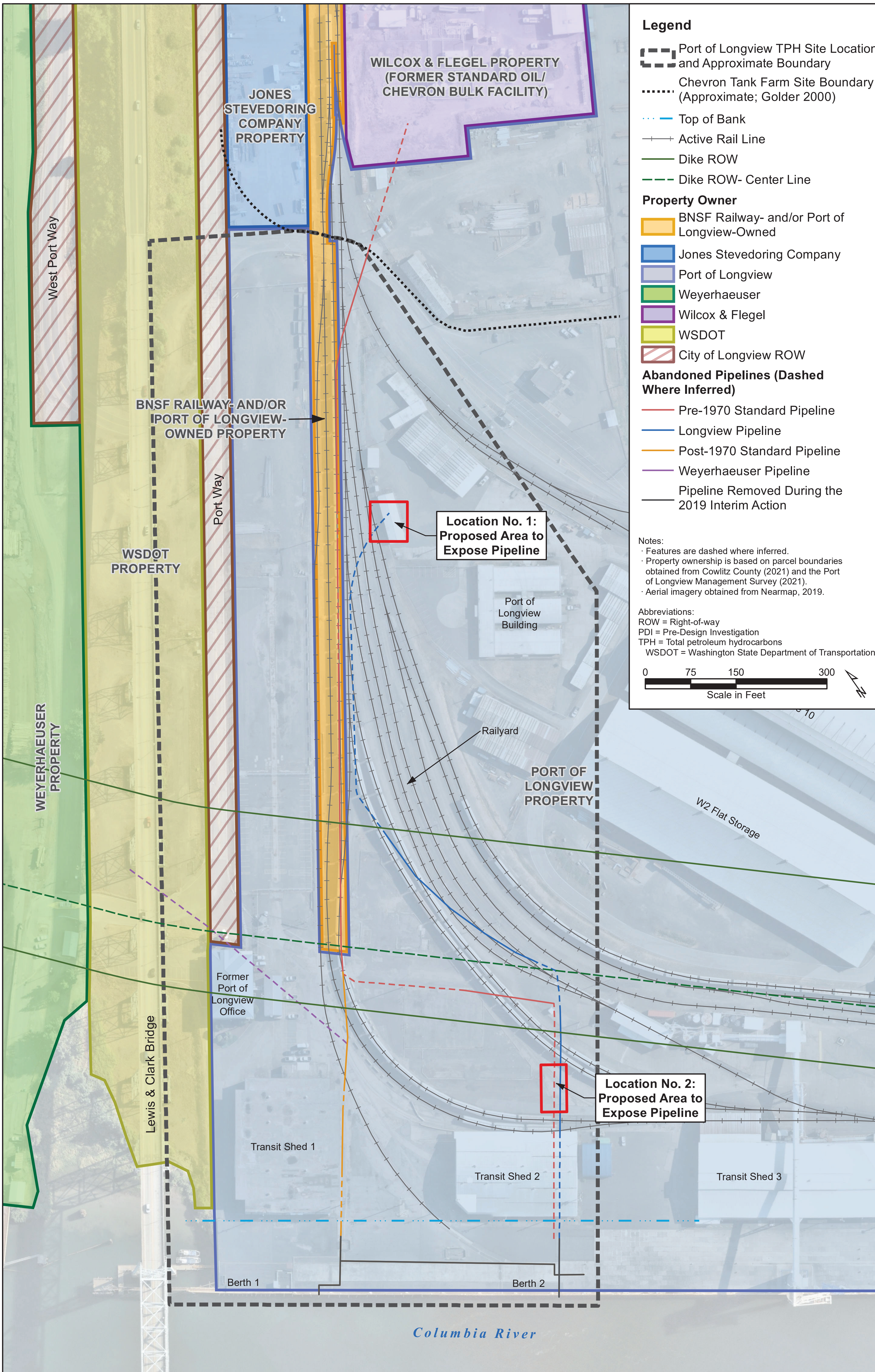
7/24/2024



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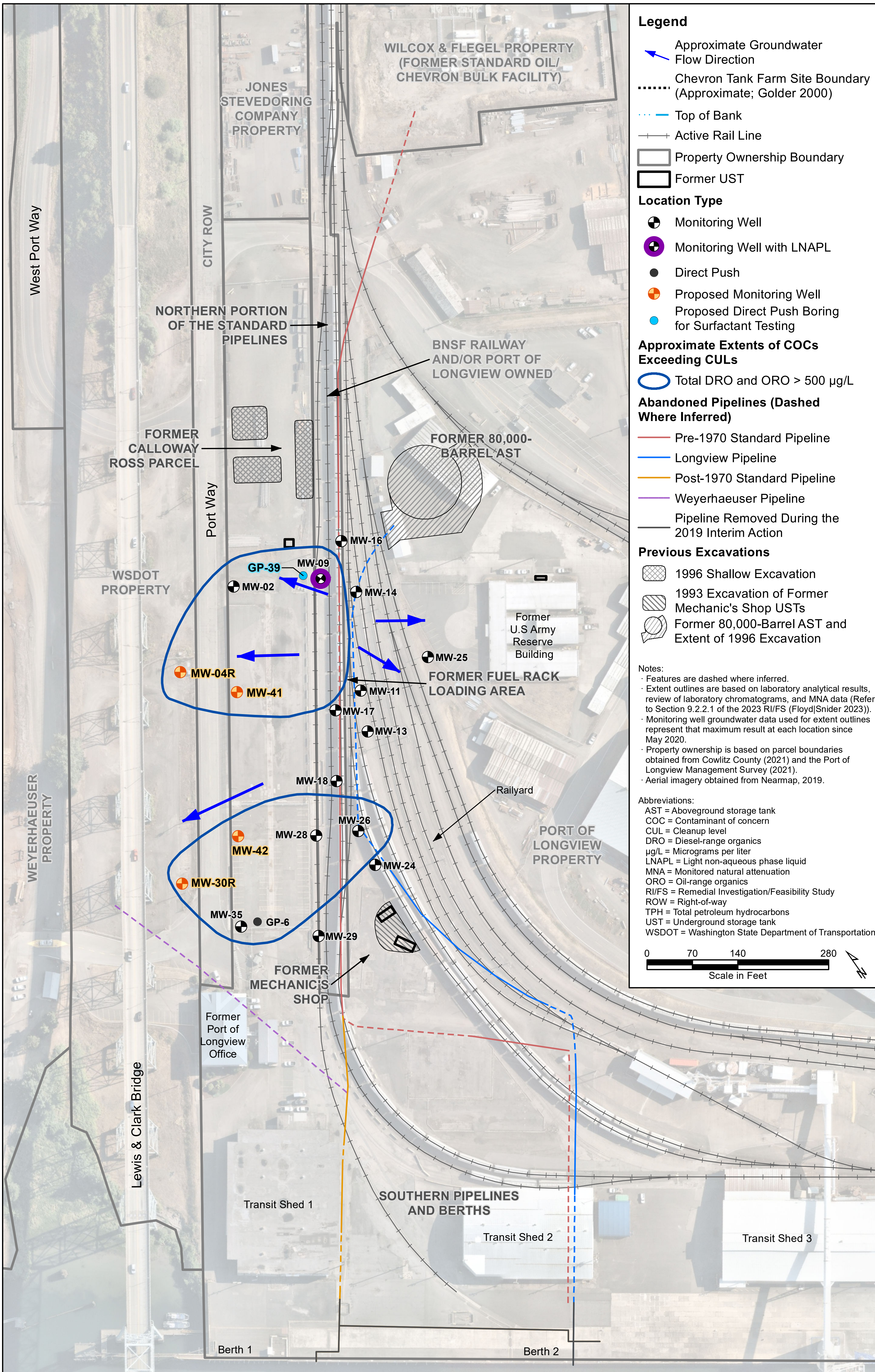
PDI Work Plan
Port of Longview TPH Site
Longview, Washington

Figure 2
Site Map and Vicinity Property Ownership

I:\GIS\Projects\POL-TPH\01-Tasks\08-PDI_WP\01-MapFiles\Figure 2 Site Map and Vicinity Property Ownership.mxd
9/9/2024



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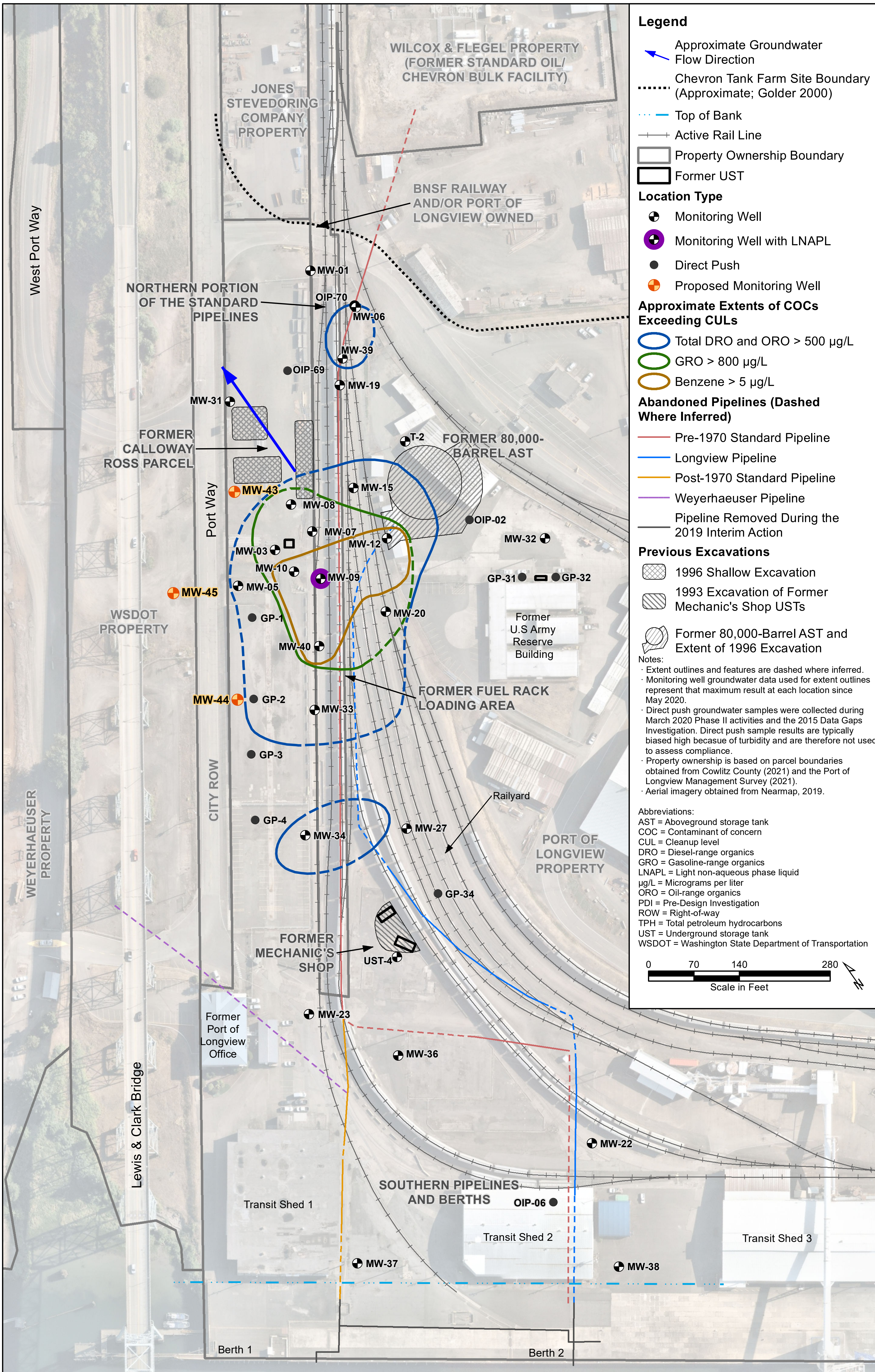
PDI Work Plan
Port of Longview TPH Site
Longview, Washington

Figure 3
Proposed PDI Locations
(Perched Zone)

I:\GIS\Projects\POL-TPH\01-Tasks\08-PDI_WP\01-MapFiles\Figure 3 Extent of COCs in Perched Zone Groundwater Exceeding PCULs.mxd
7/29/2024



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PDI Work Plan
Port of Longview TPH Site
Longview, Washington

Figure 4
Proposed PDI Locations
(Alluvial Aquifer)

I:\GIS\Projects\POL-TPH\01-Tasks\08-PDI_WP\01-MapFiles\Figure 4 Extent of COCs in Alluvial Aquifer Groundwater Exceeding PCULs.mxd
7/24/2024

Attachment 1
Standard Field and OilScreenSoil Guidelines

Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

F|S STANDARD GUIDELINE

Soil Sample Collection

DATE/LAST UPDATE: December 2022

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field but are not intended to be step by step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines for the sampling method they intend to use and should review and understand these procedures prior to going into the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline presents commonly used procedures for collection of soil samples for characterization and laboratory analysis. The methods presented in this guideline apply to the collection of soil samples during the following characterization activities: soil borings via drilling, manual collection of shallow soil samples, test pit excavation, excavation confirmation, and stockpile characterization. Specific details regarding the collection of discrete and composite samples, and special sampling techniques for volatile organic compounds (VOCs) are also included. The guideline is intended to be used by staff who collect soil samples in the field.

It is important that the field staff completing the soil sample collection discusses the specific needs for a particular investigation with the project geologist, the project manager, or whoever will ultimately be responsible for interpreting the findings of the field investigation. This discussion is in addition to field training and general knowledge about soil sampling, and should happen prior to entering the field, with additional follow-up before finalizing the field forms, after the investigation is complete.

2.0 Equipment and Supplies

Soil Sampling Equipment and Tools:

- Tape measure or measuring wheel
- Stainless steel bowls and spoons
- Trowel, hand auger, or shovel (if needed)
- Table and disposable sheeting, tape or clamps to hold down sheeting (if needed).
- White board and dry erase pen
- Graduated plunger and collection tubes for VOC samples (if needed)
- Photoionization detector (PID) (if needed)
- Ziploc bags (sandwich and gallon sizes)
- Trash bags
- Decontamination tools including:
    - Paper towels or shop towels
    - Spray bottles of Alconox (or similar) solution
    - Deionized or distilled water
    - Scrubbing brush and bucket
- Adhesive drum labels, and paint or grease pen
- Washington State Department of Transportation- (WSDOT) approved drums for investigation-derived waste (IDW) disposal, if needed (if drilling, to be provided by driller)
- Camera
- Hand-held global position system (GPS; if needed)
- Coolers, sample jars, labels, ice

Paperwork:

- Work Plan and/or Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP)
- Field map printed on Rite in the Rain paper
- Site-specific Health and Safety Plan (HASP)
    - Tailgate meeting form (for each day you expect to be on Site)
    - Safety Data Sheets
- Floyd|Snider's Accident Prevention Plan (APP)

- Sample collection forms printed in Rite in the Rain paper
- Boring Logs
- Rite in the Rain field notebook
- Chain of custody forms
- Emergency contact numbers for utilities, property owner/manager, etc. (as needed)

Safety Equipment:

- Steel-toed boots
- Safety vest
- Safety glasses
- Nitrile gloves
- Rain gear
- Work gloves
- Hard hat
- Ear protection
- Traffic barricades or cones
- Vehicle emergency kit (road flares, fire extinguisher, first aid kit, etc.)
- Sunscreen if needed
- Hand and foot warmers, if needed
- Mosquito repellent, Hornet Spray, if needed
- Drinking water
- Rain or sun shelter, if needed
- Cell phone and charger cables

3.0 Standard Procedures

3.1 OFFICE PREPARATION

Prior to going into the field, review the SAP and QAPP to become familiar with the sampling goals, data quality objectives, desired sample intervals and nomenclature, field Quality Assurance (QA) samples (i.e., frequency of field duplicates, MS/MSDs) to be collected, analytes, sample containers, and holding times for each analytical method.

At least one week prior to sampling, coordinate with the laboratory specified in the SAP/QAPP to receive coolers and appropriate sample containers (including additional containers for

QA samples). Familiarize yourself with the volume requirements and container types, preservation methods, and holding times for each class of analytes.

If drilling or digging test pits, mark the sample area and sample locations with white spray paint prior to sampling, then submit an 811 public utility locate request at least 3 business days prior to work. Hire a private utility locator and schedule to locate utilities on private property and ensure proposed boring and/or excavation locations are free of utilities (Note: not all locators are equipped to mark non-conductible utilities).

3.2 TAILGATE SAFETY MEETING

Conduct a tailgate safety meeting prior to beginning work at the Site. Include any subcontractors working with you at the Site in this meeting. The safety meeting should cover the hazards specific to soil sampling. Typical hazards include:

- Heavy machinery/drill rig awareness (overhead hazards, pinch points, noise, uncontrolled release of energy). Always make eye contact before approaching an operator.
- Physical hazards (heavy lifting, uneven ground/trip hazards)
- Chemical hazards (dust, site-specific contaminants of concern, lab preservatives)
  - Refer to HASP for specific air monitoring requirements, permissible exposure limits (PELs), and actions if PELs are exceeded.

Additional hazards that may be present at any job site include traffic, adverse weather, slips, trips, falls, biological hazards (such as insects, plants, animals), and worksite distractions (such as pedestrians or other onsite activities).

Record the meeting attendees and topics discussed on the front page of the tailgate safety meeting form. All attendees should sign the form.

3.3 OTHER HEALTH AND SAFETY GUIDELINES

The following are additional health and safety guidelines that should be followed in the field. These guidelines are intended to supplement the guidelines and requirements identified in the HASP and are not intended to replace the HASP.

- Review and sign the HASP prior to going out into the field.
- Conduct a tailgate safety meeting prior to beginning work at the site as discussed in Section 3.2.
- If conditions change (e.g., weather or personnel) or when moving between sampling locations/switching to different sampling tasks, assess any additional hazards that may be associated with the new condition or location/task. Record additional hazards noted and corrective actions to address those hazards on the second page of tailgate safety meeting form.

Record near misses and incidents on the Near Miss and Incident Reporting Form (included as an attachment to the HASP) and conduct management/client notifications according to the protocols detailed in the HASP.

3.4 GENERAL SOIL SAMPLE COLLECTION PROCEDURES

1. Locate the desired sample location and depth interval using a handheld GPS or by taking field measurements from known site features. Record the soil type and any other observations or indications of contamination on a soil boring log (enclosed), soil sample collection form, or field notebook, as described in the Soil Logging Standard Guideline. Note the location and depth of the sample on the whiteboard or notecard and take a photograph with a scale (e.g., tape measure), if possible.
2. Refer to Sections 3.4.1 through 3.4.4 for the appropriate soil collection procedures for drilling, shallow soil, test pit excavation, excavation confirmation, and stockpiles. If collecting samples for VOC analysis by the U.S. Environmental Protection Agency (USEPA) Method 5035, refer to Section 3.5 for specific sample collection procedures for this method. If composite soil sampling is recommended, refer to Section 3.6 for details.
3. Once soil has been collected from the desired depth or interval, mix thoroughly in a disposable or decontaminated stainless-steel bowl until the sample is homogenous in color, texture, and moisture.
4. Fill the required laboratory-provided jars, taking care not to overfill. If large gravels (diameter greater than ~ 1 inch) are encountered, these should be discarded to ensure that an adequate soil volume is collected for analysis. If necessary, use a clean paper towel to remove soil particles from the threaded mouth of the jar before securing lids to ensure a good seal. Remove any soil or dirt from the outside of the jar with a clean paper or shop towel.
5. Label each jar with the sample name, date, time, field staff initials and required analyses. If collecting a field duplicate, use the sample nomenclature specified in the SAP\QAPP and note the field duplicate name and sample time in the sample log and/or field notebook. If extra volume for matrix spike/matrix spike duplicate (MS/MSD) analysis is required, use the same name on all jars. Soil samples should be protected from moisture by placing the filled sample jars into separate sealed Ziploc bags before placing them into a cooler.
6. Upon completion of each day of sampling, complete a chain-of-custody form for all samples, including sample names, date and time of collection, number of containers, and required analyses and methods. Write neatly and make sure information on the chain is legible. If you need to correct an entry, strike the incorrect entry out once, and add your initials next to the strike out. Samples collected for waste characterization purposes should be recorded on a separate chain-of-custody. Keep samples on ice (unless otherwise specified in the SAP/QAPP) to maintain

temperatures of 4-6 degrees Celsius (°C) and transport to the laboratory under chain-of-custody procedures.

3.4.1 Soil Sample Collection via Drilling

These procedures should be used for drilling via direct-push, hollow stem auger, or roto-sonic methods where a pre-designated sample interval (i.e., 0 to 5 feet below ground surface [bgs]) is retrieved from the subsurface using a split spoon sampling device, lined core, or bag sampler.

1. Ensure that reusable sampling equipment has been thoroughly decontaminated prior to sampling.
2. Collect PID measurements and other field tests, if necessary. PID measurements should be collected using the head-space method: put a small amount of soil from the selected interval into a sandwich bag and seal the bag. Label the bag with the soil interval. After at least 10 seconds, insert the tip of the PID into the bag and record the PID reading on the boring log or field collection form. If a sheen test is necessary, place a small amount of soil into a disposable or decontaminated stainless steel bowl, spray it with tap water or deionized water and observe whether a sheen appears on the water. Record results on the boring log or sample collection form.
3. Prior to sample collection, log soil on the boring log or sample collection form following the Soil Logging Standard Guideline.
4. Use a stainless-steel spoon or trowel, or disposable scoop to remove an equal volume of soil across the targeted depth interval from the sampler.
   a. If using a split spoon sampler or other reusable sampler, avoid collecting the soil that is touching the sides of the sampler to the extent practical.
   b. If the soil touching a reusable sampler must be collected to obtain adequate volume for analysis, notify the PM and record in the field logbook.

3.4.2 Manual Collection of Shallow Soil Samples

These procedures should be used for shallow soil sampling via scoop, trowel, shovel, or hand auger.

1. Dig or auger to the bottom depth of the shallowest sample to be collected, using a tool that has been thoroughly decontaminated. Verify that the target depth has been reached using a measuring tape.
2. If using a scoop or trowel, collect the soil directly into a decontaminated stainless-steel bowl.
3. If using a shovel, the soil may either be collected in bowls or set as aside on plastic sheeting in favor of collecting the sample from the sidewall of the hole. If sampling the sidewall, use a decontaminated or disposable scoop or trowel to collect soil from the target depth, or scrape along the sidewall to collect soil across a target depth

interval. Transfer soil to a disposable or decontaminated stainless-steel bowl, repeating until a sufficient volume has been collected.

4. If using a hand auger, empty the cylinder of the auger directly into a disposable or decontaminated stainless-steel bowl. It may be necessary to empty the hand auger onto plastic sheeting or into a bowl to reach the target depth without overflowing the sampler.
5. Any soil from depth intervals that are not targeted for sampling should be set aside on plastic sheeting and returned to the hole after sampling.
6. Collect PID measurements and other field tests as described in Section 3.4.1.

3.4.3 Sample Collection from Test Pits or Limited Soil Excavations

These procedures should be used for collecting samples from test pit explorations excavated using a backhoe or excavator. These same general procedures should also be followed for post-excavation soil samples used to confirm that an excavation has removed contaminated material or to document post-excavation conditions after target excavation limits have been reached.

1. Measure the length, width, and depth of the test pit or excavation area to verify that the target extents have been reached. The lateral spacing of the test pit or excavation confirmation samples, or exact location of samples should be specified in the work plan and typically depend on the size of the excavation area but can vary significantly by project.
2. If not specified in the work plan, sidewall samples may be collected either midway between the ground surface and base of the excavation, or incrementally along the entire height of the sidewall. Both sidewall and base (bottom) samples should penetrate a minimum of 6 inches into the excavated surface.
3. If the test pit or excavation is less than 4 feet deep, or has been benched to accommodate safe entry, a sample may be collected directly from the sidewall(s). Do not enter an excavation before reviewing and verifying the necessary safety requirements. Most excavations can be sampled without entering, which is preferred. If entering is safe, based on the depth or accommodations to support entry, to collect soil from a sidewall, use a decontaminated or disposable scoop, trowel, or shovel to obtain soil from the desired depth or depth interval directly into a decontaminated stainless-steel bowl.
4. If a test pit or excavation cannot be safely entered, instruct the excavator operator to scoop sidewall material from the target depth or depth interval. Collect the soil sample from the excavator bucket using a decontaminated stainless-steel spoon, trowel, or disposal scoop, avoiding material that has come into contact with the teeth or sides of the bucket. Place an adequate volume of soil into a decontaminated stainless-steel bowl. If necessary, follow the compositing procedures in Section 3.6.

3.4.4 Stockpile Sampling

These procedures should be used for classifying stockpiled soil, including excavated soil and imported backfill material.

1. Where potentially contaminated soils have been previously excavated and stockpiled on site, Washington State Department of Ecology (Ecology) guidance recommends using a decontaminated or disposable scoop or trowel, penetrating 6 to 12 inches beneath the surface of the pile at several locations until sufficient volume for analysis is achieved. A decontaminated shovel may also be used to facilitate collection of soil from large piles. The locations for soil collection should be where contamination is most likely to be present based on field screening (i.e., staining, odor, sheen, or elevated photoionization detector [PID] readings). If there are not field indications of contamination, the locations should be distributed evenly around the stockpile.
2. The stockpile may need to be broken up into sections for sample collection depending on the size of the pile (i.e., segregate the pile in half or quarters). If this is necessary, it is important to document where each set of samples were collected from (i.e., north quadrant) and create a field sketch in the project notebook of the pile for reference and mark sample locations with flags.
3. If a sampling frequency is not specified in the work plan, the general rule of thumb for contaminated soil stockpile profiling is to collect and submit 3 analytical samples (these samples can be multi-point composites or grabs) for stockpiles less than 100 cubic yards (CY), 5 samples for stockpiles between 100 and 500 CY, 7 samples for stockpiles 500 to 1,000 CY, 10 samples for stockpiles 1,000 to 2,000 CY, and 10 samples for stockpiles larger than 2,000 CY with an additional sample collected for every 500 CY of material. This rule of thumb is consistent with the Washington State Guidance for Remediation of Petroleum Contaminated Site (Ecology 2016).
4. Samples for characterization of stockpiles of imported backfill or other presumed clean material should also be collected as described under 3. If not described in the work plan, the typical sample frequency for imported or clean material characterization is one sample per 500 CY.

3.5 SOIL SAMPLE COLLECTION FOR VOC ANALYSIS

If collecting soil samples for VOC analysis by USEPA Method 5035, collect these samples first before disturbing the soil. This method uses a soil volume gauge fitted with a disposable soil sampling plunger tube to collect a soil plug that can be discharged directly to a VOA vial, limiting the loss of volatiles during sampling. The collection of VOC samples using the 5035 method specifies use of an airtight VOA vial with a septum lid. Ecology’s interpretation of the USEPA 5035 method allows for field preservation of the sample with methanol or sodium bisulfate, or laboratory preservation (i.e., field collection into an un-preserved vial). It is important to note that if laboratory preservation is the selected method, samples must be received at the laboratory within 48-hours of sample collection. The method of sample preservation for the 5035 method will vary for each site and is dependent on site-specific conditions. Preservation method selection should be coordinated with the laboratory and specified in the sampling plan. Note that not all labs use the soil volume gauge as described below (some use syringes or Terra Core samplers) and that it is important to verify the sampling process with the lab.

1. Note the volume of soil needed for analysis as specified by the laboratory (commonly 5 or 10 grams). Raise the handle of the soil volume gauge to the slot in the gauge body corresponding to the desired volume and turn clockwise until the tabs in the handle lock into the slot.
2. Insert a sample tube at the open end of the gauge body and turn clockwise until the tabs on the tube lock into the "0 gram" slot. Remove the cap from the sample tube and press directly (where possible) into the shallow soil, soil core/sampler, excavation base or sidewall, or stockpile.
3. Continue pressing the sample tube until the plunger is stopped by the sample volume gauge. If a depth interval (for example 9 to10 feet) is targeted for VOC sampling, collect small volumes of soil across this interval until the sample tube is filled
4. Twist counterclockwise to disengage the sample tube, then depress the plunger to eject the soil plug directly into a laboratory-provided VOA vial. Wipe off any soil particles on the VOA vial threads before tightening the lid. Grit on the VOA vial threads can cause a poor seal and interfere with the laboratory analyses. If multiple vials per sample are required, the same plunger may be re-used to fill the remaining vials.

3.6 COMPOSITE SAMPLE COLLECTION

For this guideline, composites are considered samples that are collected across more than one location, or multiple depth intervals at a single location. Samples collected over continuous depth intervals within a sampling device (i.e., split spoon) are addressed for each sampling method in Section 3.4 above.

Compositing of sample material may be performed in the field or by the analytical laboratory. To collect a field composite sample, identify the locations and depth(s) that will comprise the composite. Collect soil from the first target sub-sample depth or depth interval and hold in a decontaminated stainless-steel bowl, covered with aluminum foil to prevent cross contamination and label with the location and depth. Continue to collect and hold individual sub-samples until all components of the composite have been collected, then transfer an equal amount of each sub-sample to a clean bowl and homogenize. Fill necessary sample jars from homogenized composite. In some cases, project plans may require that each individual sample that comprised the composite be collected in jars and submitted to the laboratory if individual sample analysis is desired, or if laboratory compositing is requested in addition to field compositing as a field quality control measure. In this case, label each individual jar, but indicate HOLD on the chain-of-custody, and note that the sample is part of composite XYZ.

To collect a laboratory composite sample, collect, and label each sub-sample using the procedures described above in Section 3.4. Record each sub-sample on the chain-of-custody form, and indicate on this form which samples should be composited by the laboratory and the desired name of the composite sample. It is important to communicate to the laboratory if discrete samples will also require analysis (in some cases) or only the composite sample. It is helpful to send a follow up email to the laboratory PM with laboratory compositing details.

4.0 Decontamination

All reusable equipment that contacts soil or dust should be decontaminated prior to moving to the next sampling location.

Stainless-steel bowls and spoons, and any tools used for sample processing will be decontaminated between each sample; alternatively, disposable bowls and spoons may be used. Equipment decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an Alconox (or other soap)/tap water solution, and a final rinse with distilled or deionized water.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, waste soils accumulated as investigation derived waste (IDW) will be contained, transported, disposed of in accordance with applicable laws, and stored in designated drums in a designated area until transported off-site for disposal.

The approach to handling and disposal of these materials is as follows. For IDW that is containerized, such as waste soils, 55-gallon drums approved by WSDOT (or the applicable stage agency) will be used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., "soil"), the dates on which the soil was accumulated, the site owner's name (i.e., the generator), Floyd|Snider name, and the Floyd|Snider field person contact information or front desk telephone number.

Refer to the IDW Special Conditions SOP for further information on IDW storage, sampling, profiling, and handling.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy duty garbage bags or other appropriate containers and disposed of as solid waste in the municipal collection system (i.e., site dumpster).

6.0 Field Documentation

All observations including sample collection locations, soil descriptions, sample depths, collection times, analyses, and field QC samples should be recorded on a boring log, soil sample collection form, and/or bound field notebook. Information recorded should additionally include personnel present (including subcontractors), purpose of field event, weather conditions, sample collection date and times, sample analytes, and any deviations from the SAP.

At the end of the day, complete and review the second page of the tailgate safety meeting form detailing additional hazards, corrective actions, near-misses or incidents. Any incidents that result in field staff injuries or have the potential to result in staff injuries (such as hitting buried utility lines when drilling) should be reported immediately to the PM.

7.0 Demobilization

Upon returning to the office, ensure that all equipment is property cleaned and put away in the field room. Equipment with rechargeable batteries should be plugged in as appropriate so it is ready for use by the next person. It is preferable to dispose of trash at the project site, but any trash left in the field vehicle should be brought upstairs, labeled, and placed in the front production room for building staff to dispose of.

If equipment or sample coolers will be placed at the front desk for pickup, clearly label each item with the company picking it up, anticipated pickup time frame, and your contact information so front desk staff can contact you if there are any questions. Notify front desk staff if any items require a signature at pickup.

Within one week of returning from the field, the field lead for the event should review field notes, sampling forms and tailgate safety meeting forms with the PM. Following PM review and approval, field notes will be scanned and saved to the project folder. Hard copies should be filed. The PM will provide copies of near miss and incident reports to the Health and Safety Administrator.

Enclosures: Boring Log
Test Pit Log and Sample Collection Form

Record of Revisions:

Revisions	**Date**
Added H&S information and line edits for clarity.	7/22/2022
Reviewed with minor updates	SD 12/9/2022

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PROJECT:		LOCATION:	BORING ID:
LOGGED BY:		COORDINATE SYSTEM:	
DRILLED BY:		NORTHING:	EASTING:
DRILLING EQUIPMENT:		GROUND SURFACE ELEVATION:	
DRILLING METHOD:		TOTAL DEPTH (ft bgs):	DEPTH TO WATER (ft bgs):
SAMPLING METHOD:		BORING DIAMETER:	DRILL DATE:

Depth (feet)	USCS	Description	Drive	Recovery	# of Blows	PID (ppm)	Sample ID
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

ABBREVIATIONS:
ft bgs = feet below ground surface   USCS = Unified Soil Classification System
ppm = parts per million   ▼ = denotes groundwater table

NOTES:

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PROJECT:		LOCATION:	BORING ID:
LOGGED BY:		COORDINATE SYSTEM:	
DRILLED BY:		NORTHING:	EASTING:
DRILLING EQUIPMENT:		GROUND SURFACE ELEVATION:	
DRILLING METHOD:		TOTAL DEPTH (ft bgs):	DEPTH TO WATER (ft bgs):
SAMPLING METHOD:		BORING DIAMETER:	DRILL DATE:

Depth (feet)	USCS	Description	Drive	Recovery	# of Blows	PID (ppm)	Sample ID
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

ABBREVIATIONS:
ft bgs = feet below ground surface
ppm = parts per million
USCS = Unified Soil Classification System
▼ = denotes groundwater table

NOTES:

Test Pit Log and Sample Collection Form

Project:				Date:
Field Personnel:				
Test Pit #				
Pit Dimensions	Depth:_______________	Length:_______________	Width:___________	Units:____________
Soil Description: (note depth to native, presence of debris, odor, sheen)				
Sketch				
GPS coordinates				
Other Notes or Observations:				
Samples Details	Sample ID	Depth	Time	Analysis

Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

F|S STANDARD GUIDELINE

Soil Logging

DATE/LAST UPDATE: October 2019

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step by step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines and should review and understand these procedures prior to going in the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

These soil logging standard guidelines should be used by the field staff performing subsurface investigations, such as a direct push or roto-sonic soil boring, installation of a monitoring well via hollow stem auger, or roto-sonic or mud rotary drilling. While many projects will not necessarily have a Licensed Geologist (LG) or Hydrogeologist (LHG) who reviews and stamps every boring log, it is important that the field staff discusses the soil logging needs for a particular investigation with the project geologist, the project manager, or whoever will ultimately be responsible for interpreting the findings of the field investigation. This discussion is in addition to field training and general knowledge about soil logging, and should happen prior to entering the field, with additional follow-up before drafting a final set of electronic logs, after the investigation is complete.

2.0 Equipment and Supplies

Logging Equipment and Tools:

- 100-foot tape measure or measuring wheel
- Handheld Global Positioning System (GPS; optional)
- Unified Soil Classification System (USCS) Soil Classification Field Guide
- Soil logging kit containing:

  - Stainless steel spoons
  - Paint scraper or trowel
  - Small Ziploc bags
  - Small stainless steel bowls or black mining pans for sheen testing
  - Spray bottle filled with water
  - Paper towels (preferably white)
  - Engineers tape
  - Note cards
  - Optional items include:
    - Empty VOA vials or small glass jars
    - Munsell color chart
    - Sieves
    - White and grayscale color cards for photographs
- Plastic sheeting and duct tape or clamps to cover the sampling table
- Camera
- Trash bags
- Coolers
- Jars
- Labels
- Ice

Paperwork:

- Work Plan and/or Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP)
- Health and Safety Plan (HASP)
- Copies of figures showing previous boring locations and boring logs from previous investigations, if available
- Boring log forms (enclosed) appropriate for drilling method, printed in Rite in the Rain paper and/or bound field notebook
- Permanent markers and pencils

Personal Equipment:

- Steel-toed boots
- Hard hat
- Safety vest

- Safety glasses
- Nitrile gloves
- Ear plugs
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 OFFICE PREPARATION

First, meet with the project manager or field manager to identify the key information and goals of the soil boring investigation. These may include fill history, known or suspected sources of contamination and potential field indications of these contaminants, identification of specific units, or important geotechnical measurements. If possible, select a boring log template that is appropriate for the project needs.

Next, review the work plan and all available existing materials such as cross-sections or boring logs from previous investigations to familiarize yourself with the site geology. In addition (or alternatively if other information is not available), you may also review a geologic map of the area from a reputable source such as United States Geological Survey (USGS).

Finally, check the area of the site where drilling will occur for underground objects. At minimum, a OneCall locate request should be made at least one week in advance of drilling in order to give public utility locators time to mark known buried utility lines. All planned boring locations should be marked on the ground with white spray paint prior to making a locate request. In almost all cases, a private utility locator should also clear the area of drilling any underground objects using electromagnetic techniques. If drilling is to occur in close proximity to buried utilities, the work plan may specify use of an air knife or vacuum to clear the borehole to a depth below the utility lines.

3.2 COLLECTING SOIL SAMPLES FOR CLASSIFICATION

1. Before beginning drilling, record the following information on each log:
   a. Operator's name and company, equipment make/model, equipment measurements (i.e., sampler length and diameter, hammer weight and stroke if using hollow stem auger, boring diameter)
   b. Your name, date, project, boring name and approximate descriptive location (i.e., where is the soil boring relative to known site features). Include a description of the ground surface and whether or not coring was necessary, if coring was necessary, include core diameter, concrete thickness, and subcontractor information.

   c. A small hand drawn map showing your location with measurements to a stationary reference point, or GPS coordinates (ideally, both). This is also a good place to note if you have had to move a boring location because of underground utilities, access issues, etc. It is important to note the reason for relocation and the direction and distance moved (i.e., moved 10 feet to the north due to presence of subsurface water line).

2. If you are using a hollow stem auger drilling method, it is important to communicate to the driller how often you would like a split spoon sample collected. Typically this would be continuous or every 5 feet but may be different depending on the project needs.
3. Note any feedback from the driller about the drilling conditions. This may include difficult drilling or rig chatter (usually caused by hard materials), heaving sands (usually caused by hydrostatic pressure on the borehole), caving, or hole instability.
4. For split spoon samples, record the number of hammer blows (blow counts) necessary to drive the sampler each 6-inch increment, as reported by the driller. If more than 50 blows are needed, record the distance that the sampler was driven in 50 blows (i.e., 2-inches in 50 blows). This is referred to as the standard penetration test.
5. Cover the sampling table with plastic sheeting. Lay an engineer's tape lengthwise across the sampling table. Once a sample has been collected, orient it on the table so that the top is aligned with the 0-foot mark on the tape.
6. Split open the sampler, core barrel liner, or sample collection bag. Record the depth interval that the sampler was driven and the depth interval of soil that was recovered. For split spoons or single-cased core barrels, such as Geoprobe direct-push rods, determine whether any loose 'slough' soil has been dislodged by the drilling equipment and deposited at the top of your core (AMS direct push rods are double cased and do not create slough). Do not include slough in the measurement of the soil recovered. Often the core will be filled with an uninterrupted column of soil that is shorter in length than the total drive interval. In such cases, record the recovery interval as it is situated in the core unless you are able to determine the actual depth where the soil sample originated. For the purposes of recording soil observations and collecting samples for analysis, assume that the recovered column of soil has been evenly compressed unless you are able to determine the interval(s) in which compression has occurred. Decompress the recovered soil when making further observations (e.g., if the recovered soil column is 80 percent of the length of the drive interval, assume 0.8 feet of recovered soil represent 1 foot of soil in situ).
7. Before further disturbing the soil, take volatile organic compound (VOC) measurements with a photoionization detector (PID), if using. Take measurements by making crevices in the soil with a spoon or scraper and inserting the PID probe into these openings. Alternatively, collect small spoonfuls of soil into Ziploc bag(s), seal the bag(s), gently shake the bag(s), and insert the PID probe through the top of the bag(s) and into the headspace once the soil vapor has been allowed to equilibrate with the

surrounding air (headspace method). The bag headspace screening method is typically more accurate and is useful at sites with low concentrations of VOCs, whereas the in-situ method is a faster and more qualitative method, best used at sites with higher VOC concentrations. If sampling for VOCs by the U.S. Environmental Protection Agency (USEPA) Method 5035, these soil samples should also be collected prior to disturbing the core. Soil sampling procedures using USEPA Method 5035 are described in detail in the Soil Sample Collection Standard Guideline.

8. Use a straight edge to scrape the soil level and expose the center of the core. Photograph the core alongside the measuring tape and an index card displaying the soil boring location/ID and depth interval.

3.3 SOIL CLASSIFICATION

Soils are described using the following characteristics: Color, consistency, MAJOR CONSTITUENT, minor constituent, geotechnical properties, moisture content, other observations (e.g. visual or olfactory indications of contamination). The USCS field guide is included in this guidance for reference. The steps below should help guide the logger in classifying soils according to the USCS.

1. Record the color of the soil. A descriptive color (i.e., light brown) or a color identified using the Munsell color chart are both valid.
2. Determine whether organic matter influences the properties of the material. If so, record as an organic soil.
3. If the soil is predominantly inorganic, identify whether the major constituent is coarse- or fine-grained. Coarse-grained soils include sands and gravels; fine-grained soils include silts and clays.
   a. For coarse grained soils, determine:
      i. Grain size(s) present including fine, medium, or coarse, and grain size distribution including well-graded (a mixture of fine to coarse grains) or poorly-graded (uniform in size). The USCS guide is helpful for determining grain sizes. If the major constituent is gravel, note its angularity using “rounded,” “sub-angular” or “angular.”
      ii. Minor constituent(s). If a minor constituent represents less than approximately 15% of the sample, note this as “with [minor constituent]” and optionally, whether it is “trace” (<5%) or “few” (5-15%). If a minor constituent represents more than 15% of the sample, use “[minor constituent]-y.” For example, a sand with 5% silt would be classified as a “SAND with trace silt” and sand with 30% silt would be classified as a “SILTY SAND.” For coarse-grained soils with fines between 5% and 15%, the USCS includes several dashed classifications, such as SW-SM. It is often helpful to record an estimated percentage for soil constituents to aid in classification according to the USCS.

b. For fine-grained soils, determine:

   i. Major constituent. To determine whether a material is silt or clay, a simple settling test may be performed in a glass vial or gloved hand by spraying a small amount of the sample with water. Silt particles will settle out of suspension in water within a few minutes, whereas clay particles will remain suspended for a longer period of time.

   ii. Minor constituent(s). As described above, determine the approximate percentage and record as "with [minor constituent]" or "[minor constituent]-y" as appropriate. It is often helpful to record an estimated percentage to aid in classification according to the USCS.

   iii. Geotechnical properties. Depending on project data needs, geotechnical properties may be optional but often provide helpful information. Geotechnical properties include plasticity (ranging from "non-plastic" to "highly plastic" as determined by a thread test) and consistency (ranging from "loose" to "very dense" for coarse-grained soils and "soft" to "hard" for fine-grained soils). When using split spoon samplers, blow counts recorded during the standard penetration test (also referred to as N-values) are used to determine consistency; when using direct-push or sonic drilling, consistency is described qualitatively.

4. Using the USCS guide and the description of the soil, determine the appropriate USCS symbol and record it on the log. If it is difficult to distinguish the major constituent of a soil, a borderline "/" symbol may be used to denote the two potential major constituents present. This is not the same as the USCS classifications that utilize a dash, such as SW-SM.

5. Determine whether contacts between stratigraphic units are abrupt, or gradational. Note abrupt contacts using a solid line and gradational contacts using a dotted line. If the contact between units is not visible and was missed between sample depths, a dashed line is used.

6. If the site or area geology is known, and you are confident in your identification of a specific stratum, note the geologic unit. At a site where the geology is uncertain, you may make some more general notes about the depositional environment, such as identifying probable estuarine deposits, colluvium, glacial till, etc.

7. Note the moisture content of the soil, using "dry," "moist," "wet," or "saturated." Mark the water table at the time of drilling on the log at the depth where saturated soil is first observed.

3.4 OTHER OBSERVATIONS

1. Record other materials observed in the sample. These may include minor amounts of rootlets or other plant matter, evidence of organisms such as shell fragments, and/or anthropogenic debris such as brick fragments, plastic, or metal debris.
2. Record potential indications of contamination. These may include odors, colored or black staining on soils, colored crystals, hydrocarbon sheens, or non-aqueous phase liquid (NAPL) product.
   a. To test for hydrocarbon sheen, put a small amount of soil in a bowl, saturate with water and swirl, noting whether a rainbow sheen appears on the surface of the water. Alternatively, place a small amount of water in the bottom of the bowl and a small amount of soil along the side, then tilt the bowl so that the water slowly touches the soil. If observed, note the color of the sheen and describe as slight (discontinuous on the water surface), moderate (continuous but spreading slowly) or high (rainbow sheen covering entire surface water).
   b. To test for the presence of NAPL, use a clean paper towel to blot the surface of the core and note the proportion of the towel that is saturated with oil (be sure to allow the towel to dry when blotting moist to wet soils to distinguish between saturation due to NAPL and due to water).
3. Note the final depth of the boring and any reasons for early termination of the boring (i.e., refusal).
4. If monitoring wells will be installed, follow the Standard Guidelines for monitoring well construction and well development.

4.0 Decontamination

All reusable equipment that comes into contact with soil should be decontaminated as follows prior to moving to the next sampling location.

Split spoons, stainless steel bowls and spoons, and any other tools used for soil classification must be decontaminated between boring locations. If collecting soil samples for chemical analysis, split spoons and any tools used for sample processing must be decontaminated between each sample; alternatively, disposable bowls and spoons may be used. Equipment decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or similar)/clean water solution and a final rinse with distilled or deionized water.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, waste soils and other drilling materials generated during soil boring activities will be contained, transported, disposed of in accordance with applicable laws, and stored in a designated area until transported off-site for disposal.

The approach to handling and disposal of these materials is as follows. For investigation-derived waste (IDW) that is contained, such as waste soils, 55-gallon drums approved by the Washington State Department of Transportation (WSDOT) will be supplied by the driller and used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., "soil cuttings"), the dates on which the wastes were placed in the container, the owner's name, contact information for the field person who generated the waste, and the site name.

Whenever possible, IDW contained within drums will be characterized relative to applicable waste criteria using data from the sampling locations. Material that is designated for off-site disposal will be transported to an off-site facility that is permitted to accept the waste. Manifests will be used as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy duty garbage bags or other appropriate containers and disposed of as solid waste in the municipal collection system (i.e., site dumpster).

6.0 Field Documentation

All observations should be recorded on a soil boring form appropriate for the drilling method or in a bound field notebook. Field staff should make an effort to record as much detail as possible in the field log. After the field work is complete, a set of final logs (usually electronic) that serve as the record for the project will be completed in consultation with the project manager or field manager.

Enclosure: USCS Soil Classification Field Guide
Boring Log

USCS SOIL CLASSIFICATION FIELD GUIDE

FIELD GUIDE FOR SOIL AND STRATIGRAPHIC ANALYSIS v.2

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START HERE

DENSITY OR CONSISTENCY

COARSE GRAINED DEPOSITS N-VALUE		FINE GRAINED DEPOSITS N-VALUE	q_u (tsf)	
0-4	► VERY LOOSE	0-2	<0.25	► VERY SOFT
5-10	► LOOSE	3-4	0.25-0.50	► SOFT
11-29	► MEDIUM DENSE	5-8	0.50-1.0	► MEDIUM
30-49	► DENSE	9-15	1.0-2.0	► STIFF
>50	► VERY DENSE	16-30	2.0-4.0	► VERY STIFF
		>30	>4.0	► HARD

COLOR
Use Standard Munsell Color Notation

IS THE COLOR A MATRIX COLOR?
- YES → **MATRIX COLOR** List in sequence, dominant first
- NO → IS THE COLOR FROM A COATING OR CONCENTRATION?
  - YES → **COATING or CONCENTRATION** Note frequency, color, and size
  - NO → **MOTTLE** Note contrast, color, and size

CLASSIFICATION
Unified Soil Classification System - adopted ASTM D2488

COARSE-GRAINED DEPOSITS >50% coarse-grained sediments, <50% fines

STEP 1: IS SEDIMENT COARSE GRAINED OR FINE GRAINED?

FINE-GRAINED DEPOSITS (organic and inorganic) >50% fines, <50% coarse-grained sediments

STEP 2: DETERMINE SAND VS. GRAVEL RATIO

INCREASING GRAIN SIZE

SAND			GRAVEL	
FINE	MEDIUM	COARSE	SMALL	LARGE

0.075 MM — 0.425 MM — 2.0 MM — 4.75 MM — 19.0 MM — 75.0 MM

STEP 3: CONTINUE WITH SAND OR GRAVEL ON FLOW CHART (REVERSE)

STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL

INCREASING PLASTICITY

NON PLASTIC	LOW PLASTICITY	MEDIUM PLASTICITY	HIGH PLASTICITY
ML		CL	CH

STEP 3: CONTINUE WITH GROUP SYMBOL ON FLOW CHART (REVERSE)

MOISTURE

MOISTURE ABSENT ► DRY
DAMP ► MOIST
VISIBLE WATER ► WET

FOR NON-PLASTIC FINES:
WATER RISES TO SURFACE SLOWLY ► SLOW DILATENCY
WATER RISES TO SURFACE QUICKLY ► RAPID DILATENCY

PLASTICITY
(Use with CLASSIFICATION)

WILL NOT SUPPORT 6mm DIAMETER ROLL IF HELD ON END ► NON-PLASTIC
6mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 4mm DIA. ROLL DOES NOT ► LOW PLASTICITY
4mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF, 2mm DIA. ROLL DOES NOT ► MEDIUM PLASTICITY
2mm DIA. ROLL CAN BE REPEATEDLY ROLLED AND SUPPORTS ITSELF ► HIGH PLASTICITY

(6mm) (4) (2)

COHESIVENESS

6mm DIAMETER ROLL CANNOT BE FORMED ► NONCOHESIVE
6mm DIAMETER ROLL CAN BE FORMED ► COHESIVE

SEDIMENTARY STRUCTURE

UNIFORM ► MASSIVE
BEDS >30cm ► THICKLY BEDDED
BEDS 3cm to 30cm ► BEDDED
BEDS 0.5cm to 3cm ► THINLY BEDDED
BEDS <0.5cm ► LAMINATED

SECONDARY SOIL STRUCTURE (IN SOLUM ONLY)
Spheroidal peds or granules usually packed loosely ► GRANULAR
Irregular, roughly cubelike peds with planar faces (angular or subangular) ► BLOCKY
Flat and horizontal peds ► PLATY
Vertical, pillarlike peds with flat tops ► PRISMATIC
Vertical, pillarlike peds with curved tops (which are commonly "bleached") ► COLUMNAR

WEATHERING ZONE ABBREVIATION

MODIFIER SYMBOL (if present)		1st SYMBOL		2nd SYMBOL		LAST SYMBOL (if present)	
MOTTLED	► M	OXIDIZED	► O	LEACHED	► L	SECONDARY CARBONATE	► 2
JOINTED	► J	REDUCED	► R	UNLEACHED	► U		
		UNOXIDIZED	► U				

EXAMPLE: solum, OJL, MOJL, MOJL2, MOJU — MRJU, RJU, RU, UU

SECONDARY GRAIN SIZE INFORMATION

< 5% ► TRACE
6% to 15% ► LITTLE
16% to 30% ► FEW
31% to 49% ► SOME

► UNIFORM (poorly graded)
► NON-UNIFORM (well graded)

► FINE SAND
► MEDIUM-GRAINED SAND
► COARSE-GRAINED SAND
► FINE GRAVEL
► COARSE GRAVEL

FOR GLACIAL DIAMICTONS ► CLAST FRACTION ► CLAST LITHOLOGY

DEPOSITIONAL ENVIRONMENT

VARIOUS DEPOSITIONAL ENVIRONMENTS (interpretation) ► EOLIAN (LOESS) ► FLUVIAL ► ALLUVIAL ► LACUSTRINE ► COASTAL ► RESEDIMENTED

GLACIAL DEPOSITIONAL PROCESSES ► SUBGLACIAL ► GLACIOFLUVIAL ► GLACIOLACUSTRINE ► RESEDIMENTED

GENERALIZED RESEDIMENTATION PROCESSES ► MASS SLUMP ► SEDIMENT FLOW ► COLLUVIUM

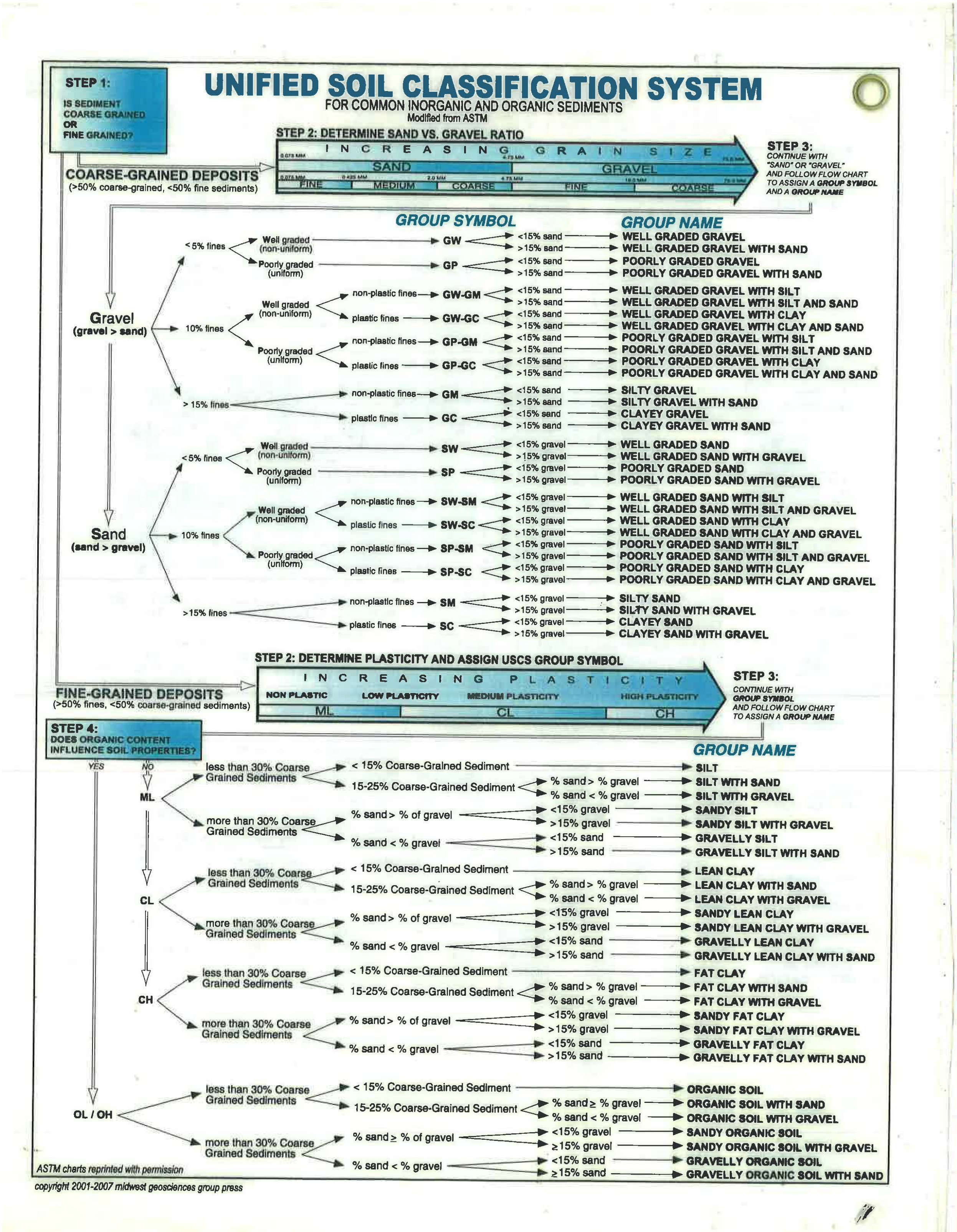
STRATIGRAPHIC NAME

USE FORMAL STATE GEOLOGICAL SURVEY NOMENCLATURE WHEN POSSIBLE;
IF NOT POSSIBLE, ASSIGN SITE-SPECIFIC UNIT NAME ACCORDING TO DEPOSITIONAL ENVIRONMENT / FACIES ASSEMBLAGE

STRATIGRAPHIC CONTACT

010106

< 10 cm ► SHARP (or ABRUPT for pedogenic alternation)
> 10 cm (Note transition interval) ► GRADATIONAL (or TRANSITIONAL for weathering zone change)


STEP 1:
IS SEDIMENT COARSE GRAINED OR FINE GRAINED?
UNIFIED SOIL CLASSIFICATION SYSTEM
FOR COMMON INORGANIC AND ORGANIC SEDIMENTS
Modified from ASTM
STEP 2: DETERMINE SAND VS. GRAVEL RATIO
INCREASING GRAIN SIZE
SAND
GRAVEL
FINE
MEDIUM
COARSE
FINE
COARSE
STEP 3: CONTINUE WITH "SAND" OR "GRAVEL" AND FOLLOW FLOW CHART TO ASSIGN A GROUP SYMBOL AND A GROUP NAME
COARSE-GRAINED DEPOSITS
(>50% coarse-grained, <50% fine sediments)
GROUP SYMBOL
GROUP NAME
Gravel
(gravel > sand)
< 5% fines
Well graded (non-uniform)
Poorly graded (uniform)
10% fines
> 15% fines
non-plastic fines
plastic fines
GW
GP
GW-GM
GW-GC
GP-GM
GP-GC
GM
GC
<15% sand
>15% sand
WELL GRADED GRAVEL
WELL GRADED GRAVEL WITH SAND
POORLY GRADED GRAVEL
POORLY GRADED GRAVEL WITH SAND
WELL GRADED GRAVEL WITH SILT
WELL GRADED GRAVEL WITH SILT AND SAND
WELL GRADED GRAVEL WITH CLAY
WELL GRADED GRAVEL WITH CLAY AND SAND
POORLY GRADED GRAVEL WITH SILT
POORLY GRADED GRAVEL WITH SILT AND SAND
POORLY GRADED GRAVEL WITH CLAY
POORLY GRADED GRAVEL WITH CLAY AND SAND
SILTY GRAVEL
SILTY GRAVEL WITH SAND
CLAYEY GRAVEL
CLAYEY GRAVEL WITH SAND
Sand
(sand > gravel)
SW
SP
SW-SM
SW-SC
SP-SM
SP-SC
SM
SC
<15% gravel
>15% gravel
WELL GRADED SAND
WELL GRADED SAND WITH GRAVEL
POORLY GRADED SAND
POORLY GRADED SAND WITH GRAVEL
WELL GRADED SAND WITH SILT
WELL GRADED SAND WITH SILT AND GRAVEL
WELL GRADED SAND WITH CLAY
WELL GRADED SAND WITH CLAY AND GRAVEL
POORLY GRADED SAND WITH SILT
POORLY GRADED SAND WITH SILT AND GRAVEL
POORLY GRADED SAND WITH CLAY
POORLY GRADED SAND WITH CLAY AND GRAVEL
SILTY SAND
SILTY SAND WITH GRAVEL
CLAYEY SAND
CLAYEY SAND WITH GRAVEL
STEP 2: DETERMINE PLASTICITY AND ASSIGN USCS GROUP SYMBOL
INCREASING PLASTICITY
NON PLASTIC
LOW PLASTICITY
MEDIUM PLASTICITY
HIGH PLASTICITY
ML
CL
CH
STEP 3: CONTINUE WITH GROUP SYMBOL AND FOLLOW FLOW CHART TO ASSIGN A GROUP NAME
FINE-GRAINED DEPOSITS
(>50% fines, <50% coarse-grained sediments)
STEP 4: DOES ORGANIC CONTENT INFLUENCE SOIL PROPERTIES?
YES
NO
GROUP NAME
ML
CL
CH
OL / OH
less than 30% Coarse Grained Sediments
more than 30% Coarse Grained Sediments
< 15% Coarse-Grained Sediment
15-25% Coarse-Grained Sediment
% sand > % gravel
% sand < % gravel
% sand > % of gravel
% sand ≥ % gravel
% sand ≥ % of gravel
<15% gravel
>15% gravel
≥15% gravel
<15% sand
>15% sand
≥15% sand
SILT
SILT WITH SAND
SILT WITH GRAVEL
SANDY SILT
SANDY SILT WITH GRAVEL
GRAVELLY SILT
GRAVELLY SILT WITH SAND
LEAN CLAY
LEAN CLAY WITH SAND
LEAN CLAY WITH GRAVEL
SANDY LEAN CLAY
SANDY LEAN CLAY WITH GRAVEL
GRAVELLY LEAN CLAY
GRAVELLY LEAN CLAY WITH SAND
FAT CLAY
FAT CLAY WITH SAND
FAT CLAY WITH GRAVEL
SANDY FAT CLAY
SANDY FAT CLAY WITH GRAVEL
GRAVELLY FAT CLAY
GRAVELLY FAT CLAY WITH SAND
ORGANIC SOIL
ORGANIC SOIL WITH SAND
ORGANIC SOIL WITH GRAVEL
SANDY ORGANIC SOIL
SANDY ORGANIC SOIL WITH GRAVEL
GRAVELLY ORGANIC SOIL
GRAVELLY ORGANIC SOIL WITH SAND
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strategy ▪ science ▪ engineering

PROJECT:		LOCATION:	BORING ID:
LOGGED BY:		COORDINATE SYSTEM:	
DRILLED BY:		NORTHING:	EASTING:
DRILLING EQUIPMENT:		GROUND SURFACE ELEVATION:	
DRILLING METHOD:		TOTAL DEPTH (ft bgs):	DEPTH TO WATER (ft bgs):
SAMPLING METHOD:		BORING DIAMETER:	DRILL DATE:

Depth (feet)	USCS	Description	Drive	Recovery	# of Blows	PID (ppm)	Sample ID
0							

ABBREVIATIONS:
ft bgs = feet below ground surface
ppm = parts per million
USCS = Unified Soil Classification System
▼ = denotes groundwater table

NOTES:

F|S STANDARD GUIDELINE

Well Construction

DATE/LAST UPDATE: May 2015

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines and should review and understand these procedures prior to going in the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline presents commonly used procedures for the installation of resource protection wells, in accordance with applicable sections of the Washington State Minimum Standards for Construction and Maintenance of Wells (Washington Administrative Code [WAC] 173-160, Part Two) and ASTM Standard Practice for Design and Installation of Groundwater Monitoring Wells (ASTM D5092-04[2010]e1). These wells may include groundwater monitoring wells, piezometers, groundwater extraction wells, injection wells, or vapor extraction wells. The guideline is intended to be used by field staff who are overseeing well drilling and construction.

2.0 Equipment and Supplies

Well Installation Equipment and Tools:

- Tape measure or measuring wheel
- Weighted tape or leadline
- Water level meter
- Hand-held Global Positioning System (GPS; optional)
- Camera
- Trash bags

- Well construction materials including polyvinyl chloric (PVC) screen and riser, sandpack, bentonite and well monument will be provided by the drilling subcontractor.

Paperwork:

- Work Plan and/or Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP)
- Health and Safety Plan (HASP)
- Copies of figures showing previous boring locations and boring logs from previous investigations and historical depth to water levels, if available
- Well installation forms (printed on Rite in the Rain paper)
- Permanent markers and pencils

Personal Equipment:

- Steel-toed boots
- Hard hat
- Safety vest
- Safety glasses
- Nitrile gloves
- Ear plugs
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 PREPARATION

First, before going into the field, it is important to discuss the project needs with the Project Manager (PM). These include the appropriate aquifer for well screening (especially if it is not the shallowest aquifer), soil sampling interval (if applicable to drilling method), screen length and placement (especially important at tidally influenced sites), well construction materials (i.e., screen slot size and grain size of the filter pack), surface completion of the wells, and any other important construction details. Any non-standard materials needed for well construction should also be communicated to the drilling firm when the work is scheduled, or a minimum of two weeks prior to the field event. Select a boring log template that is appropriate for the project needs.

Next, review the work plan and existing materials such as cross-sections, historical depth to water levels, or boring logs from previous investigations (if available) to familiarize yourself with the site geology. In addition to site-specific information (or alternatively if other information is not available), a geologic map of the area from a reputable source such as the U.S. Geological Survey (USGS) may also be reviewed.

Finally, check the area of the site where drilling will occur for underground objects. A OneCall locate request should be made at least one week and no less than three days prior to commencement of drilling in order to give public utility locators time to mark known, buried utility lines. All planned boring locations should be marked on the ground with white spray paint prior to making a locate request. In almost all cases, site maintenance managers or equivalent should be consulted for site selection and a private utility locator should clear any underground objects using electromagnetic techniques from the drilling area. If drilling in close proximity to buried utilities, field staff may need to request authorization for use of an air knife or vacuum extraction to clear the borehole to a depth below the utility lines.

3.2 DRILLING

1. Mark the desired well location using coordinates pre-loaded into a handheld GPS, or by measuring from known Site features. It is best to use both methods, if possible.
2. Before drilling begins, record the following information on each log:
    a. Operator’s name and company, equipment make/model, equipment measurements (i.e., sampler length and diameter, hammer weight and stroke if using hollow stem auger, boring diameter).
    b. Your name, date, project, boring name, and approximate descriptive location relative to existing site features. Include a description of the ground surface and whether or not concrete coring was necessary; if so, include core diameter, concrete thickness, and subcontractor information.
    c. A small hand drawn map showing your location with measurements to a stationary reference point, or GPS coordinates (or ideally, both). This is also a good place to note if you have had to move a boring location because of underground utilities, access issues, etc. It is important to record the reason for relocation and the direction and distance moved (i.e., moved 10 feet to the north due to presence of subsurface water line).
3. If you are using a hollow stem auger, it is important to communicate to the driller how often you would like a split spoon sample collected. Typically this would be continuous or every 5 feet but may be different depending on the project needs. Usually this is established before the driller issues a quote. Any changes will affect the cost of the work and should be discussed with the PM.
    a. Record any feedback from the driller about the drilling conditions. This may include difficult drilling or rig chatter (usually caused by hard materials), heaving sands (usually caused by hydrostatic pressure on the borehole), caving, or hole instability.

4. For split spoon samples, record the number of hammer blows (blow counts) necessary to drive the sampler each 6-inch increment, as reported by the driller. If more than 50 blows are needed, record the distance that the sampler was driven in 50 blows (i.e., 2-inches in 50 blows). This is referred to as the standard penetration test (SPT).
5. For all drilling methods, create a log of the soils encountered according to the Floyd|Snider Soil Logging Standard Guideline. Pay particular attention to the moisture content of the soils, making careful notation of the water table where free water is first encountered. After drilling has been completed to the desired depth, confirm the depth to the water table using a water level meter.

3.3 WELL DESIGN AND CONSTRUCTION

1. Determine the length and placement of the well screen based on the observed depth to the water table, the specifics of the work plan, and the observed lithology. The well screen is typically set across the water table of shallow aquifers for monitoring wells and piezometers. However, the screened interval may be fully submerged for groundwater extraction wells, sites with very shallow groundwater, or wells installed in deeper aquifers below confining units. If an area is tidally influenced, note the tide elevation during well completion; if the tide is at a high or low at the time of drilling the well screen may need to be lowered or raised accordingly so that the screen spans the water table when the tide is at zero. The hydraulic conductivity of the aquifer material will also factor into well screen placement. For example, wells screened in tight silts may not produce enough water to adequately develop and sample. In this case, it may be preferable to screen the well in a more transmissive unit. Include the length of any required bottom caps or sumps below the well casing when determining the total depth of the boring required to place the well screen at the desired interval. The Washington State minimum standards also require that the diameter of the well screen relative to the diameter of the borehole (annual space) be small enough to allow placement of a filter pack that is 4 inches in diameter larger than the screen. For example, a 2-inch diameter monitoring well should be completed within a borehole that has a minimum 6-inch diameter.
2. Determine the filter pack material. The purpose of the filter pack is to prevent fine-grained aquifer material from entering the well while still allowing groundwater to flow through. Filter pack is composed of clean, rounded, relatively uniform silica sand. The choice of sand for the filter pack will depend on the grain size range of the aquifer material, with emphasis on the finest aquifer material. Filter pack material should be approximately 10 to 15 times the grain size of the surrounding aquifer material. The particle size ranges of fine, medium, and coarse sand, and the particle size ranges of common filter pack materials are given in the two tables below. As indicated in these tables, suitable filter pack choices for an aquifer with appreciable fine sand would include a range from 20-40 to 10-20 sand. For aquifers where the smallest particle size is medium sand, a filter pack of 2-12 sand or similar may be appropriate. More precise filter pack designs are possible based on grain size curves (see Driscoll 1986, Blair 2006).

Unified Soil Classification System (USCS) Classification	U.S. Sieve Size	Grain Size (inches)	Grain Size (millimeters)
Fine Sand	40 to 200	.003 to 0.16	.074 to .42
Medium Sand	10 to 40	.016 to .06	.42 to 1.68
Coarse Sand	10 to 4	.06 to 0.19	1.68 to 4.76

Example Sand Pack Gradations (U.S. Sieve Sizes)	Grain Size (inches)	Grain Size (millimeters)
32-40	.016 to .02	.42 to .55
20-40	.016 to .03	.42 to .84
16-30	.05 to .02	.59 to 1.2
10-20	.03 to .08	.84 to 2
2-12	.06 to .3	1.7 to 8

3. Determine the screen slot diameter. The purpose of the well screen is to allow groundwater to flow into and through the well screen for sample collection. Monitoring well casings are typically constructed of PVC (Washington State minimum standards require Schedule 40 or thicker-walled PVC for borings up to 200 feet deep); however, materials such as stainless steel may be used for the purposes of longevity, heat, specific chemical resistance, or other site-specific concerns. The screened interval of the well consists of a series of slots that are commonly 0.01 inch or 0.02 inch in width. Similar to filter pack material, narrower slots allow less fine-grained material and also less groundwater to pass through them. The screen slot size should be selected to retain approximately 90% or greater of the filter pack material. The largest screen slot size practical should be selected.

4. Once the driller has assembled the well casing of the appropriate length, oversee placement of the casing and filter pack. The casing should be centered in the borehole and level. When using a hollow stem auger, the sand is typically poured from the surface while the augers are being lifted from the borehole. When using sonic drilling or other methods where the drill rods are removed prior to sand placement, it is preferable to use a Tremie tube lowered to the bottom of the borehole to deliver the sand, which helps to ensure that the sand has actually reached the bottom of the borehole. As the driller is pouring sand into the annular space, monitor the height of the sand in the borehole using a weighted tape or leadline to ensure that the space is being filled evenly. If possible, use a surge block to force water from the well out into the sand pack periodically to eliminate any bridges or gaps in the sand. The sand pack

placement is complete when it has reached a height minimum of 1 foot (but no more the 5 feet) above the top of the well screen.

5. A bentonite seal must be placed above the sand pack to isolate the screened interval of the aquifer and to prevent the annular space from acting as a preferential pathway for surface water, water above the screen zone, or other liquid (i.e., free product). The purpose of the bentonite plug is to prevent downward migration inside the borehole, which has the potential to cause groundwater contamination. Monitor the placement of the bentonite plug above the sand pack. The bentonite plug is typically composed of dehydrated bentonite chips, which are poured into the annual space from the surface; or a bentonite slurry, which is pumped into the space via a Tremie tube. A bentonite chip seal is still recommended (but not necessary) immediately above the sand pack when using bentonite slurry to minimize migration of the slurry into the sandpack. Pumping is preferable in situations where bentonite will be placed below the water table. The U.S. Environmental Protection Agency (USEPA) recommends that the bentonite seal consist of a minimum of 2 feet of bentonite placed above the sand pack. If using a bentonite chip seal, hydrate the chips with clean water so that they expand to seal the borehole.
6. Communicate the desired surface completion to the driller (i.e., an aboveground well monument or a monument flush with the ground surface) if you have not already done so. Verify that the well monument has been installed correctly. For flush-mounted wells, ensure that the well is level with the surrounding grade, especially in areas with pedestrian or vehicle traffic. In areas with frequent or heavy vehicle traffic, heavy-duty traffic-rated monuments or manholes should be used. For aboveground well monuments (i.e., stand pipes), ensure that the monument is level, anchored in a minimum of 2 feet of concrete, and protected by steel bollards, unless otherwise specified in the work plan. The concrete surrounding any well monument should seal the borehole at the ground surface.

4.0 Decontamination

All reusable equipment that comes into contact with soil and groundwater should be decontaminated as follows prior to moving to the next sampling location.

Split spoons, stainless steel bowls and spoons, the water level tape, and any other tools used for well drilling and installation must be decontaminated between boring locations. If collecting soils samples for chemical analysis, split spoons and any tools used for sample processing will be decontaminated between each sample; alternatively, disposable bowls and spoons may be used. Equipment decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or similar)/clean water solution, and a final rinse with distilled or deionized water.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, waste soils, liquids, and other drilling materials generated during well drilling and installation will be contained in accordance with applicable laws, and stored in a designated area until transported off-site for disposal.

The approach to handling and disposal of these materials is as follows. For investigation-derived waste (IDW) that is contained, such as waste soils, 55-gallon drums approved by the Washington State Department of Transportation (WSDOT) will be supplied by the driller and used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled with its contents (e.g., “soil cuttings”), the date(s) on which the wastes were placed in the container, the owner’s name, contact information for the field person who generated the waste, and the site name.

IDW contained within drums will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy-duty garbage bags or other appropriate containers and disposed of as solid waste in the municipal collection system (i.e., site dumpster).

6.0 Field Documentation

All observations should be recorded on a soil boring/well completion form appropriate for the drilling method or in a bound field notebook. Field staff should record as much detail as possible in the field log (including well construction materials, Ecology well ID tag number, and surface completions) and note any anomalies or details that varied from the SAP. After the field work is complete, a set of final well construction logs (usually electronic) that serve as the record for the project will be completed in consultation with the project manager or field manager.

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	PROJECT:	LOCATION:	BORING ID:
	LOGGED BY:	COORDINATE SYSTEM:	
DRILLED BY:		NORTHING:	EASTING:
DRILLING EQUIPMENT:		GROUND SURFACE ELEVATION:	
DRILLING METHOD:		TOTAL DEPTH (ft bgs):	DEPTH TO WATER (ft bgs):
SAMPLING METHOD:		BORING DIAMETER:	DRILL DATE:

Depth (feet)	USCS	Description	Drive	Recovery	# of Blows	PID (ppm)	Sample ID

ABBREVIATIONS:
ft bgs = feet below ground surface
ppm = parts per million
USCS = Unified Soil Classification System
▼ = denotes groundwater table

NOTES:

F|S STANDARD GUIDELINE

Well Development

DATE/LAST UPDATE: May 2015

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines and should review and understand these procedures prior to going in the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This Standard Guideline for Well Development presents commonly used procedures for monitoring well development for newly installed monitoring wells and/or existing wells that may require redevelopment. Monitoring well development restores hydraulic conductivity with the surrounding formations that were disturbed during the drilling process. Development removes residual fines from well filter pack materials and the borehole wall and reduces the turbidity of the water, which provides more representative groundwater samples. These wells may include groundwater monitoring wells, piezometers, or groundwater extraction wells. This guideline describes the purge and surge method of development and is intended to be used by field staff who are overseeing or completing well development. Often, the drilling subcontractors are asked to complete well development activities subsequent to new well installations, in which case, Floyd|Snider staff would oversee the development. Other development methods, such as jetting, are not described herein, but may be used if specified in the project-specific Work Plan or Sampling and Analysis Plan (SAP).

Well development shall be completed by continuous pumping at a steady rate using a portable pump and polyethylene tubing, with regular surging (e.g., using a surge block) to force water through the filter pack and surrounding formation. Wells should ideally be developed either during installation (following sand placement but prior to sealing) or soon after installation, unless otherwise specified in the work plan, using the described methodologies or equivalents. For wells that are completed using a grout or concrete seal, if development does not take place prior to sealing, it should be completed within 48 hours following well installation in order allow for grout and concrete to cure.

2.0 Equipment and Supplies

Well Development Equipment and Tools:

- Appropriate high volume pump (centrifugal, submersible, etc.) and correct diameter tubing, or bailer
- Hose clamps (optional)
- Power source (generator, 12-volt battery, or car battery) and appropriate power adapter for pump
- Water quality meter or turbidity meter (if needed)
- 2-, 4-, or 6-inch surge block (typically provided by the driller)
- Water level meter
- Washington State Department of Transportation (WSDOT)-approved 55-gallon drums
- Equipment decontamination supplies including:
    - Scrub brushes
    - Alconox or other soap
    - Distilled or deionized water
    - Paper towels
- Trash bags
- Camera

Paperwork:

- Work Plan and/or SAP/Quality Assurance Project Plan (QAPP)
- Bound field notebook or appropriate field forms
- Well development form (printed on Rite in the Rain paper)
- Health and Safety Plan (HASP)
- Well installation forms (printed on Rite in the Rain paper)

Personal Equipment:

- Steel-toed boots
- Safety vest
- Safety glasses
- Nitrile gloves
- Rain gear
- Work gloves

3.0 Standard Procedures

3.1 OFFICE PREPARATION

Meet with the project manager to identify key information and goals of the well development, including how long after construction the wells should be developed. Determine if Floyd|Snider or the driller will be doing the development.

3.2 WELL DEVELOPMENT PROCEDURES

The following procedures are general guidelines for monitoring well development. These same procedures are also appropriate for extraction wells, injection wells, and/or piezometers. Specific instructions provided in individual work plans shall supersede these procedures in the event there are discrepancies.

Visually inspect all well development equipment for damage; repair as necessary.

1. Decontaminate all hoses, surge blocks, and/or submersible pump by scrubbing with brush and alconox or other soap solution and rinsing with deionized water.
2. Prior to development, use a water level meter to measure the depth in each well to the static water level and total depth to a reference mark on the top of the well casing.
3. Attach a length of clean or disposable tubing, approximately 5 feet longer than the well casing, to the outlet of the submersible pump.
4. Each well development cycle consists of surging followed by well evacuation (pumping). Surging may be accomplished with a surge block sized to fit snugly inside the well casing, or with the submersible pump. Surging using a pump increases the hydraulic gradient and velocity of groundwater near the well by drawing the water level down and moving more fine-grained soil particles into the well casing. Surging using a pump is only effective if the well produces enough water for continuous pumping and the pump is of a large enough diameter relative to the well casing. If

pumping must be stopped to allow the well to recharge, a surge block is preferable for surging. If using a surge block, connect polyvinyl chloride (PVC) pipe or other rods longer than the well casing to the surge block. Lower the surging device into the well to a depth within the screened interval. A bailer can be used to surge in situations when a surge block is not available and the well has insufficient recharge for the submersible pump.

5. During development, it is important to note the color and clarity of the water and any other visual or olfactory observations on the field form or in the field notebook. Note any significant changes as development progresses.
6. Surging should consist of a minimum of ten consecutive surges (i.e., quickly raise and lower surge block or pump in well) with an appropriately sized surge block or pump over the full length of the screen. For long well screens (greater than 10 feet), surging should be done in short intervals of 2 to 3 feet at a time. In cases where the screen extends to above the water table, clean water may have to be added to the well to develop the top of the filter pack.
7. After surging, water is purged from well until the pumped stream starts to run clear. At that point, stop pumping and initiate another surge cycle. If a well has more hydraulic head than the pump is able to overcome, or if an insufficient volume of water for pumping is present, a disposable bailer may also be used for purging.
8. Repeat this procedure until evacuated water is visibly clear and essentially free of sediment. Perform a minimum of three surge and pump cycles.
9. Well development will be terminated when the variation in the turbidity Nephelometric Turbidity Units (NTUs) readings is less than 10 percent or until the discharge is visibly clear and free of sediment after a minimum of three surge and purge cycles. As an alternative, periodic water samples can be collected for field measurements of temperature, specific conductivity, and pH; well development should continue until field parameters stabilize to within ±5 percent on three consecutive measurements or 10 well volumes have been purged. If it is not possible reduce the turbidity further, the well should be purged up to a maximum of four hours or as determined sufficient by the field geologist or project manager.
10. Report field observations and volume of water removed on the standard well development form (attached). Take final water level measurements and record then on the field form or in the field notebook.
11. Contain the purged water and manage in accordance with the project-specific SAP or Section 5.0 below. Prior to developing the next well or after the completion of development activities, decontaminate all reusable equipment used in development in accordance with Section 4.0 below.
12. If feasible, it is best to wait at least two weeks after development to sample the wells. Wells can be sampled a minimum of 48 hours after the completion of development if

the project schedule requires a quick turnaround. However, the groundwater sample will be more representative of static conditions in the aquifer if allowed to stabilize for at least one to two weeks after development.

4.0 Decontamination

All reusable equipment that comes into contact with groundwater should be decontaminated as follows prior to moving to the next sampling location.

Water level meter and surge block: The water level indicator and tape will be decontaminated between sampling locations and at the end the day by spraying the entire length of tape that came in contact with groundwater with an Alconox (or similar)/clean water solution followed by a thorough rinse with distilled or deionized water. Surge block decontamination will consist of a tap water rinse to remove soil particles, followed by scrubbing with brushes and an alconox (or similar)/clean water solution and a final rinse with distilled or deionized water.

Submersible Pump: Decontaminating the pump requires running the pump in three progressively cleaner grades of water. Place the pump and the length of the power cord that was in contact with water into a bucket containing approximately four gallons of an Alconox (or similar)/clean water solution. Run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted. Next, place the pump and cord into a second bucket containing approximately four gallons of clean water and run the pump for approximately two minutes or until the volume of water in the bucket is exhausted. Lastly, place the pump and power cord into a third bucket containing approximately four gallons of distilled or deionized water and run the pump for approximately two minutes or until the volume of water in the bucket is exhausted. The soap/water solution and rinse water may be re-used. When done for the day, dry the exterior of the pump and power cord with clean paper towels to the extent practical prior to storage. All decontamination water and rinse water (including soapy solution) should be managed in accordance with Section 5.0 below.

5.0 Investigation-Derived Waste

Unless otherwise specified in the project work plan, well development and decontamination water generated during development and any drilling materials will be contained and stored in a designated area until transported off-site for disposal in accordance with applicable laws.

The approach to handling and disposal of these materials is as follows. For investigation-derived waste (IDW) that is contained, such as well development water, WSDOT-approved 55-gallon drums will be supplied by the driller and used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., “MW-1 Well development water”), the date(s) on which the wastes were placed in the container, the owner's name, contact information for the field person who generated the waste, and the site name.

IDW contained within drums will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used as appropriate for disposal.

Disposable sampling materials and incidental trash such as paper towels and personal protective equipment (PPE) used in sample processing will be placed in heavy duty garbage bags or other appropriate containers and disposed of as trash in the municipal collection system (i.e., site dumpster).

6.0 Field Documentation

Well development procedures will be documented on the well development field form (attached) or a bound field notebook. Information recorded will at a minimum include date, personnel present (including subcontractors), purpose of field event, weather conditions, depth of water, well construction details for the well(s) being developed (i.e., diameter, total depth, screen interval), water quality field measurements (if collected), amount of purged water generated, and any deviations from the SAP.

Enclosure: Well Development Field Form

WELL DEVELOPMENT FIELD FORM

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Project Name:____________________________ Date: ____________

Project Number:____________________________ Field Personnel: ______________________________

Driller (if applicable): ____________________

Purge Data

Well ID:	Total Well Depth:	Well Condition/Damage Description:
Well Casing Type/Diameter/Screened Level:	One Casing Volume (gal):	
Method of Development (Circle): Surge Block Pump Surge Bailer	Equipment Used (type of pump, etc.):	

Begin Purge (time):	
End Purge (time):	
Gallons Purged (time):	
Purge Water Disposal Method (circle): On-site Storage Tank On-site Treatment Drum Other:	

Volume of Schedule 40 PVC Pipe

Diameter	O.D.	I.D.	Volume (Gal/Linear Ft.)	Weight of Water (Lbs/Lineal Ft.)
1 ¼"	1.660"	1.380"	0.08	0.64
2"	2.375"	2.067"	0.17	1.45
3"	3.500"	3.068"	0.38	3.2
4"	4.500"	4.026"	0.66	5.51
6"	6.625"	6.065"	1.5	12.5

Time	Depth to Water (feet)	Vol. Purged (gallons)	Rate (gpm)	pH	Conductivity	Turbidity	Temp	Comments
			--	--	--	--	--	Prior to purging

Notes:

Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

F|S STANDARD GUIDELINE

Low-Flow Groundwater Sample Collection

DATE/LAST UPDATE: November 2023

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines for the sampling method they intend to use and should review and understand these procedures prior to going into the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline provides details necessary for collecting representative groundwater samples from monitoring wells using low-flow methods. These guidelines are designed to meet or exceed guidelines set forth by the Washington State Department of Ecology (Ecology). Low-flow sampling provides a method to minimize the volume of water that is purged and disposed from a monitoring well, and minimizes the impact that purging has on groundwater chemistry during sample collection.

2.0 Equipment and Supplies

Groundwater Sampling Equipment and Tools

- For wells with head less than 25 feet:
  - Peristaltic pump with fully charged internal battery or standalone battery and appropriate connectors
- For wells with head greater than 25 feet:
  - Bladder pump and controller, as well as an air cylinder, or air compressor (with extension cord if near an electrical outlet; with battery and appropriate connectors or generator if not near an outlet)

    OR

- Low-flow submersible pump and controller (with extension cord if near an electrical outlet; with battery and appropriate connectors or generator if not near an outlet)

- Multi-parameter water quality meter
- Turbidity meter
- Water level meter
- Polyethylene tubing, Teflon tubing, or similar (assume polyethylene unless otherwise specified in SAP) and tubing weights (for wells deeper than approximately 10 feet)
- Silicone tubing
- Filters (if field filtering)
- Tools for opening wells and drums (1/2-inch, 9/16-inch, 5/8 and 15/16-inch sockets ratchet, screwdriver, hammer/rubber mallet, bung wrench; any other necessary tools if non-standard monuments have been used)
- Well keys
- Tube cutters, razor blade, or scissors
- 5-gallon buckets, lids, and clamp
- Decontamination supplies: Alconox (or similar), distilled or deionized water, spray bottles, and paper towels
- Bailer or hand pump to drain well box if full of stormwater
- Trash bags

Lab Equipment

- Sample jars/bottles
- Coolers
- Chain-of-Custody Forms
- Labels
- Ice
- Ziploc bags

Paperwork

- Field notebook with site maps
- Table of well construction details and/or well logs, if available
- Sampling forms (enclosed)
- Purge water plan

- Rite-in-the-Rain pens, paper, and permanent markers
- Site-Specific Health and Safety Plan (HASP) and F|S Accident Prevention Plan (APP)
- List of emergency contacts for the Site or facility
- Safety Data Sheets (SDS) binder
- Sampling and Analysis Plan (SAP) and/or Quality Assurance Project Plan (QAPP) (including tables of analytes and bottle types)

Safety Equipment

- PPE:
  - Waterproof boots (safety toed, depending on site)
  - Safety vest
  - Safety glasses
  - Rain gear
  - Nitrile gloves
  - Work gloves
- First Aid kit
- Emergency kit (fire extinguisher, road flares)
- Traffic barricades or cones

3.0 Standard Procedures

Low-flow groundwater sampling consists of purging groundwater within the well casing at a rate equal to or less than the flow rate of representative groundwater from the surrounding aquifer into the well screen. The flow rate will depend on the hydraulic conductivity of the aquifer and the drawdown, with the goal of minimizing drawdown within the monitoring well. Field parameters are monitored during purging and groundwater samples are collected after field parameters have stabilized. Deviations from these procedures should be approved by the Project Manager and fully documented.

3.1 OFFICE PREPARATION

First, meet with the PM to identify the key objectives of the groundwater sampling effort. This may include the order of wells to be sampled (e.g., if using non-dedicated equipment, wells may need to be sampled in order of least contaminated to most contaminated), whether any wells require redevelopment at least 24-hours prior to sampling, and/or key stabilization parameters (e.g., elevated turbidity may require purging beyond 30 minutes, even if the readings are within 10%).

Conduct a kick-off meeting with the sampling team to discuss site health and safety protocols, data quality objectives, and any site-specific special considerations or sampling procedures.

3.2 TAILGATE SAFETY MEETING

Conduct a tailgate safety meeting prior to beginning work at the site. Emergency evacuation procedures, rally points, and onsite communication protocols should be discussed at the first tailgate meeting and repeated if new personnel join the field team onsite.

The safety meeting should cover the hazards specific to groundwater sampling. Typical hazards include the following:

- Chemical hazards (refer to HASP for site chemical exposure hazards)
- Site hazards
  - Traffic hazards onsite (e.g., truck traffic, heavy machinery)
  - Biological hazards (e.g., spiders or wasps within well monuments)
- Physical hazards associated with lifting and carrying heavy equipment and repeated bending while sampling
- Cuts and abrasions associated with using blades and tools
- Electrical hazards (make sure all wires/cables are in good condition and connections to battery or outlet are secure)
- Heat stress and cold stress

Record the meeting attendees and topics discussed on the front page of the tailgate safety meeting form (included as an attachment to the HASP). All attendees should sign the form.

3.3 OTHER HEALTH AND SAFETY GUIDELINES

The following are additional health and safety guidelines that should be followed in the field. These guidelines are intended to supplement the guidelines and requirements identified in the HASP and are not intended to replace the HASP.

- Review and sign the HASP prior to going into the field.
- Conduct a tailgate safety meeting prior to beginning work at the site as discussed in Section 3.2
- When moving between monitoring wells or switching to different tasks (e.g., transitioning from sampling to cooler QC prior to lab pickup), assess any additional hazards that may be associated with the new location or task. Record additional hazards noted and corrective actions to address those hazards on the Daily Tailgate Safety Meeting and Debrief Form (included as an attachment to the HASP).
- Record near misses and incidents on the Near Miss and Incident Reporting Form (included as an attachment to the HASP) and conduct management/client notifications according to the protocols detailed in the HASP.

3.4 CALIBRATION OF WATER QUALITY METERS

All multi-parameter water quality meters to be used will be calibrated prior to each sampling event. Calibration procedures are outlined in each instrument's specific user manual.

3.5 MONITORING, MAINTENANCE, AND SECURITY

Prior to sampling, depth to water and total depth measurements will be collected and recorded for accessible monitoring wells onsite (or an appropriate subset for larger sites). Check for an existing measuring point (notch or visible mark on top of casing). If a measuring point is not observed, a measuring point should be established on the north side of the casing. The conditions of the well box and bolts will also be observed, and deficiencies will be recorded on the sampling forms or logbook (i.e., missing or stripped bolt). The following should also be recorded:

- Condition of the well box, lid, bolts, locks, and gripper cap, if deficiencies
- Condition of gasket if deficient and if water is present in the well box
- Note any obstructions or kinks in the well casing
- Note any equipment in the well casing, such as transducers, bailers, or tubing
- Condition of general area surrounding the well, such as subsidence, potholes, or if the well is submerged within a puddle.

Replace any missing or stripped bolts and redevelop wells if needed.

3.6 LOW-FLOW PURGING METHOD AND SAMPLING PROCEDURES

Groundwater samples will be collected using low-flow purging and sampling procedures consistent with Ecology guidelines and the U.S. Environmental Protection Agency (USEPA) standard operating procedures (USEPA 1996). The following describes the Low-Flow purging and sampling procedures for collecting groundwater samples using a peristaltic pump. If the water level is greater than approximately 20 to 25 feet below ground surface (bgs), Grundfos or Geotech submersible pumps or bladder pumps can be used since their pumping rates can be adjusted to low-flow levels. Submersible pumps are preferable to bladder pumps in situations where less than 5 feet of water column are present in the well casing.

- Place the peristaltic pump and water quality equipment near the wellhead. Slowly lower new poly tubing down into the well casing approximately to the middle of the well screen. When sampling wells with a bottom screen depth greater than approximately 10 feet, it is important to measure the length of tubing prior to placement as longer lengths of tubing are more likely to get caught or otherwise obstructed and feel like it has reached the well bottom; this issue can be mitigated by using decontaminated stainless steel tubing weights. If the depth of the well screen is not known, lower the appropriate length of tubing to the bottom of the well, making sure that the tubing has not been caught on the slotted well casing, and then raise the tubing 3 to 5 feet off the bottom of the casing (limit this distance to 2 feet for wells with total depth less than 10 feet). Document the estimated depth of the tubing placement within the well. Connect the tubing to the peristaltic pump using new flex tubing and connect the discharge line to the flow-through cell of the water quality meter. The discharge line from the flow cell should be directed to a bucket to contain the purged water.

- If using a low-flow submersible pump, connect the pump head to dedicated or disposable tubing. If using a bladder pump, connect both the air intake and water discharge ports to decontaminated or disposable tubing, using the manufacturer's instructions to ensure a secure connection. Lower the pump with tubing into the well as described above and connect the water discharge tubing directly to the flow-through cell.
- Measure the depth to water to the nearest 0.01 foot with a decontaminated water level meter and record the information on a sampling form.
- Start pumping the well at a purge rate of 0.1 to 0.2 liters per minute and slowly increase the rate. Purge rate is adjusted using a speed control knob or arrows on peristaltic and low-flow submersible pumps. The purge rate for bladder pumps is controlled by the air compressor, which first pressurizes the pump chamber in order to compress the flexible bladder and force water through the discharge line, and then vents the chamber in order to allow the bladder to refill with water.
    - A good rule of thumb is to pressurize to 10 psi + 0.5 psi/foot of tubing depth and begin with 4 discharge/refill cycles per minute; using greater air pressure and accelerating the pump cycles will increase the purge rate.
- Check the water level. If the water level is dropping, lower the purge rate. Maintain a steady flow with no or minimal drawdown (less than 0.33 feet according to USEPA 2002). Maintaining a drawdown of less than 0.33 feet may not be feasible depending on hydrogeological conditions. If possible, measure the discharge rate of the pump with a graduated cylinder or use a stopwatch when filling sampling jars (500 milliliters [mL] polyethylene or glass ambers) to estimate the rate. When purging water through a flow cell, the maximum flow rate for accurate water quality readings is about 0.5 liters per minute (L/minute).
- The discharge tubing should be connected to the flow cell immediately upon initial water discharge, unless the discharge water is visibly turbid or flocculant is observed. Monitor and record water quality parameters every three to five minutes after one tubing volume (including the volume of water in the flow cell) has been purged.
    - One foot of ¼-inch interior diameter tubing holds about 10 mL of water, and flow-through cells typically hold less than 200 mL of water; one volume should be purged after about 5 minutes at a flow rate of 0.1 L/minute.
- Water-quality indicator parameters that will be monitored and recorded during purging include:
    - pH
    - Specific conductivity

- Dissolved oxygen
- Temperature
- Turbidity
- Oxidation reduction potential (ORP)

- Continue purging until temperature, pH, turbidity, and specific conductivity are approximately stable (when measurements are within 10 percent) for three consecutive readings, or 30 minutes have elapsed. Because these field parameters (especially dissolved oxygen and ORP) may not reach the stabilization criteria, collection of the groundwater sample will be based on the professional judgment of field personnel at the time of sampling. A minimum of 5 water quality readings should be collected prior to sampling.
- The water sample can be collected once the criteria above have been met.
- If drawdown in the well cannot be maintained at 0.33 feet or less, reduce the flow or turn off the pump for 15 minutes and allow for recovery. If the water quality parameters have stabilized, and if at least two tubing volumes and the flow cell volume have been purged, then sample collection can proceed when the water level has recovered, and the pump is turned back on. This should be noted on the sampling form.
- To collect the water sample, maintain the same pumping rate. After the well has been purged and the sample bottles have been labeled, the groundwater sample will be collected by directly filling the laboratory-provided bottles from the pump discharge line prior to passing through the flow cell. All sample containers should be filled with minimum disturbance by allowing the water to flow down the inside of the bottle or vial. When collecting a volatile organic compound (VOC) sample, fill to the top to form a meniscus over the mouth of the vial prior to placing the cap to eliminate air bubbles. Be careful not to overflow preserved bottles/pre-cleaned Volatile Organic Analyte (VOA) vials.
- If sampling for filtered metals, collect these samples last and fit an in-line filter at the end of the discharge line. Take note of the flow direction arrow on the filter prior to fitting, invert filter to eliminate air bubbles, and allow minimum of 0.5 to 1 liter of groundwater to pass through the filter prior to collecting the sample.
- Sample labels will clearly identify the project name, sampler's initials, sample location and unique sample ID, analysis to be performed, date, and time. After collection, place samples a cooler maintained at a temperature of approximately 4 to 6 degrees Celsius (°C) using ice (if required). Complete the chain-of-Custody forms. Upon transfer of the samples to the laboratory, the Chain-of-Custody Form will be signed by the persons transferring custody of the sample containers to document change in possession.
- When sample collection is complete at a designated location, remove and properly dispose of the non-dedicated tubing. In most cases, this waste is considered solid waste and can be disposed of as refuse. Close and lock the well.

4.0 Decontamination

All reusable equipment that comes into contact with groundwater should be decontaminated using the processes described in this section prior to moving to the next sampling location.

Water Level Meter: The water level indicator and tape will be decontaminated between sampling locations and at the end the day by spraying the entire length of tape that came in contact with groundwater with an Alconox (or similar)/clean water solution followed by a thorough rinse with distilled or deionized water.

Water Quality Sensors and Flow-Through Cell: Distilled water or deionized water will be used to rinse the water quality sensors and flow-through cell. No other decontamination procedures are recommended since they are sensitive equipment. After the sampling event, the water quality meters will be cleaned and maintained according to the specific manual.

Submersible Pump (if applicable): Decontaminating the pump requires running the pump in three progressively cleaner grades of water.

1. Fill a bucket with approximately 4 gallons of an Alconox (or similar)/clean water solution to sufficiently cover the pump. Place the pump and the length of the power cord (if applicable) that was in contact with water into the bucket and run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted.
2. Fill a second bucket containing approximately 4 gallons of clean water to sufficiently cover the pump. Place the pump and cord into this bucket and run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted.
3. Fill a third bucket with approximately 4 gallons of distilled or deionized water to sufficiently cover the pump. Place the pump and cord into this bucket and run the pump for approximately two minutes or until the volume of water in the bucket has been exhausted.

The soap/water solution may be reused; however, rinse water should be collected for disposal as described in Section 5.0 below. When done for the day, dry the exterior of the pump and cord with clean towels to the extent practical prior to storage.

Bladder Pump: Clean the inside and outside of the pump body with an Alconox (or similar)/clean water solution, followed by a thorough rinse with distilled or deionized water. The outside of the air supply line that came in contact with groundwater may also be cleaned with Alconox (or similar) solution and re-used; bladders and water discharge lines must be replaced after each sample is collected.

5.0 Investigation-Derived Waste (IDW)

Unless otherwise specified in the project work plan, water generated during groundwater sampling activities will be contained, transported, disposed of in accordance with applicable laws, and stored in a designated area until transported off-site for disposal. This includes purge water and decontamination waste water.

The approach to handling and disposal of these materials for a typical cleanup site is as follows.

For IDW that is containerized, such as purge water, 55-gallon drums (or other smaller sized drums) approved by the Washington State Department of Transportation will be used for temporary storage pending profiling and disposal. Each container holding IDW will be sealed and labeled as to its contents (e.g., "purge water"), the dates on which the wastes were placed in the container, the owner's name and contact information for the field person who generated the waste, and the site name.

IDW containerized within drums will be characterized relative to applicable waste criteria using data from the sampling locations whenever possible. Material that is designated for off-site disposal will be transported to an off-site facility permitted to accept the waste. Manifests will be used, as appropriate for disposal. Refer to the FS Special Condition Standard Guideline for Investigation Derived Waste for additional information regarding proper profiling and disposal of wastewater generated by groundwater sampling.

Disposable sampling materials and incidental trash such as tubing, paper towels and gloves/other disposable used in sample processing will be placed in heavy-duty garbage bags or other appropriate containers and disposed of as trash in the municipal collection system unless otherwise specified in the SAP.

6.0 Field Documentation

Groundwater sampling activities will be documented in field sampling forms and/or field notebooks, and Chain-of-Custody Forms. Information recorded will, at a minimum, include personnel present (including subcontractors or client representatives), purpose of field event, weather conditions, sample collection date and times, sample analytes, depths to water, water quality parameters, well box/lid conditions, amount of purged water generated, and any deviations from the SAP. Photographs of damaged well casings or well boxes should be taken.

At the end of the day, complete and review the second page of the tailgate safety meeting form detailing additional hazards, corrective actions, near-misses or incidents. Any incidents that result in equipment damage or field staff injuries should be reported immediately to the PM.

7.0 Demobilization

Upon returning to the office, ensure that all equipment is property cleaned and put away in the field room. Equipment with rechargeable batteries should be plugged in as appropriate. It is preferable to dispose of trash on-site, but any trash left in the field vehicle should be disposed as regular trash at Two Union Square.

If rented equipment or sample coolers will be placed at the front desk for pickup, clearly label each item with the company picking it up, anticipated pickup time frame, and your contact information so front desk staff can contact you if there are any questions. Notify front desk staff if any items require a signature at pickup.

Within one week of returning from the field, the field lead for the event should review field notes, sampling forms and tailgate safety meeting forms with the PM. Following PM review and approval, field notes will be scanned and saved to the project folder. Hard copies should be filed. The PM will provide copies of near miss and incident reports to the Safety Program Manager.

8.0 References

U.S. Environmental Protection Agency (USEPA). 1996. Low-Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, Revision 2. Region 1. July 30, 1996.

_____. 2002. Groundwater Sampling Guidelines for Superfund and CAR Project Managers. Office of Solid Waste and Emergency Response. EPA 542.S-02-001. May 2002.

Enclosures: Groundwater or Surface Water Sample Collection Form

Record of Revisions:

Revisions	**Date**
Added health and safety information, reviewed EPA guidance, and added revisions table.	12/9/2022
Added turbidity meter to equipment list and appended updated field form to PDF	11/29/2023

Cheiron Resources Ltd develops and manufactures high quality, easy to use, cost effective field tests for the "instant" detection of petroleum hydrocarbons and chlorinated solvents in soil.

The **OilScreenSoil™** tests are field presence/absence indicators of non-volatile petroleum hydrocarbons and chlorinated solvents.

The kits:

- Produce "instant" results (under two minutes)
- Detect oils as low as 500 ppm of TPH (total petroleum hydrocarbon) in soil
- Screen for DNAPLs (dense non-aqueous phase liquid), and LNAPLs (light non-aqueous phase liquid)
- Can be used with salt-water, or on frozen soils with the addition of hot water
- Do not require specialized training, or additional instrumentation
- Are non-hazardous to human health and the environment

NOTE: Esters (detergents) are the only "known" substances to interfere with the dye's ability to stain petroleum hydrocarbon products. This may be applicable when screening for Ester based (i.e. synthetic) motor oils.

Cheiron Resources Ltd.
#124, 919 Centre St NW
Calgary, AB,
Canada T2E 2P6
Tel: 1 (403) 241-3276
Fax: 1 (403) 398-0705
info@cheiron-resources.com
www.cheiron-resources.com

MANUFACTURER'S GUARANTEE:

We will replace any broken or defective kits. If you are not satisfied with our product, return any defective kits to Cheiron for a refund. We reserve the right not to provide refunds if the kits have been tampered with in any way, or if not used in accordance with the product MSDS and Instruction Manual.

Cost effective "instant" and disposable tests for field screening of petroleum hydrocarbons and chlorinated solvents in soil

Success Through A Commitment To Excellence

OIL screen SOIL

OilScreenSoil (Sudan IV)™ with Kerosene is shown above

OilScreenSoil™ kits were developed as fast, reliable, easy to use and inexpensive field monitoring tools.

OilScreenSoil™ kits are "non-precision" qualitative tests that screen for petroleum hydrocarbons (aliphatic and aromatic) and chlorinated solvents (TCE, TCA & PCE) in soil, sand, or gravel.

OilScreenSoil™ kits are **NOT** suitable for detection of gases (compounds with 4 carbons or less), or for use with heavy crude oils (Bunker C), or solid bituminous materials like asphalt or waxes.

The following is intended as a general overview of the possible applications for the **OilScreenSoil™** kits. Please contact the manufacturer for more detailed information.

Petroleum products are complex mixtures of multiple hydrocarbon compounds and their composition varies depending upon the source of the crude oil and refining practices used. However:

OilScreenSoil™ test kits are typically used with a wide range of petroleum hydrocarbon products including:

- Automotive Gasolines **(C5-C12)**
- Jet Fuels **(C5-C16)**
- Fuel Oils #1 & 2 **(C9-C20)**
- Mineral Oils **(C15-C29)**
- Petroleum-based Chlorinated Solvents (**C7–C12) i**ncluding: TCE, TCA and PCE (e.g. Dry Cleaning Solvent)

OilScreenSoil™ kits can be used to:

- Quickly and easily determine spill boundaries and depths and to identify spill directions in soil
- Detect chlorinated hydrocarbon compounds (Dense Non Aqueous Phase liquid-DNAPL) in drill/core samples
- Detect direction and depths of spills from leaking underground (LUSTs) and aboveground storage tanks
- Test excavation floor and walls for petroleum hydrocarbons

QUICK AND EASY TO USE – SIMPLY: Add soil, add water - shake!

OilScreenSoil™ tests release specially formulated dyes that stain petroleum hydrocarbons.

The presence of an "expandable polystyrene (EPS) bead" allows users to rapidly identify the presence of free petroleum products as **low as 500ppm TPH**.

Use **OilScreenSoil™** Kits for:

- ✓ Instant delineation of spill depth and direction during response initiatives
- ✓ Cost effective, immediate qualitative field screening/sampling tests for Phase II site assessments and excavations
- ✓ Ease of use - requires no special training, or external instrumentation
- ✓ Working with a safe test containing a "De Minimus" (<0.1%) concentration of test chemicals

Other OilScreenSoil™ test Kits include:

- ***OILSCREENSOIL (INDIGO BLUE)™***
For use with red soils/clays

- ***OILSCREENSOIL (FLUORESCENT)™***
For use with black oils

- ***OILSCREENSOIL (SCARLET)™***
A non-mutagenic red dye