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DRAFT
Remedial Investigation and Feasibility Study Work Plan

Precision Engineering Facility
Seattle, Washington

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Prepared for

Washington State Department of Ecology

Toxics Cleanup Program

P.O. Box 47600
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Section 1: Background

The former Precision Engineering facility (Site) is a former manufacturing facility that specialized in the production and repair of large hydraulic cylinders used in the manufacture of paper and metal sheets. The property is located at 1231 South Director Street in Seattle, Washington. The facility operated from 1968 through 2005. The property was sold in 2005 and is now operated as a retail warehouse (Pacific Industrial Supply) for construction and machinery supplies.

While the property was operating as Precision Engineering, services included precision grinding and polishing, honing, hard-chrome plating, milling, welding, and other flame and arc-applied metal coatings. Precision Engineering's work involved the use of a number of chemicals, particularly chromic acid for plating, and tricholorethene (TCE) as a solvent. A number of chromic acid plating tanks were located in the former chrome shop, as were tanks containing hydrochloric acid, sodium carbonate, and sodium hydroxide. At least four trench drains were present in the grinding and chrome shops, located along the eastern and western walls of the shop.

The Site is located near the municipal boundary between the cities of Seattle and Tukwila, Washington, near the southwestern corner of South Director Street and 14th Street South, and is situated less than 2,000 feet west of the Lower Duwamish Waterway. Adjacent properties are developed with residences to the north and northwest, Seattle Refrigeration to the west up a steep embankment, Highway US-99/West Marginal Way with cloverleaf interchange to the south and southeast, and Seattle Limousine to the east. East of Seattle Limousine and 14th Avenue South, is the Sea King Industrial Park, extending to the western bank of the Lower Duwamish Waterway. A drainage ditch is situated along the southern property line of the Site, and extends north along the eastern property line of the Seattle Limousine property.

1.1 Geology and Hydrogeology

Prior drilling and well installations at the Site suggest soils have been investigated to a maximum depth of 30 feet below ground surface (bgs) at the Site. Based on available information, shallow soils are dominantly silty sands and sandy silts with up to 15 percent gravel. A glacial till layer was encountered during drilling at monitoring well MW-7, occurring from approximately 18 to 29 feet bgs and consisting of dry, dense gravelly sand with silt [Maul Foster Alongi (MFA) 2006].

Depth to groundwater at the Site has been previously measured ranging from 2 to 7 feet bgs. Groundwater appears to be possibly under partially confined aquifer conditions, with saturated soils first observed between 5 and 10 feet bgs, and saturated soils apparently not occurring continuously to depth. Reportedly, tidal fluctuation at the adjacent Seattle Limousine site has been investigated and shown to be minimal. The Maul Foster Alongi Remedial Investigation/Risk Assessment (RI/RA) (MFA 2008) interprets groundwater flow to be westerly toward the Lower Duwamish Waterway, with groundwater occurring in two confined saturated units. The lithology or hydrogeology of either saturated unit has not been fully defined during previous investigations.

1.2 Previous Environmental Investigations

In February 1986, King County Department of Transportation, Metro Transit Division (Metro) issued a discharge violation to Precision Engineering for discharging chrome-plating wastes to sanitary sewer following cancellation of their Waste Discharge Permit in September 1985. Following a complaint, Washington State Department of Ecology (Ecology) and Metro inspected the Site in March 1968, and observed several environmental conditions including:

- Leaks in concrete sump containing waste chromic acid
- Improper hazardous waste storage
- Discharge of waste water, detergent, and oil from the steam cleaning area to the drainage ditch
- Chrome-contaminated roof due to ineffective scrubbers (repaired and addressed by November 1987)
- Consolidated chrome wastes in an evaporator tank
- Oil-contaminated surface/near surface soil near the facility dumpster
- Groundwater accumulation in Tank 7.

Later in 1986, Ecology reportedly issued an Administrative Order requiring a number of compliance activities, as well as characterization of the nature and extent of soil and groundwater contamination at the Site and at the drainage ditch south of the property.

In 1986, accumulated sediment was sampled in the drainage ditch located south of the Site, adjacent to the Highway 99 on-ramp, and soil samples were later collected at the Site. Between 1988 and 1989, Sweet Edwards-Emcon conducted soil investigation activities near former chrome plating tanks 1 and 3, after yellow stained soil was observed in an opening in the concrete floor.

In 1990, a Site Hazard Assessment of the Site was conducted by Ecology, and a ranking of 1 was assigned to the property.

By 1993, monitoring wells MW-1 through MW-4, and two piezometers had been installed at the Site, and an Independent Remedial Action Report was prepared, documenting three rounds of groundwater monitoring as well soil removal activities conducted near the former chromic acid plating tanks in the Chrome Shop. Following issuance of the Independent Remedial Action Report (Precision Engineering 1993), Ecology expressed concern that operations following the remedial action may have resulted in recontamination of soil and groundwater at the Site.

In 2005, Maul Foster Alongi conducted additional site characterization and investigation activities, installing four groundwater monitoring wells and advancing 32 soil borings using direct-push techniques. Further investigation activities in 2006 included sampling sediment in the drainage ditch, groundwater sampling, subslab vapor sampling, and indoor air sampling. A RI/RA was prepared by Maul Foster Alongi, documenting the findings of the 2005 and 2006 investigation activities (MFA 2008). A sediment removal action was conducted in 2007 to address hydrocarbon- and metals-impacted sediment in the drainage ditch, and one additional round of groundwater sampling was conducted in 2010, prior to presentation of the 2011 Feasibility Study (MFA 2011). The groundwater fate and transport model developed indicates groundwater contamination at the Site would not reach the lower Duwamish Waterway; however, Ecology has since determined that the extent of the groundwater contaminant plume has not been defined and may be commingled with the plume associated with the Kaspac/Chiyoda property plume on the adjacent eastern property.

In May 2013, the former Precision Engineering site was considered in the Lower Duwamish Waterway Source Control Investigation (SAIC 2013).

Section 2: Remedial Investigation (RI) Objectives and Approach

The principal objective of the RI is to characterize the nature and extent of chemically-impacted soil, groundwater, surface water, soil vapor, and indoor air at the Site and evaluate the potential risks those chemicals pose to human health and the environment, especially the Duwamish Waterway. Additionally, the vapor intrusion (VI) exposure pathway will be evaluated to determine whether chemicals present in the soil and groundwater may be impacting indoor air quality within the onsite buildings.

The objective for further groundwater characterization is to define the lateral and vertical extent of impacted groundwater at the Site and to assess whether impacted groundwater is migrating offsite toward the Duwamish Waterway. Previous investigations have yielded soil and groundwater analytical results for the Site. However, the available data may not accurately reflect current site conditions. To augment the existing data set, additional groundwater and soil sampling is warranted. Limited groundwater reconnaissance sampling will be performed prior to installation of permanent groundwater monitoring wells. Rationale for reconnaissance drilling and sampling locations is presented in Appendix A. The additional sampling will supplement the existing data set in the following ways:

- Confirming the general distribution of metals and solvent concentrations in groundwater is consistent with historical results.
- Defining the vertical and lateral extent of groundwater bearing soils across the Site, establishing a better understanding of Site hydrogeology and lithology of Site soils.
- Defining groundwater hydraulic conditions, including flow gradients, saturated thickness, and tidal influence, and determining whether additional hydraulic data are needed to select a remedial alternative for the FS.
- Developing an understanding of the hydraulic connection of Site groundwater to the Duwamish Waterway.

The groundwater investigation will consist of reconnaissance groundwater sampling, sampling of existing monitoring wells, and installation and sampling of new permanent groundwater monitoring wells (both in shallow zone and deeper till zone) to assess the presence of impacted groundwater. Additionally, characterization of hydraulic conditions will be performed as part of the RI, as needed. Hydraulic characterization will include:

- Evaluating stratigraphic conditions to assess lateral continuity of saturated units.
- Measuring water levels to assess the magnitude and direction of the hydraulic gradient and assumed direction of groundwater flow.
- Assessing the vertical hydraulic gradient and relationship between the shallow zone and the deeper till zone at the Site through the installation of paired wells.

- Performing slug test(s) or pumping tests to assess the hydraulic conductivity of the saturated zone(s), as needed.

Reconnaissance groundwater sampling and an initial evaluation of shallow stratigraphic conditions will be performed primarily using direct-push drilling/sampling techniques. A description of general subsurface soil boring and sampling procedures is provided in Kennedy/Jenks Consultants Standard Operating Guidelines (SOGs) presented in Appendix B. Findings during the reconnaissance groundwater sampling and soil investigation will be used to select locations for permanent groundwater wells. A description of general procedures for groundwater well construction and development, measuring groundwater levels, groundwater sampling, and slug test(s) is included in Kennedy/Jenks Consultants SOGs presented in Appendix B.

The objective of indoor air and sub-slab soil vapor sampling at the Site is to evaluate the VI exposure pathway for the current overlying building at the Site. Chemicals present in soil and groundwater may be present in the vapor phase as well. Soil vapor can enter overlying structures at the Site through the foundation floor or through utility conduits. Volatile organic compounds (VOCs), specifically TCE, have been confirmed present in soil and groundwater beneath the overlying building, and during previous field investigation activities, TCE has been detected in soil vapor and indoor air. Limited sampling of indoor air, paired with sub-slab soil vapor, is warranted to evaluate this exposure pathway at the Site. Indoor air sampling will provide the following information:

- Evaluate whether TCE and its daughter products present in the soil and groundwater are diffusing into the vadose zone as soil vapor and accumulating beneath the existing concrete slab.

- Evaluate whether VI of VOCs may pose an adverse risk to occupants of onsite building(s).

The VI investigation will consist of collecting three vapor samples; one in the breathing space of the building, one of ambient air located outdoors (at an upgradient location), and one from a sub-slab vapor sampling port to be installed beneath the building by drilling through the existing concrete slab. Sampling will be completed in general accordance with Ecology's Draft *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009).

Further description about soil vapor and air sampling procedures is provided in Kennedy/Jenks Consultants SOGs in Appendix B.

Section 3: Scope of Work

The scope of work for this investigation includes the following general tasks:

- Site reconnaissance and mapping of underground utility and former sub-surface chemical use features.
- Inspect and survey the existing monitoring wells and assess their suitability for use in this investigation.
- Conduct an initial water level monitoring event to evaluate the direction of the hydraulic gradient at the Site.
- Collect groundwater samples from existing monitoring wells suitable for use.
- Soil and reconnaissance groundwater sampling using direct-push soil sampling techniques at up to 20 onsite locations (proposed soil boring locations are shown on Figure 1 and discussed in Appendix A). Reconnaissance groundwater samples will be collected in the upper saturated unit, where conditions permit, and may be conducted in two separate phases of field investigation.
  - A subset of these sampling locations (approximately three to five locations) will be located offsite between the Site and the Duwamish Waterway to characterize potential offsite migration downgradient of the Kaspac/Chiyoda property.
- Install and develop up to four new shallow monitoring wells, and up to two new deeper monitoring wells. The need for and location of the new wells will be determined based on the results of the soil and reconnaissance groundwater sampling activities described above and in areas to assess possible migration of metals and solvents.
- Collect groundwater samples from new and existing monitoring wells on a quarterly basis for four events. (Note: New monitoring wells may only be sampled during three quarterly events).
- Sub-slab soil vapor and indoor air sampling at the current warehouse building.
- Analysis of soil, groundwater, and air samples for constituents of concern (COCs).

Specific field activities related to the implementation and performance of these tasks are described below.

3.1 Field Activities

Prior to invasive activities, a private utility survey will be performed to evaluate the potential for underground utilities at each proposed soil boring/well location. The utility survey will augment existing information provided by the property owner and public Utility Notification Center (One-Call). A One-Call utility locate request will be made at least 2 business days prior to intrusive sampling activities, and a private utility locator will be contracted to identify other potential underground utilities present at the Site, and assist in locating accessible and appropriate sub-slab soil vapor sampling locations beneath the existing building.

A site Health and Safety Plan (HASP) that documents the specific procedures to be used to protect the health and safety of Kennedy/Jenks Consultants personnel during the site investigation is presented in Appendix C.

3.2 Site Reconnaissance and Survey

Site reconnaissance and survey activities will be conducted prior to drilling or sampling activities. Groundwater monitoring wells will be individually visited to confirm location and access, and top of casing and ground surface will be surveyed. Survey activities will be conducted by a surveying contractor and overseen by Kennedy/Jenks Consultants field staff.

Additional site reconnaissance will be conducted to identify and map the location of underground or overhead utilities, as marked or observed at the Site, and to review the current status of several site features previously identified as possible source areas or areas of concern. Such features will be mapped/surveyed, if appropriate. These features include the following:

- Tank 7 and the deep sump vault – determine whether these features are still present or how they may have been closed/decommissioned and whether they may pose a source to future groundwater contamination.

- Former scrubber room – review configuration, current use, and conditions near the former holding tank.

- Site perimeter – identify and map catch basins or other drainage features.

- Former test pit located near previously drilled location GP05 – determine whether the pit has been filled, covered, or otherwise removed from service.

- Visual survey of concrete slab – identify locations of concrete patches, cuts, drains, or cracks.

- Drainage ditch reconnaissance – identify drainage inlets/outlets in the ditch, as well as locations with standing water, groundwater seeps, or other features of interest.

3.3 Soil Investigation

Subsurface soil investigation will be performed using direct-push drilling and sampling techniques to collect continuous core soil and reconnaissance groundwater samples. Direct-push sampling is performed by hydraulically pushing a drive rod against the weight of the sampling vehicle or by hydraulic hammering, depending on the penetration resistance. The drive rod will be fitted with a continuous soil coring devise to characterize the vertical soil column at each sampling location. Attempts will be made to advance each probe boring from ground surface until refusal or the top of glacial till, whichever is encountered first. The top of the glacial till unit is anticipated to occur at approximately 20 feet bgs. Multiple interconnected perched groundwater-bearing units may be present.

Direct-push sampling and borehole logging will be conducted in accordance with procedures outlined in Kennedy/Jenks Consultants SOGs provided in Appendix B.

Soil samples will be collected continuously during advancement of the probe borings (continuous coring). Grab soil samples of the cores will be collected for field screening purposes, including:

- Visual assessment of the soil conditions, soil type logging, and documentation of visible stains and odors.
- Water/hydrocarbon sheen testing.
- VOC head-space screening.

Based on field screening and observations, at least one, and possibly more, soil samples will be submitted for chemical analysis from each boring. Field screening techniques and the laboratory analyses that will be performed are identified in Summary of Soil Sampling and Analysis Plan table below.

One groundwater grab sample will be collected from each direct-push borehole. The specific details for groundwater sampling and analysis are discussed in further detail in Section 3.4, Groundwater Investigation.

Soil samples will be packaged and handled in accordance with SOGs provided in Appendix B. Following completion of sampling, the boring will be abandoned by backfilling the borehole with bentonite chips.

Soil samples will be submitted for chemical analyses, which may include total petroleum hydrocarbons as oil- and diesel-range hydrocarbons by Northwest Total Petroleum Hydrocarbon Method NWTPH-Dx; metals by U.S. Environmental Protection Agency (EPA) Method 6010C; hexavalent chromium by EPA Method 7196A; and VOCs, including TCE and TCE degradation products (specifically 1,2-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride), using EPA Method 8260B. Soil samples for chemical analysis will be stored in a cooled ice chest pending transportation to a certified analytical laboratory under chain-of-custody protocol.

A summary of soil sampling and analyses to be performed is tabulated below. The quality assurance/quality control (QA/QC) samples to be collected during each field sampling activity and the data quality objectives (DQOs) are presented in Table 1, attached. Soil sampling and analysis will be conducted in accordance with the Quality Assurance Project Plan (QAPP) presented in Appendix D.

Table 1: Summary of Soil Sampling and Analysis Plan

Sample Type	Number of Samples	Field Screening	Laboratory Analyses
Soil	Up to 24 locations ~1 sampling depth	HS, ST, VI	NWTPH-Dx
Soil	~24 locations ~1 sampling depth	HS, ST, VI	Hexavalent Chromium
Soil	~24 locations ~1 sampling depth	HS, ST, VI	Metals (As,Cr, Pb & Se)
Soil	~24 locations ~1 sampling depth	HS, ST, VI	VOCs (TCE + degradation products)

Notes:

HS = headspace VOC screening for soils
ST = water/hydrocarbon sheen test for soils
VI = visual inspection of soils
NWTPH-Dx = Northwest Total Petroleum Hydrocarbons Analytical Method for diesel and semi-volatile petroleum products
TCE = trichloroethene
Degradation products = 1,2-Dichloroethene, Vinyl Chloride, cis-1,2-Dichloroethene, and trans-1,2-Dichloroethene
Field duplicate and matrix spike/matrix spike duplicate QA/QC samples will be collected at a rate of 5 percent each, or one in 20 samples.

3.4 Groundwater Investigation

As discussed above, both reconnaissance groundwater sampling and standard monitoring well sampling techniques will be used to meet the objectives for groundwater investigation.

Reconnaissance groundwater sampling will consist of collecting grab groundwater samples from either the uppermost saturated zone and/or the deeper saturated zone (if the uppermost zone is not present or has low hydraulic conductivity) without installing permanent monitoring wells. Reconnaissance groundwater sampling will be performed during direct-push drilling, which will include the insertion of plastic tubing through the center of the drive rod once the target sampling depth has been reached. A minimum of approximately 1/2 gallon of groundwater will be purged using a peristaltic pump. After purging, a grab groundwater sample will be collected (using the peristaltic pump) and transferred to the appropriate sample containers in accordance with the groundwater sampling SOG in Appendix B. Analyses for reconnaissance groundwater samples are identified in the Summary of Reconnaissance Groundwater sampling and analysis Plan (Table 2) below. Following completion of sampling, the boring will be abandoned by backfilling the borehole with bentonite chips.

The locations for permanent groundwater monitoring wells will be identified during the field investigation based on field screening conducted during the advancement of soil borings across the site. Up to four additional shallow monitoring wells and up to two deep monitoring wells will be constructed of 2-inch schedule 40 polyvinyl chloride (PVC) well construction materials with pre-packed well screens. The general procedures (e.g., drilling, sampling, and logging) used for construction and development of monitoring wells are presented in the SOGs in Appendix B. Monitoring wells will be constructed in accordance with Washington Administrative Code

(WAC) 173-160, *Minimum Standards for Construction and Maintenance of Wells* (Ecology 2008), and SOGs provided in Appendix B.

The wells will be installed using hollow stem auger or sonic drilling techniques. Lithologic information collected during drilling activities will be uses to identify screening intervals and total well depth. In general, the new monitoring wells will be constructed with a minimum 5-foot section of factory slotted schedule 40 PVC well screen. A 0.010-inch slot size will be used for the screened portion of the well. Other well construction details are described in SOGs in Appendix B. Monitoring wells will be completed in accordance with the requirements of WAC Chapter 173-160-450. This includes sealing the annual space of each boring (approximately 2 inches in diameter) with granular bentonite hydrated with water. This sealing method used will result in a continuous and effective seal meeting the minimum sealing standards of WAC Chapter 173-160.

Following installation, each well will be developed to remove silt and sand from the well and filter pack. Well development will be performed by over-pumping with an aboveground centrifuge pump or submersible pump and surging with a surge block. Wells will be developed until the water is generally free of suspended sediment and water quality parameters (i.e., pH, specific conductivity, and temperature) have stabilized (variance of less than 20 percent). Wells will be allowed to stabilize for at least 24 hours prior to sampling. Additional details regarding well development are described in SOGs in Appendix B.

The vertical elevation (i.e., top of casing) of each monitoring well at the site will be surveyed to the nearest 0.01 foot relative to a referenced benchmark. Well survey activities will be conducted by a Washington State licensed surveyor. Newly constructed, as well as the currently existing, monitoring wells are recommended for inclusion in survey activities, which may be conducted over two surveyor mobilizations.

Monitoring wells, including new and existing monitoring wells, will be sampled to evaluate water quality conditions at the Site over four quarterly monitoring events. Groundwater samples will be collected using a peristaltic pump with the bottom of the intake tube positioned near the top of the well screen interval. The tube intake position is intended to maximize the potential for the entire well screen interval to be represented in the sample. Wells will be purged at a slow rate [less than 0.25 gallon per minute (gpm)] to minimize sample turbidity until field parameters (pH, temperature, and conductivity) are stabilized (approximately three casing volumes). Sampling purge water will be contained in 55-gallon drums and retained on the property pending disposal.

Groundwater samples will be submitted for chemical analysis of hexavalent chromium by EPA Method 7196A, total metals (As, Cr, Pb, and Se) by EPA Methods 200.8 and 245.1, and VOCs using EPA Method 8260B Samples may also be analyzed for total petroleum hydrocarbons as oil- and diesel-range hydrocarbons by NWTPH-Dx if field indications of petroleum impact are observed. Groundwater samples for chemical analysis will be stored in a cooled ice chest pending transportation to a certified analytical laboratory under chain-of-custody protocol.

A summary of groundwater sampling and analyses to be performed is tabulated below. The QA/QC samples to be collected during each field sampling activity and the DQOs are presented below in Table 2 and Table 3. Groundwater sampling and analysis will be conducted in accordance with the QAPP presented in Appendix D.

Table 2: Summary of Reconnaissance Groundwater Sampling and Analysis Plan

Sample Type	Number of Samples	Field Screening	Laboratory Analyses
Groundwater	–up to 18[(a)]	N/A	NWTPH-Dx
Groundwater	18	N/A	Hexavalent Chromium
Groundwater	18	N/A	Metals
Groundwater	18	N/A	VOCs

Notes:

N/A = not applicable

(a) Diesel-range petroleum hydrocarbon analysis will be conducted if field indications of petroleum impact are observed.

Field duplicate and matrix spike/matrix spike duplicate QA/QC samples will be collected at a frequency of 5 percent each, or one in 20 samples.

Table 3: Summary of Standard Monitoring Well Groundwater Sampling and Analysis Plan

Sample Type	Number of Samples/Qtr	Field Screening	Laboratory Analyses
Groundwater	up to 6*	N/A	NWTPH-Dx
Groundwater	15	N/A	Hexavalent Chromium
Groundwater	15	N/A	Metals
Groundwater	15	N/A	VOCs

Notes:

N/A = not applicable

(a) Diesel-range petroleum hydrocarbon analysis will be conducted if field indications of petroleum impact are observed.

Field duplicate and matrix spike/matrix spike duplicate QA/QC samples will be collected at a frequency of 5 percent each, or one in 20 samples.

3.5 VI Investigation

The VI investigation will consist of collecting three vapor samples; one in the breathing space of the building, one at an outdoor upgradient location, and one in the sub-slab space below the building. Sampling will be completed in general accordance with Ecology's Draft *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Ecology 2009).

The indoor air sample will be collected from the building in the areas of previously or newly detected VOCs in soil and/or groundwater above Model Toxics Control Act (MTCA) Method A cleanup levels. The occupants of the buildings will be requested to suspend certain activities, if possible, such as smoking, use of sprays, solvents, paints, etc., 24 to 48 hours prior to sampling and during indoor air sampling activities. Occupants will be asked to keep windows and doors shut as much as possible during sampling; however, traffic in and out of the building may not be able to be controlled.

During sample collection, the sample canister will be placed within the structure at the identified locations. If it is possible to determine the possible point of entry for vapors from the ground surface beneath the structure based on the information obtained during the survey, the indoor air sample location(s) may be modified to sample near a suspected point of entry. Samples will be collected from the breathing zone, approximately 3 to 5 feet above the floor. Sampling locations adjacent to windows and other potential outdoor air entry points will be avoided. Before sample collection, the current building occupant will be interviewed and a questionnaire may be completed to inventory items that may influence indoor air quality.

A background, ambient air sample will be collected from an outdoor, upgradient locations concurrently with collection of indoor air samples. Efforts will be made to conduct sampling activities during dry weather conditions. The ambient air sample will be collected and analyzed in a manner consistent with indoor air samples.

Indoor air samples will be collected using certified 1- or 6-liter Summa™ canisters, and flow controllers will be obtained from the analytical laboratory. Air pumps will not be used with the canisters. The analytical laboratory will calibrate flow controllers for a 24-hour sample, or an alternate sampling interval, as agreed upon with the owner/operator. Soil vapor and air samples will be collected in accordance with the procedures outlined in SOGs in Appendix B.

When collecting 24-hour samples, the final vacuum of the canister should be 5 inches of mercury (in. Hg) or greater. If insufficient differential pressure is present, the flow through the controller will decrease as the canister pressure approaches ambient. Normal fluctuations in the flow rate during sampling due to changes in ambient temperature, pressure, and diaphragm instabilities will result in a final vacuum range between 2 and 10 in. Hg. The analytical laboratory will be notified of pressure (or elevation at the sample location) at the time the equipment is ordered, so the flow controller can be adjusted accordingly.

Samples collected for this VI investigation will be submitted to the analytical laboratory as described in the SOGs in Appendix B, and will be analyzed for VOCs (consisting of the full EPA Method TO-15 analyte list).

Indoor air sampling and analysis will be conducted in accordance with the QAPP presented in Appendix D.

A summary of indoor air sampling and analyses to be performed is presented in Table 4 below, including a summary of QA/QC sampling frequency and the DQOs.

Table 4: Summary of Indoor Air Sampling and Analysis Plan

Sample Type	Number of Samples	Laboratory Analyses	DQOs	QA/QC Frequency
Ambient Air	1	VOCs by EPA Method TO-15	chemical specific[(a)]	Field duplicates (none). Trip blanks (none).
Indoor Air and Sub-Slab Vapor	Up to 2	VOCs by EPA Method TO-15	chemical specific[(a)]	

Note:

(a) Refer to Table B-1 of Ecology's Draft *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* for chemical specific cleanup levels. Laboratory reporting limits should meet Method B (Unrestricted Land Use) Screening Levels for Potential VI Contaminants of Concern to the extent practicable based on individual laboratory capabilities (Ecology 2009).

Sub-slab soil vapor sampling and analysis will be conducted in accordance with the QAPP presented in Appendix D. A sub-slab soil vapor sample will be collected from a location adjacent to the indoor air sampling point; however, the sample intake will be located beneath the concrete slab in fill material. A semi-permanent soil vapor sampling port will be installed in the concrete floor with a seal to minimize infiltration from ambient air. The sampling port will be enclosed in a shroud, and helium tracer gas used within the shroud to minimize the influence of ambient air during collection of the sub-slab vapor sample.

A summary of indoor air sampling and analyses to be performed is presented in the table below, including a summary of QA/QC sampling frequency and the DQOs.

3.6 Laboratory Analyses

Soil and groundwater samples will be submitted under standard chain-of-custody protocol to Analytical Resources, Inc (ARI) of Seattle, Washington, (or equivalent laboratory) for analysis and will be analyzed on a standard turn-around basis (approximately 3 weeks).

Soil vapor and/or indoor air samples will be submitted under standard chain-of-custody protocol to H&P Mobile Geochemistry (H&P) of Carlsbad, California, (or equivalent laboratory) for analysis and will be analyzed on a standard turn-around basis (approximately 3 weeks).

Laboratory analyses will be conducted in accordance with the QAPP presented in Appendix D.

Section 4: Decontamination Procedures

Decontamination of sampling equipment helps minimize cross-contamination among sampling locations and helps ensure the integrity of samples collected at each sampling location. Equipment decontamination will vary depending on equipment used. Equipment decontamination procedures that will be followed by Kennedy/Jenks Consultants personnel and its subcontractors are detailed in the SOGs provided in Appendix B.

Section 5: Control of Investigation-Derived Wastes

Because wastes derived during this investigation may be contaminated, it will be containerized pending receipt of analytical results. Investigation-derived wastes include purge water from groundwater monitoring well development and sampling, soil cuttings from boreholes (if any), and decontamination wastes. These materials will be placed in U.S. Department of Transportation (DOT)-approved 55-gallon drums and temporarily stored onsite. All drums will be labeled with its contents, the date and origin/location of collection, and level of personal protective equipment used during waste production (e.g., Level D).

Final disposal of the investigation-derived wastes will be completed by Kennedy/Jenks Consultants on behalf of Ecology. Handling and disposal of investigation-derived waste procedures that will be followed by Kennedy/Jenks Consultants personnel and its subcontractors are described in the SOGs presented in Appendix B.

References

Maul Foster Alongi. 2005. Preliminary Soil and Groundwater Site Assessment Report. 5 August 2005.

Maul Foster Alongi. 2005. Work Plan for Soil and Groundwater Supplemental Remedial Investigation. 23 November 2005.

Maul Foster Alongi. 2006. Supplemental Remedial Investigation. 22 February 2006.

Maul Foster Alongi. 2008. Final Remedial Investigation and Risk Assessment Report. 21 July 2008.

Maul Foster Alongi. 2011. Final Feasibility Study. 3 March 2011.

M&M Environmental. 1990. Letter to Judith M. Aitken regarding Precision Engineering, Inc. Status on the Department of Ecology's Site Register Toxics Cleanup Program Listing. 4 December 1990.

Precision Engineering, Inc. 1993. Independent Remedial Action Report. 21 July 1993.

SAIC. 2013. Lower Duwamish Waterway RM 3.8 to 4.2 West Sea King Industrial Park Summary of Existing Information and Identification of Data Gaps. May 2013.

United States Geolgical Survey. 1995. Occurrence and Quality of Ground Water in Southwestern King County, Washington. Woodward, D.G., Packard, F.A., Dion, N.P., and Sumioka, S.S. USGS Water Resources Investigations Report 92-4098.

United States Geolgical Survey. 2005. The Geologic Map of Seattle – a Progress Report. Troost, K.G., Booth, D.B., Wisher, A.P., and Shimel, S.A. Prepared by USGS, City of Seattle, and Universtiy of Washington Department of Earth and Space Sciences. Prepared for the 5th Washington Hydrogeology Symposium. April 2005.

Washington State Department of Ecology. 2007. Model Toxics Control Act Statute and Regulation. Publication No. 94-06. Revised November 2007.

Washington State Department of Ecology. 2008. Minimum Standards for Construction and Maintenance of Wells, Chapter 173-160 WAC. Publication No. 08-11-051. 19 December 2008.

Washington State Department of Ecology. 2009. Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, Review Draft. Publication No. 09-09-047. October 2009.

Figure

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Map Source: Maul Foster & Alongi. Final Feasibility Study, Former Precision Engineering, Inc., Site. March 3, 2011.
Imagery Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Legend

- Existing Deep Monitoring Well
- Existing Geoprobe Boring
- Existing Shallow Monitoring Well
- Prior Reconnaissance Groundwater Sampling Location
- Proposed Phase I Geoprobe Boring for Reconnaissance Groundwater Sampling
- Potential Phase II Geoprobe Boring for Reconnaissance Groundwater Sampling
- Approximate Parcel Boundary
- Approximate Electrical Line
- Approximate Water Line
- Approximate Sewer and Drainage Line

Notes:

1. All locations are approximate

N

100 50 0 100 Feet

Kennedy/ Jenks Consultants

Precision Engineering Facility
Seattle, Washington

Reconnaissance Soil and Groundwater Sampling Locations

Figure 1

K/J Project Number 1396024.00

Appendix A

Rationale for Reconnaissance Drilling and Sampling Locations

Appendix A: Rationale for Reconnaissance Drilling and Sampling Locations

In December 2013, Kennedy/Jenks Consultants prepared a Draft Technical Memorandum which identified potential data gaps to be considered in the development of a Remedial Investigation work plan. The following table describes individual sampling locations proposed on Figure 1 and identifies location-specific field sampling protocol to address many of those potential data gaps at the former Precision Engineering facility (Site) located at 1230 South Director Street, Seattle, Washington.

Table A1: Summary of Locations and Sampling Protocol

Location	Target Depth	Soil Sampling Protocol	Groundwater Sampling Protocol	Purpose of Location
SB1 through SB4	Refusal or upon encounter of competent glacial till	• Sample at approximately 16 feet to 20 feet below ground surface (bgs). Analyze for arsenic, chromium, lead, selenium, hexavalent chromium (Cr VI), and volatile organic compounds (VOCs). If field indications of hydrocarbons are observed, also analyze for diesel-range hydrocarbons.	• Grab groundwater sample from at least 16 feet bgs. Analyze for arsenic, chromium, lead, selenium, Cr VI, and VOCs. • Analyze groundwater for diesel-range hydrocarbons if field indications of hydrocarbons are observed. • Measure static groundwater level prior to sample collection with an oil/water interface meter.	• Characterize groundwater quality and flow conditions near southern property line. • Characterize lithology of shallow soils.
SB5 through SB9	Refusal or upon encounter of competent glacial till	• Sample at approximately 16 feet to 20 feet bgs. Analyze for arsenic, chromium, lead, selenium, Cr VI, and VOCs. If field indications of hydrocarbons are observed, also analyze for diesel-range hydrocarbons.	• Grab groundwater sample from at least 16 feet bgs. Analyze for arsenic, chromium, lead, selenium, Cr VI, and VOCs. • Analyze groundwater for diesel-range hydrocarbons if field indications of hydrocarbons are observed. • Measure static groundwater level prior to sample collection with an oil/water interface meter.	• Characterize groundwater quality and flow conditions near eastern property line. • Characterize lithology of shallow soils • Characterize groundwater leaving the property.

Notes:

Additional analytes may be appropriate based on field observations.

- Analysis of diesel-range hydrocarbons may be added for soil or groundwater samples if field screening identifies either a hydrocarbon-like sheen or odor.
- Analysis of VOCs may be added for soil or groundwater samples if field screening with a PID identifies elevated headspace readings.
- If yellow-stained soils are encountered, at least one soil sample should be collected from stained soil, and one soil sample should be collected from 6 inches to 12 inches below the base of soil staining. These soil samples should be analyzed for Cr VI and metals (As, Cr, Pb and Se).

Additional locations may be identified during the first phase of Geoprobe investigation.

Drilling locations and analytical protocol for a second phase of Geoprobe investigation will be determined based on observations and analytical findings during the first phase of Geoprobe investigation. The second phase investigation will include some offsite drilling and sampling of shallow groundwater at locations downgradient of the former Precision Engineering facility.

Appendix B

Standard Operating Guidelines

Standard Operating Guideline
Borehole Logging

Introduction

This Standard Operating Guideline (SOG) provides the procedures typically followed by Kennedy/Jenks Consultants personnel for classifying soils and preparing boring logs and other types of soil reports. The purpose of this SOG is to facilitate the acquisition of uniform descriptions of soils encountered during borehole programs and to promote consistency in the logging practices used by Kennedy/Jenks Consultants personnel. This SOG provides guidance on procedures that are generally consistent with standard practices used to classify soils. Deviations from, and additions to, the procedures described herein may be appropriate based on project-specific objectives, site-specific conditions, and/or regulatory requirements. The user of this SOG should modify the sampling procedures used, as appropriate, to conform to the project-specific requirements and then document such deviations from this SOG in the project-specific documentation of subsurface exploration activities.

Borehole logging is the systematic observation and recording of geologic and hydrogeologic information from subsurface borings and excavations. The Unified Soil Classification System (USCS) (ASTM D2487-00) is used to identify, classify, and describe soils principally for engineering purposes, and is based on laboratory tests.

For field applications, ASTM D2488-06 (Visual-Manual Procedure) is used as the general guide adopted under this SOG.

Both ASTM D2487 and ASTM D2488 utilize the same group names and symbols. However, soil reports should state that boring logs are not formal USCS laboratory determinations, but are based on the visual-manual procedures described in ASTM D2488.

This SOG contains the following sections:

- Field Equipment/Materials
- Typical Procedures
  - Soil Classification
  - Classification of Coarse-Grained Soil
  - Classification of Fine-Grained Soil including Organic Soils
- Other Logging Parameters
- Logging Refuse
- References.

Field Equipment/Materials

Material/equipment typically required for classifying soils and preparing boring logs may include:

- Pens, pencils, waterproof pens, and field logbook or other appropriate field forms (e.g., boring log forms), water-tight field case.
- Daily inspection report forms

- USCS (ASTM D 2488-06) table and classification chart
- Soil color chart (i.e., Munsell) If used, the edition of the Munsell chart should be specified on each borehole log as the color descriptions and hue, color values and chromas have changed between editions. Also, whenever possible, the newest version of Munsell's color charts should be used due to fading of color chips over time.
- American Geological Institute (AGI) Data Sheets
- Graph paper
- Engineer's scale
- Previous project reports and boring logs (if available)
- Pocket knife or putty knife
- Hand lens
- Supply of clean water
- Dilute hydrochloric acid (HCl) (make sure and MSDS for HCl is included in the project HASP)
- Aluminum foil, Teflon® sheets, and paper towels
- Sample containers (brass, stainless steel or aluminum liners, plastic or glass jars)
- Clean rags or paper towels
- Sample shipping and packaging supplies
- Personnel and equipment decontamination supplies
- Personal protective equipment as described in the Health and Safety Plan (HASP).

Typical Procedures

Soil classification and borehole logging should be conducted by a qualified geologist, engineer or other personnel trained and experienced in the classification of soils.

Soils are typically logged in conjunction with advancing boreholes and sampling subsurface soils. Although the guideline focuses on classifying soil samples obtained from boreholes, this particular procedure also applies to soils and sediments collected using other techniques (e.g., post hole digger, scoop, Ekman, Ponar, or Van Veen grab samplers, and backhoe).

The USCS as described in ASTM D2488-06 categorizes soils into 15 basic group names, each with distinct geologic and engineering properties. The following steps are required to classify a soil sample:

1. Observe basic properties and characteristics of the soil. These include grain-size grading and distribution and influence of moisture on fine-grained soil.
2. Assign the soil a USCS classification and denote it by the standard group name and symbol.
3. Provide a written description to differentiate between soils in the same group, if necessary.

Many soils have characteristics that are not clearly associated with a specific soil group. These soils might be near the borderline between groups, based on either grain-size grading and distribution, or plasticity characteristics. In this case, assigning dual group names and symbols might be appropriate (e.g., GW-GC or ML-CL).

The two basic soil groups are:

1. **Coarse-Grained Soils –** For soils in this group, more than half of the material is larger than No. 200 sieve (0.074 mm).
2. **Fine-Grained Soils (including Organic Soils) –** For soils in this group, one half or more of the material is smaller than No. 200 sieve (0.074 mm).

Note: No. 200 sieve is the smallest size that can be seen with the naked eye.

Classification of Coarse-Grained Soils

Coarse-grained soils are classified on the basis of:

1. Grain size and distribution
2. Quantity of fine-grained material (i.e., silt and clay)
3. Character of fine-grained material

Classification uses the following symbols:

Basic Symbols	**Modifying Symbols**
G - gravel	W - well graded
S - sand	P - poorly graded
	M - with silt fines
	C - with clay fines

The following are basic facts about coarse-grained soil classification:

- The basic symbol G is used if the estimated volume percentage of gravel is greater than that for sand. In contrast, the symbol S is used when the estimated volume percentage of sand is greater than the percentage of gravel.
- Gravels include material in the size range from 3 inches to 0.2 inches (i.e., retained on No. 4 sieve). Sand includes material in the size range from 0.2 inches to 0.003 inches. Use the grain size scale used by engineers (ASTM Standards D422-63 and D643-78) to further classify grain size as specified by the USCS.
- Although not specifically treated in ASTM D2488-06, cobbles range in size from 3 inches to 10 inches and boulders refer to particles with a single dimension greater than 10 inches. They are included here for the purpose of completeness and for their hydrogeologic significance.
  Note: The ASTM grain size scale differs from the Modified Wentworth Scale used in teaching most geologists. Also, it introduces a distinction between sorting and grading (i.e., well graded equals poorly sorted and poorly graded equals well sorted.)
- The modifying symbol W indicates good representation of a range of particle sizes in a soil.
- The modifying symbol P indicates that there is a predominant excess or absence of particle sizes.

- The symbol W or P is only used when a sample contains less than 15 percent fines.
- Modifying symbol M is used if fines have little or no plasticity.
- Modifying symbol C is used if fines have low to high plasticity (clayey)

The following rules apply for the written description of the soil group name:

Types of Soil	Rule
Sands and gravels (clean)	Less than 5 percent fines
Sands (or gravels) with fines	5 to 15 percent fines
Silty (or clayey) sands or gravels	Greater than 15 percent fines

- Other descriptive information may include:
  - Color (e.g., Munsell Soil Color chart, specify edition). Soil color is named and coded using the Munsell Soil Color chart if required for the project. The code should be in parentheses immediately following the written description. Presence of mottling and banding is also recorded. For example, "dk brn (7.5 YR, 3/4)."
  - Relative Density/Penetration Resistance. For cohesionless materials use very loose, loose, medium, dense, or very dense estimated from drive sample hammer blows or other field tests. Blow counts may be used, if reliable.
  - Maximum grain size (fine, medium, coarse, as described in AGI data sheets or USCS). Note the largest cross-sectional dimension measured in tenths of an inch for grains larger than sand size.
  - Composition of grains (mineralogy)
  - Approximate percentage of gravel, sand, and fines (use a percentage estimation chart as provided in the AGI data sheets)

Modifiers	Description
Trace	Less than 5 percent
Few	5 to 10 percent
Little	15 to 25 percent
Some	30 to 45 percent
Mostly	50 to 100 percent

  - Angularity (round, subround, angular, subangular)
  - Shape (flat or elongated)
  - Moisture Condition (dry, moist, wet)
    - Dry - Absence of moisture to the touch.
    - Damp - Contains enough water to keep the sample from being brittle, dusty or cohesionless; is darker in color than the same material in the dry state.
    - Moist - Leaves moisture on your hand, but displays no visible free water.
    - Wet - Displays visible free water.
  - HCl Reaction (none, weak, strong)
  - Cementation (Crumbles under finger pressure: weak, moderate, or strong)
  - Range of Particle Sizes (sand, gravel, cobble, boulder)
  - Maximum Particle Size (fine, medium, coarse)
  - Cementation (weak, moderate, or strong)
  - Hardness (breaks with hammer blow)
  - Structure (stratified, laminated, fissured, slickensided, blocky, lensed, homogeneous)
  - Organic material
  - Odor
  - Iridescent sheen (based on sheen test)
  - Debris (e.g., paper, wood, plastic, cloth, concrete, construction materials, etc.).

- o Additional Comments (e.g. roots or rootholes, difficult drilling, borehole caving, presence of mica, contact and/or bedding dip, bedding features, sorting, structures, fossils, cementation, geologic origin, formation name, minerals, oxidation, etc.

Classification of Fine-Grained Soils

Fine-grained soils are classified on the basis of:

1. Liquid limit

4. Plasticity

Classification uses the following symbols:

Basic Symbols	**Modifying Symbols**
M - silt	L - low liquid limit
C - clay	H - high liquid limit
O - organic	
Pt - peat	

The following rules apply for the written description of the soil group name:

Types of Soil	**Rule**
Silts and clays with sand and/or gravel	5 to 15 percent sand and/or gravel
Sandy or gravelly silts or clays	Greater than 15 percent sand and/or gravel

The following are basic facts about fine-grained soil classification:

- The basic symbol M is used if the soil is mostly silt, while symbol C applies if it consists mostly of clay. Use of symbol O indicates that organic matter is present in an amount sufficient to influence soil properties. The symbol Pt indicates soil that consists mostly of organic material.
- Modifying symbols are based on the following hand tests conducted on a soil sample:
  - Dry strength (crushing resistance : none, low, medium, high, very high)
  - Dilatancy (molded ball reaction to shaking: none, slow, rapid)
  - Toughness (resistance to rolling or kneading near plastic limit : low, medium, high)
  - Plasticity (nonplastic, low, medium, high).
- Soil designated ML has little or no plasticity and can be recognized by none to low dry strength, slow to rapid dilatency, and low toughness.
- CL (lean clay) indicates soil with medium plasticity, which can be recognized by medium to high dry strength, no or slow dilatency, and medium toughness.
- OL is used to describe an organic, fine-grained soil that is less plastic than CL soil and can be recognized by low to medium dry strength, medium to slow dilatency, and low toughness. In some cases, it may be possible to differentiate organic silts (OL) from organic clays (OH), based on correlations between dilatancy, dry strength, toughness, or laboratory tests.
- MH soil has low to medium plasticity and can be recognized by low to medium dry strength, no to slow dilatency, and low to medium toughness.
- Soil designated CH (fat clay) has high plasticity and is recognizable by its high to very high dry strength, no dilatency, and high toughness.

- OH is used to describe an organic fine-grained soil that is less plastic than CH soil and can be recognized by medium to high dry strength, slow dilatency, and low to medium toughness. In some cases, it may be possible to differentiate organic silts (OL) from organic clays (OH), based on correlations between dilatancy, dry strength, toughness, or laboratory tests.

Note: PT (peat) is used to describe a highly organic soil composed primarily of vegetable tissue with a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor.

- Other descriptive information includes:
  - Color (e.g., Munsell) Soil color is named and coded using the Munsell Soil Color chart if required for the project. The code should be in parentheses immediately following the written description. Presence of mottling and banding is also recorded. For example, "reddish brn (5YR, 4/4)."
    - Moisture condition,
  - Omit moisture terms below the regional water table and when drilling with mud or air-mist rotary systems.
  - Consistency (thumb penetration test: very soft, soft, firm, hard, very hard . For fine sediments use very soft, soft, medium, stiff, very stiff, and hard.) These are estimated from drive sample hammer blows or other field tests. Blow counts may also be used, if reliable.
    - Structure (same descriptors as coarse grain)
    - Compactness (loose, dense) for silts
    - Odor
    - Iridescent sheen (based on sheen test)
    - Debris (e.g., paper, wood, plastic, cloth, concrete, construction materials, etc.).
    - HCl Reaction (none, weak, strong).
  - Additional Comments (e.g. roots or rootholes, difficult drilling, borehole caving, presence of mica, , contact and/or bedding dip, bedding features, cementation, structures, fractures, fracture fillings, fossils, formation name, minerals, oxidation).

Fine-Grained Rock Description

- Textural Classification
- Color. Rock color is named and coded using the Geological Society of America rock color chart. The code should be in parentheses immediately following the written description. Presence of mottling and banding is also recorded. For example, "gry grn (5G, 5/2)."
- Hardness. Very hard, hard, medium, soft, very soft..
- Moisture Content. Dry, damp, moist, wet (saturated).
- Size Distribution. Approximate percentage of gravel, sand, and fines (silt and clay).
- Estimated Permeability. Very low, low, moderate, or high. This is based primarily on grain size, sorting, and cementation. Estimate secondary permeability due to natural rock fractures when applicable.
- Miscellaneous. Odor, contact and/or bedding dip, cementation, bedding, inclusions, secondary mineralization, fossils, structures, formation name, and fractures.

- Fractures are identified by depth, angle, width, and associated mineralization if applicable. The interpretation of the fracture type (i.e., as natural [N], coring induced [CI], or handling induced [HI]) should be stated. For example, "NF @90.8', 25 deg to axis, 0.1" wide, minor calcite."
- Coarse-Grained Rock Description
- Textural Classification.
- Color. Rock color is named and coded using the Geological Society of America rock color chart. The code should be in parentheses immediately following the written description. Presence of mottling and banding also is recorded. For example, "gry olive grn (5GY, 3/2)."Hardness. Very hard, hard, medium, soft, very soft.
- Moisture Content. Dry, damp, moist, and wet (saturated).
- Size Distribution. Approximate percentage of gravel, sand, and fines (silt and clay).
- Grain Shape. Angular, subangular, subrounded, rounded, or well-rounded, for grains larger than sand size.
- Grain Size. The largest cross-sectional dimension measured in tenths of an inch for grains larger than sand size.
- Miscellaneous. Odor, contact and/or bedding dip, cementation, bedding, inclusions, secondary mineralization, fossils, structures, formation name, and fractures.
- Fractures are identified by depth, angle, width, and associated mineralization, if applicable. The interpretation of the fracture type (i.e., as natural [N], coring induced [CI], or handling induced [HI]), should be stated. For example, "NF @126.1', 35 deg to axis, 0.1" wide, minor calcite."

Other Logging Parameters

Rock Quality Designation

This designation generally follows ASTM D6032-08 Standard Test Method for Determining Rock (RQD) of Rock Core.

The RQD denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. This method is generally applied to core barrel samples.

Standard Penetration Tests

This method generally follows ASTM D1586-08A Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils. This method provides a means of assigning a relative density to the soil by counting the number of hammer blows (blow counts) required to advance a split-barrel sampler a specified distance into the undisturbed soil ahead of the lead auger. This method is not applicable to boreholes advanced with direct-push sampling equipment. It is used primarily in conjunction with hollow stem auger drilling apparatus as the test can be performed through the auger string without removal of the augers thereby allowing the borehole to remain open to the bottom of the drill string without risk of caving. As the sampler is advanced by the repeated drop of a hammer of known weight, the blow counts are recorded on the log and used to provide a relative density descriptor to the soil penetrated during the test.

The number of blows required to drive the sampler 6 in. by a 140-lb hammer falling 30 in. Fifty blow counts per 6-in drive is considered “refusal,” and sampling at this depth is usually terminated. In addition, a total of 100 blow counts per 18-in. drive, or no observed advance of the sampler during ten successive hammer blows, is also considered “refusal.” During coring, leave this section blank. Normally, the second and third 6-in. intervals are recorded and added as the number of blows per feet.

Sampler Type/Depth. Give sampler type by the letter code listed below and identify the depth at the top of the sampling interval in feet below ground surface (bgs).

Sampler type	Inside diameter(in.)	Code
Standard penetrometer	1.38	SP
Split-barrel (small)	2.0	SBS
Split-barrel (large)	2.5	SBL
HQ wireline core	2.3	PC

Those descriptors are as follows for coarse grained soils:

Very Loose	0 to 3 SPT Sampler	0 to 4 Mod CA Sampler
Loose	4 to 7 SPT Sampler	5 to 10 Mod CA Sampler
Medium Dense	8 to 23 SPT Sampler	11 to 30 Mod CA Sampler
Dense	24 to 38 SPT Sampler	31 to 50 Mod CA Sampler
Very Dense	> 38 SPT Sampler	>50 Mod CA Sampler

Relative Density Descriptors for fine grained soils are as follows:

Very Soft	<1 SPT Sampler	0 to 1 Mod CA Sampler
Soft	1 to 3 SPT Sampler	2 to 4 Mod CA Sampler
Firm	4 to 6 SPT Sampler	4 to 8 Mod CA Sampler
Stiff	7 to 12 SPT Sampler	8 to 15 Mod CA Sampler
Very Stiff	13 to 23 SPT Sampler	15 to 30 Mod CA Sampler
Hard	> 23 SPT Sampler	>30 Mod CA Sampler

Regardless of the degree of adherence to the ASTM Standard Method, split barrel samplers are used as the preferred method of undisturbed sample acquisition in a hollow stem auger drilling. Upon retrieval of the sampler from the borehole, the sampler should be opened without making contact with its interior contents and the logging personnel should record the percent recovery or length of the sample recovered. Sample containers should be removed with a clean gloved (gloves may not be needed, depending upon requirements of HASP) hand and placed in a clean, dry area for examination and logging. The sample will be described per the above. Any lithologic changes that may be observable in the exposed ends of the intact core over the sampled interval should be recorded on the log before any disturbance thereof. The depth of the lithologic changes should be estimated and recorded on the boring log. The least disturbed sample container of the two deeper six-inch sample increments should be secured with Teflon® or aluminum end sheets and snug fitting plastic end caps, sealed with silicon tape, depending upon testing, sampler may be filled with one inch rings instead of 6 inch. Sealing material should also be compatible with subsequent testing requirements.

Ambient Temperature Head-Space:

Organic vapor analyzers such as photoionization detectors (PIDs) or flame ionization detectors (FIDs) are generally used to assess the relative concentration of volatile hydrocarbons in the soil as the borehole is advanced and recorded as a value in parts per million on the boring log. This can be done by placing a uniform amount of soil in a Ziploc® bag, glass jar or other clean container, allowing the soil in the container to equilibrate to the ambient temperature, then inserting the probe of the PID or FID into the sealed container and recording the maximum PID or FID reading.

Non-Aqueous Phase Liquid (NAPL) Containing Soil

Appropriate observations of NAPL containing soil should include the following:

Appearance: If a separate phase liquid appears to be present, it might be described as “dark brown viscous fluid or liquid observed in the soil matrix.” This remark should follow the lithologic description in the borehole log. Observations of color should be made such as “black streaks” or “mottled gray to “olive brown”, however, it should not be inferred or remarked that the color is a necessary consequence of petroleum staining.

Odor: If the soil smells like petroleum it might be remarked that it has a “petroleum like” or “solvent like” odor. The use of terms like “strong” or “slight” should be avoided because there is no way to ensure that these terms can be applied uniformly in the field between various persons performing the logging (i.e. ,each persons olfactory sense is different). The use of terms like “chemical odor” should also be avoided as there is no common reference point. Notations regarding the type of petroleum distillate present (e.g., “diesel-like odor” or “gasoline odor”) are inappropriate as these are determination s that can only be accurately made by laboratory analysis.

Logging Refuse

This procedure applies to the logging of subsurface samples collected from a landfill or other waste disposal sites:

1. Observe refuse as it is brought up by the hollow stem auger, bucket auger, or backhoe.
2. If necessary, place the refuse in a plastic bag to examine the sample.

3. Record observations according to the following:
   a. Composition (by relative volume), e.g., paper, wood, plastic, cloth, cement, construction debris. Use such terms as "mostly" or "at least half." Do not use percentages.
   b. Moisture content: dry, damp, moist, wet.
   c. State of decomposition: highly decomposed, moderately decomposed, slightly decomposed, etc.
   d. Color: obvious mottling included.
   e. Texture: spongy, plastic (cohesive), friable.
   f. Odor.
   g. Combustible gas indicator readings (measure downhole).
   h. Miscellaneous: dates of periodicals and newspapers, degree of drilling effort (easy, difficult, very difficult).

References

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils. ASTM D1586-08A

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). ASTM D2488-06.

Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System. ASTM D2487-00

Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core. ASTM D6032-08.

Grain Size Scale Used by Engineers. ASTM D422-63 and ASTM D643-78.

Compton, R. R. 1962. *Manual of Field Geology*. New York: John Wiley & Sons, Inc.

U.S. Department of the Interior. 1989. *Earth Manual*. Washington, D.C.: Water and Power Resources Service.

International Society for Rock Mechanics. Commission on Classification of Rocks and Rock Masses. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. 1981, Vol. 18, pp. 85-110, Great Britain.

Standard Operating Guideline
Equipment Decontamination

Introduction

This guideline describes field procedures typically followed by Kennedy/Jenks Consultants personnel during the decontamination of sampling and monitoring equipment. Proper decontamination procedures minimize the potential for cross-contamination among sampling points on a single site or between separate sites.

Equipment

- Two or three containers (e.g., 5-gallon buckets, or 5- or 10-gallon plastic tubs) for dip rinsing, washing, and collection of rinse water.
- Two or three utility brushes or test tube brushes for removal of visible contamination. A test tube brush (or similar) can be stapled to the end of a dowel and used to clean the inside of a bailer.
- Non-phosphate Alconox, Liquinox, or trisodiumphosphate (TSP) to be mixed with potable or distilled water.
- Rinse solutions, such as methyl alcohol (methanol), dilute nitric acid (0.1 molar), deionized or distilled water, and/or tap water. Deionized water is preferable to distilled water because the deionization process typically results in greater removal of organic compounds as discussed below:

    Acid rinse (inorganic desorption) 10% nitric or hydrochloric acid solution reagent grade nitric or hydrochloric acid and deionized water (1% to be used for low carbon steel equipment).
    Solvent rinse (organic desorption isopropanol, acetone, or methanol; pesticide grade).
    Deionized water is preferable to distilled water because the deionization process typically results in greater removal of organic compounds.
- Multi-gallon storage containers filled with potable water to be used for rinsing or washing.
- Spray bottles, squirt bottles, or garden sprayers to apply rinse liquid. A separate bottle should be used for each liquid.
- Solvex or neoprene gloves that extend, as a minimum, halfway up the forearm. In cooler weather, it is advisable to use different resistant chemicals neoprene gloves that provide better insulation against cold temperatures.
- Paper towels to wipe off gross contamination.
- Garbage bags, or other plastic bags, and aluminum foil to wrap clean sampling equipment after decontamination, to store sampling equipment or and to dispose of decontamination debris.
- Sample bottles for rinsate blanks. For these blanks, Laboratory Type II (millipore) water should be used. Purified water from the selected analytical laboratory is recommended. This water is often filtered and boiled to remove impurities.
- DOT-approved container (e.g., 55-gallon drum) to store contaminated wash and rinse water. Contained decontamination should be labeled appropriately.
- Steamcleaner with power source and water supply.

Procedures

In most cases, the following procedures are adequate to remove contamination.

1. Preclean sampling equipment. If there is gross contamination on equipment, wipe it off with paper towels and/or rinse it off with water. Additional internal decontamination may be possible by circulation of water or cleaning solutions.
2. Wash all parts of equipment with detergent water and scrub with brushes. Take equipment apart when appropriate to remove visible contamination.
3. Steamclean sampling equipment. The steamcleaner is effective in removing contamination, especially volatile hydrocarbons. Steamcleaning is highly recommended in most cases and sometimes is the only method for decontaminating equipment that is grossly contaminated with hydrocarbons.
4. Rinse equipment by dipping in rinse solution, spraying, or pouring solution over it. Dip rinsing can introduce contaminants into solution. Spraying might not allow a thorough rinsing of the equipment, but it is a more efficient rinsing method because less rinse solution is used. Appropriate rinsing solutions are specified in the project sampling and analysis plan. Some typical solutions are indicated in the equipment section of this SOG.

    Methanol (used to remove organic compounds)

    Dilute acids (used to remove metals and other cations)

    Tap water

    Deionized/distilled water.

5. Rinse the sampler with generous amounts of deionized water. Pouring water over the sampler is best, although spraying or using a squirt bottle to apply rinse water might be adequate if you are trying to minimize waste.
6. Prepare rinsate blanks. To ensure proper decontamination, submit a rinsate blank for analysis. It is best to do this just before sampling. The blank should be analyzed for the same chemicals the samples are being checked for and for the chemical used to decontaminate equipment, if appropriate.

    [Note: The heading for this section indicates procedures to remove contamination.]

    To prepare a rinsate blank, pour millipore analyte-free water through or over the into the sampler. Collect the rinsate water in a clean bottle. Pour the collected rinsate water into the appropriate sample container(s). It is advisable to prepare one rinsate blank every day in the field. Use water specifically for blank preparation.

7. Wipe sampling equipment with a paper towel or allow it to air dry.
8. Place samplers in clean plastic bags or sealed containers, or wrap them in aluminum foil for storage in an undisturbed location that is free of contamination.

Investigation-Derived Residuals

For details of handling investigation-derived residuals refer to the project sampling and analysis plan.

Special Notes

- To reduce the potential for cross-contamination, samples should be collected so that the least contaminated stations areas are sampled first. Subsequent sampling should be completed in the order of increasing contamination. Areas that typically have lower levels of contamination include those upgradient of source, background areas, and the periphery of the contaminated area.
- Prepare rinsate blanks. To ensure proper decontamination, submit a rinsate blank for analysis. It is best to do this just before sampling. The blank should be analyzed for the same chemicals the samples are being checked for and for the chemical used to decontaminate equipment, if appropriate.
- To prepare a rinsate blank, pour analyte-free water through or into the sampler. Pour the collected rinsate water into the appropriate sample container(s). It is advisable to prepare one rinsate blank every day in the field. Use water specifically for blank preparation.
- Monitoring instruments that come into contact with sampled materials must be decontaminated, along with sampling devices. They should be washed, or at least rinsed before monitoring other sampling sites.
- As determined from analysis of rinsate blanks, decontamination using soap and water is adequate in removing detectable quantities of contaminants. This type of decontamination has been compared to laboratory procedures for decontaminating sampling bottles. Using methanol as a rinse does help in cases of contamination with organic compounds.

References

U.S. Environmental Protection Agency. 1987. *Handbook: Groundwater*. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio.

Washington Department of Ecology. 1982. *Methods for Obtaining Waste Samples*. Ch. 173-303 WAC. Washington State Department of Ecology, Olympia, Washington.

Standard Operating Guideline
Measuring Groundwater Levels

Introduction

This guideline describes the field procedure typically followed by Kennedy/Jenks Consultants when measuring groundwater levels. Groundwater levels in wells will be measured prior to commencing developing, purging, sampling, and pumping tests.

Equipment

- Electronic water level monitoring probe or other measuring device
- Decontamination supplies (e.g., buckets, Alconox, distilled water, squirt bottle)
- Field notebook
- Groundwater purge-and-sample form(s) if in conjunction with groundwater sampling
- Keys for locks (if necessary)
- Tools to open well covers (e.g., socket wrench, spanner wrench)
- Disposable gloves (as a minimum), and other protective clothing (as necessary).

Typical Procedure

1. If more than one well will be measured, begin depth measurement in the order in terms of lowest to highest chemical concentrations in the monitoring wells.
2. Remove well caps from all wells prior to initiation of water level measurement activities. This will allow wells to equilibrate, if necessary.
3. If the potential exists for floating product (LNAPL) to be present, use an electric oil-water interface probe or oil-sensitive paper to measure depth of the floating product and the electronic depth probe to measure the depth-to-water. Record both depths in field notebook and note the water depth as the "depth with oil layer present." Unless otherwise instructed, always measure depths to floating product layer and groundwater from the top of the north side of the well casing.
4. When floating product is not present, measure depth-to-water using a pre-cleaned water level probe from the top of the north side of the well casing, unless otherwise instructed.
5. Repeat measurements a minimum of three times or have field partner confirm measurement.
6. Record time of day the measurement was taken using military time (e.g., 16:00).
7. Decontaminate water level and/or oil-water interface probe and line prior to reuse (refer to SOG for Equipment Decontamination).

Standard Operating Guideline
Groundwater Sampling

Introduction

This Standard Operating Guideline (SOG) provides the procedures typically followed by Kennedy/Jenks Consultants personnel during the collection of groundwater samples from monitoring wells. Groundwater sampling from temporary boreholes (e.g., grab groundwater samples collected from direct push borings) is not addressed by this SOG. This SOG provides guidance on procedures that are generally consistent with standard practices used in environmental sampling. Federal, state and/or local regulatory agencies may require groundwater sampling procedures that differ from those described in this SOG and/or may require additional procedures. As guidance, this SOG does not constitute a specification of requirements for groundwater sampling. Deviations from, and additions to, the procedures described herein may be appropriate based on project-specific sampling objectives, site-specific conditions, and/or regulatory requirements. The user of this SOG should modify the sampling procedures used, as appropriate, to conform to the project-specific requirements and then document such deviations from this SOG in the project-specific documentation of groundwater sampling activities.

This SOG does not address Quality Assurance/Quality Control (QA/QC) procedures for groundwater sampling in detail. While some general QA/QC procedures are addressed, project-specific QA/QC procedures should be developed and presented in a Quality Assurance Project Plan (QAPP), field sampling and analysis work plan, or other project- or activity-specific document.

This SOG contains the following sections:

- Field Equipment/Material
- Typical Procedures for Monitoring Well purging and Groundwater Sampling
- Stabilization Criteria for Adequacy of Monitoring Well Purging
- Typical Procedures for Groundwater Sampling using Passive Diffusion Bags (PDBs)
- Quality Control Guidance
- Investigation-Derived Waste (IDW) Management
- References

Field Equipment/Materials

Material/equipment typically required for the collection of groundwater samples from monitoring wells may include:

- Electric water-level monitoring probe
- Multi-phase interface monitoring probe
- Bladder pump, peristaltic pump, pre-cleaned, disposable, 2- or 4-inch bailers with disposable cord, inertial pump, submersible pump, passive diffusion bags or other suitable apparatus for purging the well and sampling

- Flexible discharge tubing [polyethylene (PE), Teflon™, or similar]
- Purge water collection container
- Multi-parameter water quality meter (temperature, pH, specific conductance, redox potential)
- Turbidity meter
- Flow-through cell
- Nitrocellulose filters (if conducting field filtering)
- Sample containers (laboratory-supplied) with appropriate preservatives
- Additional chemical preservatives (if necessary)
- Watch or stopwatch
- Sample labels, pens, field logbook, or other appropriate field forms (e.g., groundwater purge and sample forms, chain-of-custody forms), and access agreements and third-party sample receipts (if warranted)
- Previous purging and sampling data for monitoring wells to be sampled, including water levels, purging parameters, and laboratory analysis results.
- Monitoring well boring and construction log (including wellhead elevation survey and reference point information)
- Personnel and equipment decontamination supplies
- Sample shipping and packaging supplies
- Personal protective equipment as specified in the Health and Safety Plan (HASP).

Typical Procedures for Monitoring Well Purging and Groundwater Sampling

1. **<u>Pre-Purging Data Collection and Purging Equipment Placement.</u>** Record the data and information collected during this procedure on a groundwater purge and sample form. Perform the following prior to groundwater sampling:
   a. Calibrate the multi-parameter water quality meter, prior to beginning sampling and as necessary based on field conditions, in accordance with the instructions in the manufacturer's operation manual. Note that it may be appropriate to keep a written log of the calibration procedures and an instrument maintenance with the instrument.
   b. Examine the monitoring well to be sampled and associated protective surface enclosure for any structural damage, poorly fitting caps, and leaks into the inner casing. If notable conditions exist, they should be recorded on the sampling log for the well so that any necessary follow-up corrective actions can be planned and implemented.
   c. Record an initial measurement of the depth to water. Calculate the volume of water in the well casing if wetted-casing-volume-based purging is to be used to remove the so-called "stagnant water" from the well prior to sampling. The volume of water in the wetted well casing should be calculated using the formula: $V = (\pi r^2) \times L$ where r is one half of the inner diameter of the well casing/screen and L is the length of wetted casing/screen (calculated by subtracting the depth to water from the total well depth). Total well depth should not be measured at the start of a sampling event (due to the potential to cause turbidity). Measure the total well depth after sample collection. Note that some regulatory agencies require that the calculated "stagnant water" volume include the water contained

in the pores space of the wetted portion of the monitoring well filter pack in addition to the casing/screen. If this is a requirement, it should be defined in the project-specific sampling requirements.

d. If light non-aqueous phase liquid (LNAPL) is potentially present, measure the depth and thickness of the LNAPL and the static water level using a multiphase interface monitoring probe. Use one of the following devices for purging:
e. Bladder pump: adjust the pump intake at a depth approximately equal to the middle or just slightly below the middle of the well screen interval or water column unless another position is justified based on site-specific conditions.
f. Peristaltic pump: place the pump intake at a depth equal to the approximate middle or just slightly above the middle of the well screen interval or water column unless another position is justified based on site-specific conditions. Note If degassing of water is occurring when sampling with a peristaltic pump, alternative types of sampling equipment should be used for volatile organic compound (VOC) or volatile petroleum hydrocarbon (VPH) sample collection.
g. Inertial pump: place the pump intake at a depth approximate to the middle or just slightly below the middle of the well screen interval or water column unless another position is justified based on site-specific conditions. Note: Some studies suggest that the use of inertial pumps for purging and/or sampling may produce a low bias when collecting samples for VOC and VPH analyses. This should be considered along with regulatory requirements when selecting an inertial pump for purging and/or sampling.
h. Submersible pump: place the pump intake at a depth approximate to the middle or just slightly below the middle of the well screen interval unless another position is justified based on site-specific conditions.
i. Pre-cleaned or disposable bailers. Note: The use of bailers for low-flow purging/sampling is not appropriate.
j. Another suitable purging/sampling device may be selected for use depending upon project requirements.

2. **Monitoring Well Purging and Sampling.** When purging of a monitoring well prior to sampling is appropriate and/or required, purge the well using either (a) wetted-casing-volume-based purging or (b) low-flow purging as described in the following sections. If a well exhibits evidence of slow recharge, or produces excessively silty water, etc., the well may need to be redeveloped.
   a. Wetted-casing-volume-based purging.
      (1) Establish a purging rate to pump or bail approximately three wetted-casing volumes of groundwater without dewatering the well.
      (2) If using a pump, set-up the discharge tubing, flow-through cell, water quality meter, and purge water collection container. If turbidity is measured, collect the sample for turbidity measurement after groundwater passes through the flow-through cell in the vial provided with the turbidity meter. If using a bailer, maintain a clean plastic container next to the well for collecting observation samples. Begin purging the well.
      (3) At the beginning of purging and periodically thereafter, record the following information and water quality parameters/observations on the groundwater purge and sample form: As guidance, field parameters may be measured after one purge volume is removed and every ½ purge volume thereafter.
         - Date and time
         - Purge volume and/or flow rate

- Water depth
- Temperature
- pH
- Specific conductance
- Dissolved oxygen
- Oxidation-reduction potential (ORP)
- Other observations as appropriate (turbidity, color, presence of odors, sheen, etc).

(4) Continue purging until water quality parameters have stabilized (refer to “Stabilization Criteria for Adequacy of Monitoring Well Purging” below) and/or a minimum of three wetted-casing volumes of water have been removed from the well. If a well purges dry, let it recover to 80 percent of original water column, then sample. If the well takes a very long time to recover (i.e., longer than 2 hours), try to sample the well at the end of day or first thing the next day.

(5) Collect the sample in pre-cleaned sample containers suitable for the laboratory analyses to be performed.

(6) If sampling using a bailer, use a bottom-emptying device or other technique to avoid sample agitation. If the collected water is very turbid, or a bottom-emptying bailer is not used, properly transfer the water from the bailer into the appropriate sample containers. Be careful to avoid agitating the sample. When sampling for VOCs, turn the bottle upside down after filling the container to identify possible headspace. If bubbles are present, top off the sample container or resample.

b. Low-flow purging and sampling.

(1) Place the pump intake at a depth equal to the approximate middle or just slightly above the middle of the well screen interval or water column or otherwise as dictated by well-specific soil stratigraphy and project-specific requirements**.** For example, it may be appropriate that the pump intake be set opposite to any preferential flow pathways (i.e., zones of higher permeability).

(2) Place an electronic water-level indicator probe in the well, approximately 0.5 to 3 inches below the piezometric surface. If available, a transducer of sufficient accuracy can also be used to measure depth to water when purging.

(3) Connect the pump discharge tube to a flow-through cell housing a water quality parameter probe.

(4) Activate the pump for purging at a flow rate ranging from approximately 0.1 to 0.5 liters per minute (L/min) or other flow rate as dictated by project-specific and/or site-specific requirements. (Note: Some regulatory agencies may require specific flow rates). Determine the flow rate by timing the rate at which the flow-through cell is filled.

(5) During purging, monitor the water level in the well to evaluate potential drawdown. The goal is to minimize drawdown to less than approximately 4 inches. If drawdown is observed (especially rapid drawdown at the beginning of purging), decrease the pumping rate.

(6) Measure water quality parameters at approximately 3- to 5-minute intervals during purging. Continue purging until water quality parameters have

stabilized (refer to "Stabilization Criteria for Adequacy of Monitoring Well Purging" below)

(7) Immediately after purging, collect the sample in pre-cleaned sampled containers suitable for the laboratory analyses to be performed using the same flow rate that was used during purging unless it is necessary to decrease the rate to minimize aeration or turbulent filling of sample containers. If sampling for VOCs or VPH reduce the flow rate to 0.1 L/min or less.

3. **Sampling with LNAPL Present in a Monitoring Well.** Wells containing LNAPL are typically not sampled for dissolved phase constituents in groundwater due to the potential for entrainment of LNAPL in the aqueous sample matrix. If such sampling is required, and purging is not required, make sure the pump intake is placed in the upper 2 feet of water column and collect the samples without purging in a manner that reduces the potential for mixing of the groundwater sample with air or LNAPL. If groundwater sampling is required from wells containing LNAPL for the purposes of characterizing VOCs, and purging is required, purge the well prior to sampling unless or until LNAPL becomes entrained in the sampling apparatus. If LNAPL will likely become entrained in the groundwater, the sample should be collected without purging. If LNAPL becomes entrained in the sampling apparatus then the sampling effort for VOCs should be aborted.
4. **Field Filtering Groundwater Samples.** Groundwater sample filtering and/or preservation should be performed in accordance with the requirements of the analytical method being specified and any other project-specific requirements. For example, samples collected for dissolved metals are typically filtered using a 0.45 µm filter.
5. **Sample Collection Considerations.** When multiple analyses will be performed, collect the samples in order of decreasing sensitivity to volatilization (i.e., VOC samples first and metals last). When sampling for VOCs, turn the sample container upside down after filling to identify possible headspace. If bubbles are present, top off the sample bottle or resample (do not reuse bottles, especially if they have been pre-preserved by the vendor or laboratory). If possible, the pump should not be moved or turned off between purging and sampling; however, the pump may need to be turned off for a very brief period (as a practical matter) so field personnel can handle samples and minimize the potential for water to splash on the ground surface. The ground surface should be protected from incidental splashing, especially if water from the well would be considered a hazardous waste for disposal purposes.
6. **Monitoring Wells with Slow Recharge.** If a well purges dry, let it recover to 80 percent of original water column, then sample. If the well takes a very long time to recover (i.e., longer than 2 hours), try to sample the well at the end of day or first thing the next day.
7. **Sample Container Filling and Shipping.** Fill the appropriate containers for the analyses to be requested and ensure that the required label information is completely and accurately filled in. Follow sampling packaging, shipping, and chain-of-custody procedures (see applicable SOG).
8. **Decontamination.** Follow personnel and equipment decontamination procedures (see applicable SOG).

Stabilization Criteria for Adequacy of Monitoring Well Purging

Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EPA 2001) states that "with respect to groundwater chemistry, an adequate purge is achieved when pH, specific conductance, and temperature of groundwater have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). Wells should be considered stable when the criteria listed in the following table have been met for pH, specific conductance, temperature, and turbidity. Attempts should also be made to stabilize ORP and dissolved oxygen.

Field Parameters	Stabilization Criteria for Three or More Consecutive Readings	Notes
pH	Difference between three or more consecutive readings is within ±0.2 units	–
Temperature	Difference between three or more consecutive readings is constant	–
Specific Conductance	Difference between three or more consecutive readings is within ±3%	–
Turbidity	Difference between three or more consecutive readings is within ±10% or three consecutive readings below 10 NTUs	Generally, turbidity is the last parameter to stabilize. Attempts should be made to achieve stabilization; however, this may not be possible. It should be noted that natural turbidity in groundwater may exceed 10 NTUs. If turbidity is greater than 50 NTU, redevelopment of the well may be warranted.
ORP	Difference between three or more consecutive readings is within ±20mV	Very sensitive. Attempts should be made to achieve stabilization; however, due to parameter sensitivity this may not be possible.
Dissolved Oxygen	Difference between three or more consecutive readings is within ±10% or ±0.2 milligrams per liter (mg/L), whichever is greater	Very sensitive. Attempts should be made to achieve stabilization, especially when collecting samples of VOC analysis; however, due to parameter sensitivity this may not be possible.

Attempts should be made to achieve the stabilization criteria. Because of geochemical heterogeneities in the subsurface environment, stabilization of field parameters during purging may not always be achievable. If field parameter measurements do not indicate stabilization, continued conventional purging may be required until a minimum of three wetted-casing volumes have been removed. During low-flow purging of a well containing a large volume of casing water, it may be practical to discontinue low-flow purging and proceed with sampling if field parameters have not stabilized within a reasonable period. This judgment must be made on a site-specific/project-specific basis.

Typical Procedures for Groundwater Sampling Using Passive Diffusion Bags (PDBs)

Groundwater sampling using water-filled passive diffusion bag (PDB) samplers may be suitable for obtaining samples for VOC analysis. The suggested application of the method is for long-term monitoring of VOCs in groundwater wells at well characterized sites. (Note: The use of PDBs may not be suitable for the assessment of Tertiary Amyl Methyl Ether, methyl tert-butly ether, methyl-isobutyl ketone, styrene, and acetone).The effectiveness of the use of a single PDB sampler in a well is dependent on the assumption that there is horizontal flow through the well screen and that the quality of the water in the well screen is representative of the groundwater in the aquifer directly adjacent to the screen. If there are vertical components of intrabore-hole flow, multiple intervals of the formation contributing to flow, or varying concentrations of VOCs vertically within the screened or open interval, then a multiple deployment of PDB samplers within a well may be more appropriate for sampling the well.

Typically PDB samplers should not be used in wells having screened or open intervals longer than10 feet. If PDB samplers are to be used in wells with screened intervals of greater than 10 feet, then they are generally used in conjunction with borehole flow meters or other techniques to characterize vertical variability in hydraulic conductivity and contaminant distribution or used strictly for qualitative reconnaissance purposes. In larger well screens or in wells that may have vertical flow, the use of baffles should be considered.

Following are the procedures for deploying a PDB sampler.

1. **Acquire PDBs.** Obtain the pre-filled PDB samplers from the analytical laboratory. (The PDB samplers are prefilled at the laboratory with laboratory-grade deionized water. Unfilled PDB samplers can be obtained and filled in the field but this is not recommended.)
2. **Deploy PDBs in Monitoring Wells.** To deploy the PDB sampler in the well:
   a. Measure the well depth and compare the measured depth with the reported depth to the bottom of the well screen from well-construction records. This is to check whether sediment has accumulated in the bottom of the well, whether there is a non-screened section of pipe (sediment sump) below the well screen, and the accuracy of well-construction records.
   b. Attach the PDB sampler to a weighted line. (Sufficient weight should be added to counterbalance the buoyancy of the PDB sampler.) (Note: Stainless-steel or Teflon-coated stainless-steel wire is preferable, but rope can be used if it is of sufficient strength, non-buoyant, and subject to minimal stretching. However, the rope should not be reused due to the potential for cross contamination.) Additionally, to prevent cross-contamination, the weighted lines should not be reused in different wells.
   c. To prevent cross-contamination, he PDB samplers should not contact non-aqueous phase liquid (NAPL) during deployment or retrieval.
   d. Calculate the distance from the bottom of the well, or top of the sediment in the well, up to the point where the PDB sampler is to be placed.
   e. Attach the PDB sampler to the weight or weighted line at the target depth.

1) For the field-fillable type of PDB sampler, the sampler is equipped with a hanger assembly and weight that can be slid over the sampler body until it rests securely near the bottom of the sampler.
2) If using a coated stainless-steel wire as a weighted line, make loops at appropriate points to attach the upper and lower ends of PDB sampler.
3) Where the PDB sampler position varies between sampling events, movable clamps with rings can be used.
4) When using rope as a weighted line, tie knots or attach clasps at the appropriate depths. Nylon cable ties or stainless-steel clips inserted through the knots can be used to attach the PDB samplers.

f. Lower the weight and weighted line down the well until the weight rests on the bottom of the well and the line above the weight is taut. The PDB samplers should now be positioned at the expected depth. (The depth can be checked by placing a knot or mark on the line at the correct distance from the top knot/loop of the PDB sampler to the top of the well casing and checking to make sure that the mark aligns with the lip of the casing after deployment.)
g. Secure the assembly. (A suggested method is to attach the weighted line to a hook on the inside of the well cap.)
h. Reattach the well cap. The well should be sealed in such a way as to prevent surface-water in-flow into the well.
i. Allow the system to remain undisturbed until the PDB sampler equilibrates. Laboratory and field data suggest that a 2-week equilibration time is probably adequate for most applications. Note: In less-permeable formations, longer equilibration times may be required.

3. **Recovering the PDBs.** Following the equilibration time, recover the PDB sampler from the monitoring well.
   a. Remove the PDB samplers from the well by using the attached line. The PDB samplers should not be exposed to heat or agitated.
   b. Examine the surface of the PDB sampler for evidence of algae, iron or other coatings, and for tears in the membrane. Note the observations in a sampling field book. If there are tears in the membrane, the sample should be rejected. If there is evidence that the PDB sampler exhibits a coating, then this should be noted in the report.
   c. Detach and remove the PDB sampler from the weighted line. Remove the excess liquid from the exterior of the bag to minimize the potential for cross contamination.
4. **Sample Container Filling and Shipping.** Transfer the water from the PDB sampler to sample container. This is typically accomplished by carefully cutting a small hole in the bag and directing the flow into the sample container. Some commercially available PDB samplers provide a discharge device that can be inserted into the sampler. When transferring the sample to the sample container, minimize agitation. Ensure that the required label information is completely and accurately filled in. Follow sampling packaging, shipping, and chain-of-custody procedures (see applicable SOG).
5. **Decontamination.** Follow personnel and equipment decontamination procedures (see applicable SOG).

Quality Control Guidance

Follow the quality control requirements specified in the Quality Assurance Project Plan (QAPP), project-specific field sampling and analysis work plan, and/or project-specific regulatory requirements, as applicable. The following may be used as guidelines.

1. Approximately one duplicate sample should be obtained for each sampling event or for each batch of samples (a batch is typically defined as 20 samples). Collect duplicate samples immediately after the original samples are collected. Purging is not performed between original sample collection and collection of duplicate samples. Original and duplicate samples are collected sequentially, without appreciable delay between collection cycles. Duplicate samples are to be submitted to the laboratory blind (i.e., not identified as a duplicate sample).
2. Typically, at least one type of field blank sample (rinsate or transfer) should be collected per day of water sampling. All field blank samples are to be collected, preserved, labeled, and treated like any other sample. Field blank samples are to be sent blind to the laboratory (i.e., not identified as a field blank). Record in the field notebook the collection of any blank sample (rinsate, transfer, trip). The types of field blank samples are discussed below.
    a. Rinsate blank samples. If rinsate field blank samples are required, prepare the sample by pouring deionized water over, around, and through the various reusable sampling implements contacting a natural sample. Rinsate blanks need not be collected when dedicated sampling equipment is used for purging and sampling the well. Rinsate blank samples are to be analyzed for the same parameters as the environmental samples.
    b. Transfer blank samples. Transfer blank samples are routinely prepared when no rinsate blank samples are collected. (The purpose of a transfer blank sample is to monitor for entrainment of contaminants into the sample from existing atmospheric conditions at the sampling location during the sample collection process.) A transfer blank sample is prepared by filling a sample container(s) with distilled or deionized water at a given sampling location. Transfer blank samples are to be analyzed for the same parameters as the environmental samples.
    c. Trip blank samples. Trip blank samples are submitted for VOC analysis to monitor for possible sampling contamination during shipment as volatile organic samples are susceptible to contamination by diffusion of organic contaminants through the Teflon-faced silicone rubber septum of the sample vial. Trip blank samples are prepared by the laboratory by filling VOA vials from organic-free water and shipped with field sample containers. Trip blank samples accompany the sample bottles through collection and shipment to the laboratory and are stored with the samples. It is suggested that a trip blank sample be included in each cooler of samples submitted for VOC analysis.

Investigation-Derived Waste (IDW) Management

Purge water is to be contained onsite in an appropriate labeled container for disposition by the client unless other project-specific procedures are defined. Other investigation-derived wastes, such as personal protective equipment, are to be properly handled and disposed. Preferably, PPE IDW should also be containerized and left onsite for disposal by the client. As a matter of practice, any waste, or potential waste, generated onsite, should remain onsite. Refer to the IDW SOG.

REFERENCES

ASTM. 1999. Designation: D 6452 - 99. Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations. Copyright ASTM, West Conshocken, PA.

ASTM International. 2002. Designation D 6771 – 02. Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. Copyright ASTM International, West Conshocken, PA.

U.S. Environmental Protection Agency. 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM)*. Dated November 2001. U.S. EPA Region 4.

Vroblesky, Dan A. 2001. U.S. Geological Survey, User's Guide for Polyethylene Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells. Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance. Water-Resources Investigations Report 01-4060. Columbia, South Carolina.

Standard Operating Guideline
Typical Hydraulic Push/Drive Sampling Procedures

Introduction

This guideline describes the equipment and procedures typically used by Kennedy/Jenks Consultants personnel for collecting soil and reconnaissance groundwater samples with a hydraulic push/drive system.

Equipment

- Portable, hydraulic push/drive sampling system
- 6-inch long, 1.75-inch O.D. stainless steel or brass liners and liner sealing materials (Teflon sheets, plastic end caps, Ziploc plastic bags)
- Type II Portland cement
- 1-inch O.D. Schedule 40 PVC screen (0.010-inch slot size)
- 1-inch O.D. Schedule 40 PVC blank casing
- 0.75-inch diameter stainless steel or Teflon bailer
- FID or PID organic vapor analyzer
- Water level indicator
- Temperature, specific conductivity and pH meters
- Equipment cleaning materials
  - Steam cleaner
  - Generator
  - Stiff-bristle brushes
  - Buckets
  - High-purity phosphate-free liquid soap
  - Deionized water
  - Rinsate collection system
- Personal protective equipment
- Appropriate groundwater sample containers
- Chain-of-custody forms
- Insulated sample storage container and ice substitute

Typical Procedures

1. Applicable drilling permits will be obtained prior to mobilization.
2. Sample locations will be cleared for underground utilities.
3. All downhole equipment will be steam cleaned prior to use at each location.
4. Soil borings will be advanced using a portable, hydraulic push/drive sampling system that simultaneously drives two nested, steel sampling rods into the ground to collect continuous soil cores.
5. As the sampling rods are advanced, the soil core will be collected in a 1-7/8-inch diameter, 3-foot long sample barrel, which is attached to the end of the inner rods. After being advanced 3 feet, the inner rods will be removed from the borehole with a hydraulic winch. The sampler (containing new stainless steel liners) and inner rods will then be lowered back into the borehole to the previous depth and the rods are driven another 3 feet. This process will be repeated until the desired depth is reached.

6. The soil samples will be retained for lithologic logging and chemical analyses, if appropriate.
7. The soils will be classified in the field in approximate accordance with the visual-manual procedure of the Unified Soil Classification System (ASTM D-2488-93), and the Munsell Color Classification.
8. If required, soil samples will be collected at selected intervals for laboratory analysis. At these intervals, the ends of one or more of the soil sample liners will be covered with Teflon end sheets and plastic end caps, and labeled. Labels will document the sample designation, type, date and time of collection, collector(s), location, and any additional information.
9. If groundwater samples will not be collected, the soil borings will be grouted to the ground surface with a neat cement grout (Type II Portland cement) using the tremie method.
10. Upon encountering the uppermost groundwater surface during sampling, the sample barrel and inner rods will be removed and the well screen and casing will be installed within the outer drive casing to facilitate collection of a groundwater sample. The drive casing will be pulled up approximately 3 feet to expose the slotted PVC casing. Groundwater samples will then be collected from within the PVC casing with a 0.75-inch diameter Teflon or stainless steel bailer.
11. The depth to groundwater will be measured prior to groundwater sampling.
12. The sample will be drained directly from the bailer into sample containers. The containers will be labeled to document the sample designation, type, date and time of collection, collector(s), location, and any additional information.
13. After collecting the reconnaissance groundwater sample, decant groundwater into a clean container and record the following field parameters/observations:

    Temperature (°C)
    pH
    Specific conductivity (μmhos/cm)
    Depth to water
    Color
    Other observations (odors, free-phase product)
14. After sample collection, the boring will be grouted to ground surface with a neat cement grout (Type II Portland cement) using the tremie method.

Equipment Cleaning

1. Downhole equipment (rods, sampler) will be steam cleaned prior to each borehole.
2. Sampling equipment (sampler) will be steam cleaned or washed with a brush in a solution of high-purity phosphate-free soap and potable water, then rinsed with potable water followed by double rinsing with deionized water prior to each sampling run.
3. Downhole equipment and vehicles which warrant it, will be steam cleaned prior to leaving site at completion of sampling.

Investigation-Derived Residuals

Soil cuttings will be placed in labeled 5-gallon DOT-approved pails with bolt-on covers. Decontamination water and groundwater residuals will be contained in labeled 55-gallon DOT-approved drums with bolt-on covers. All residuals generated during sampling activities will be stored at the site.

Standard Operating Guideline
Sample Packaging and Shipping

Introduction

This guideline presents methods for shipping non-hazardous materials, including most environmental samples via United Parcel Service (UPS), Federal Express and Greyhound. Many local laboratories offer courier service as well.

Equipment

- Coolers or ice chests
- Sorbent material
- Bubble-wrap
- Strapping tape
- Labels and pens
- Chain-of-Custody forms
- Chain-of-Custody seals
- UPS, Federal Express, or Greyhound manifests

Samples shipped to each analytical laboratory can be sent by UPS or Federal Express on a next-day basis unless other arrangements are made. Greyhound bus service should only be used if there is direct service (e.g., Sacramento or Bakersfield to San Francisco). Ice chests, used to refrigerate perishable items, can be used to convey non-hazardous samples to the analytical laboratory.

Absorbent pads should be placed in the bottom of the shipping container to absorb liquids in the event of sample container breakage. Transportation regulations require absorbent capacity of the material to equal the amount of liquid being shipped; each pad absorbs approximately 1 quart of liquid. Liquid samples in glass jars or bottles should also be wrapped in plastic bubble wrap. A small amount of air space is desirable in filled plastic containers. This often prevents the cap of the container from coming off should the container undergo compression. Volatile organics analysis (VOA) vials should be packed in sponge holders. Additionally, exposure of filled VOA vials to other types of sample containers, by placement in the same shipping container, is not recommended. Various non-VOA sample containers are solvent-rinsed which may contaminate the VOA vials before or after sample collection. Therefore, a separate shipping container for VOA vials is recommended. An equal weight of ice substitute should be used to keep the samples below 4 degrees Centigrade for the duration of the shipment (up to 48 hours). Care in choosing a method of sample chilling should be observed so that the collected samples are not physically or chemically damaged. Re-usable blue ice blocks, block ice, ice cubes, or dry-ice are suitable for keeping samples chilled. Labels of samples may get wet. Use of waterproof pens and labels is desirable for identification of sample containers. Use of clear tape to cover each affixed sample label is helpful in ensuring sample identification. Strong adhesive tape should be used to band the coolers closed. Additionally, it is recommended that the drain plug be covered with adhesive tape to prevent any liquid from escaping.

Specific requirements for packaging materials may apply if the samples being shipped are known to be hazardous materials as defined in 49 CFR 171.8 (samples are not considered hazardous waste and therefore manifest requirements do not apply). UPS holds shippers responsible for damage occurring in the event of accidents when a hazardous material is shipped as a non-hazardous material. Samples which obviously are hazardous materials should therefore be shipped as such, and samples which most likely are not hazardous materials should be shipped in coolers. Guidelines for shipping hazardous materials by UPS are provided in the *Guide for Shipping Hazardous Materials* available from UPS. Specific labels for shipping of hazardous materials are available.

Chain-of-custody documentation should accompany shipments of samples to the analytical laboratory. Often, the chain-of-custody document contains an analytical request section which may be completed following sample collection. Chronological listing of collected samples is desirable. A copy of the completed chain-of-custody form should be retained in the event that the original form is lost or destroyed.

It should be noted that samples retained by the analytical laboratory which are not chosen for analysis may be assessed a fee for disposal. Often a disposal fee is assigned to a sample, typically soil, that has been retained beyond standard analytical holding periods. Therefore, consultation with project management is recommended to determine which samples may be of interest. Contacting the selected analytical laboratory regarding disposal policies is also recommended. Arrangements may be made with the analytical laboratory for return of the unanalyzed samples for later disposal to the area of origin.

Standard Operating Guideline
Slug Tests

Introduction

This Standard Operating Guideline provides the procedures typically followed by Kennedy/Jenks Consultants personnel during performance of slug tests. This SOG provides guidance on procedures that are generally consistent with standard practices that are described in ASTM D 4044-96 - Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers as well as other published references and consensus among various practitioners. This guideline will discuss, in detail, one of several variations on the method involving the insertion of a mechanical "slug" into the water column.

This SOG contains the following sections:

- Field Equipment/Materials
- Summary of the Method
- Typical Slug Test Procedures
- Reporting
- References

Several methods are available to interpret field data derived from the slug test.

Field Equipment/Materials

- Water level probe.
- Pressure transducer and data logger or pressure transducer with built-in data logger.
- Watertight weighted slug of known volume (a small diameter casing filled with sand, capped at each end with eye bolt and rope). The slug diameter should be approximately 1 inch smaller than the inside casing diameter, long enough to displace sufficient water and short enough to be totally immersed in the water column.
- Field portable computer and power supply loaded with data transfer software.
- Weighted tape
- Stop watch

Summary of the Method

The slug test method involves causing a sudden change in hydraulic head within a single control well by either injecting or removing a known quantity or "slug" of water from the well or inserting a weighted "slug" of known volume into the water column. This guideline will discuss the weighted "slug" method. In all of the above cases, the amount of total displacement and water level recovery to the static condition are monitored using a pressure transducer and/or hand held water level probe. It is advantageous to monitor both the displacement (falling head) and recovery (rising head) portions of the test and compare the results. The rising head portion of the test is considered to be more representative of the actual aquifer hydraulic conductivity as it is not subject to the same early filter pack effects seen in the falling head portion of the test.

Notes
There is no fixed requirement for the magnitude of head change. Some considerations include a magnitude of change that can be readily measured with the apparatus selected; for example, head change should be such that the method of measurement should be accurate to 1% of the maximum head change. Generally, an induced head change of from one-third to one meter is adequate. Although the induced head change should be sufficient to allow the response curve to be defined, excessive head change should be avoided to reduce the possibility of introducing large frictional losses in the well bore (ASTM D 4044-96)

The slug test method is not applicable to wells larger than 6 inches in diameter.

Typical Slug Test Procedures

1. Decontaminate all downhole equipment prior to its placement within the well. Measure the total depth of the well with a weighted tape and the static water level with a water level probe to determine the thickness of the water column.
2. Install the pressure transducer inside the test well to the desired depth and secure its cable at the surface so that it will not move for the duration of the test. If necessary, mark the transducer cable where it meets the measuring point at the top of the well so that it can be repositioned in the unfortunate event of slippage.
3. Allow the water level to stabilize and measure the static water level of the well.
4. Periodically measure and record water levels using the manual water level probe.
5. Establish communication between the data logger and computer with the appropriate cable. Program the data logger to collect water level measurements at increasing rates starting at one measurement per second to approximately one measurement every 60 seconds. Zero the transducers at equilibrium. Program data logger so that drawdown level is in negative numbers, rises in positive numbers. Slug tests are not anticipated to run longer than one hour each for the displacement (falling) and recovery (rising) portions of the test.
6. Insert slug of known volume and monitor water level rise and fall. When the water level has reached equilibrium and returned to within 95 percent of static conditions, reset the data logger sampling time base and remove the slug. This starts the recovery portion of the slug test.
7. Upon conclusion of the test, the monitoring data will be downloaded to a diskette using a laptop computer and all downhole equipment will be decontaminated prior to reuse.
8. Document all field measurements on calculation worksheet.
9. Record name and model number of data logger and pressure transducers as well as the serial number of the transducer.
10. Make a preliminary analysis of data before leaving the field and evaluate the test to determine if the test should be rerun.

Reporting

All test reports should include the following:

1. Date, time, and well identification,
2. Whether the test is a falling head or a rising head test,
3. Inside diameter of well screen and well casing above the screen,
4. Volume of the Slug

Establish and record the measurement point from which all measurements of water level are made. Record date, time, and depth to water level below measurement point of all water levels.

Water levels measured during the test should be recorded with information on date, clock time, and time since the test started.

References

Standard Test Method for (Field Procedure) for Instantaneous Change of Head (Slug) Tests for Determining Hydraulic Properties of Aquifers. ASTM D 4044-96 (Reapproved 2008),

Bouwer, H., and R.C. Rice. 1976. A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells, Water Resources Research, 12(3):423-428.

Cooper, H.H., Jr., J.D. Bredehoeft, and J.S. Papadapulos. 1967. Response of a Finite Diameter Well To an Instantaneous Charge of Water. Water Resources Research, 3:263-269.

Hvorslev, M.J. Time Lag and Soil Permeability in Ground-Water Observations. U.S. Army Corps. of Engineers. 1951. P. 49

U.S. Bureau of Reclamation. 1977. Ground Water Manual. First Edition.

Standard Operating Guideline
Soil Gas Sampling

Introduction

This Standard Operating Guideline (SOG) provides the procedures typically used by Kennedy/Jenks Consultants personnel in collecting soil gas samples. Typically, soil gas sampling will be performed by subcontractors which specialize in these types of investigations. This SOG provides guidance on procedures that are generally consistent with standard practices used in environmental sampling. Federal, state and/or local regulatory agencies may require soil gas sampling procedures that differ from those described in this SOG and/or may require additional procedures. As guidance, this SOG does not constitute a specification of requirements for soil gas sampling. Deviations from, and additions to, the procedures described herein may be appropriate based on project-specific sampling objectives, site-specific conditions, and/or regulatory requirements. The user of this SOG should modify the sampling procedures used, as appropriate, to conform to the project-specific requirements and then document such deviations from this SOG in the project-specific documentation of soil gas sampling activities.

This SOG does not address Quality Assurance/Quality Control (QA/QC) procedures for soil gas sampling in detail. While some general QA/QC procedures are addressed, project-specific QA/QC procedures should be developed and presented in a Quality Assurance Project Plan (QAPP), field sampling and analysis work plan, or other project- or activity-specific document.

This SOG contains the following sections:

- Equipment
- Typical Procedures for Soil Gas Sampling Within Structures
- Typical Procedures for Soil Gas Sampling
- Quality Control Guidance
- Investigation-Derived Waste (IDW) Management.

Equipment

The subcontractors typically supply the majority of the equipment necessary to conduct the soil gas sampling. However, equipment that may be provided by Kennedy/Jenks personnel include the following:

- Electric drill or rotohammer, if necessary
- Portable generator, if necessary
- Cement to subcontractor's specifications
- Sand to subcontractor's specifications
- Bentonite to subcontractor's specifications
- Lab-grade water
- Extension cords
- Measuring devices (i.e. tapes or electronic measuring tools)
- Flashlight or trouble light

- Decontamination supplies, if necessary
- Zero air or nitrogen, if necessary
- Vacuum pump, if necessary
- Tedlar bags, if necessary
- Flow-cell regulator, if necessary

Typical Procedures for Soil Gas Sampling Within Structures

The procedures typically followed by these subcontractors are outlined below.

1. Access to the structure and approval for sampling is obtained. Access is typically the responsibility of Kennedy/Jenks Consultants. Kennedy/Jenks Consultants will discuss with the owner the presence of any known utilities in the subsurface.
2. In structures with earthen floors, probes are advanced into the subsurface to a depth of approximately 2 to 5 feet below ground surface. The probes are sealed, allowed to equilibrate, the sampling train is purged, and the sample is collected.
3. In structures with concrete floors, a small hole is drilled through the concrete, and a probe placed and sealed in place. After an equilibration time, the sampling train is purged, and the sample is collected.
4. Sampling of the soil vapor stream will be performed using a disposable syringe, Tedlar bag, or stainless steel evacuated canister.
5. The sample will be analyzed onsite by the subcontractor using a mobile gas chromatograph (GC-ECD or GC-FID) or submitted to a stationary analytical laboratory.

Typical Procedures for Soil Gas Sampling

The procedures typically followed by these subcontractors are outlined below.

1. Prior to sampling, the sample locations will be identified and the possible presence of underground utilities will be checked. The utility check is typically the responsibility of Kennedy/Jenks Consultants. Kennedy/Jenks Consultants will also contact Underground Service Alert (USA) prior to commencing fieldwork (minimum 48-hour notification required).
2. Active soil gas sampling is performed by inserting a hollow probe into the subsurface, approximately 3 to 10 feet below ground surface. Typically, a vacuum is applied to the sampling probe using a vacuum pump or syringe and soil vapor is removed. If the vacuum gauge indicates that an excessive vacuum pressure is encountered (about 17 inches of mercury or more), then an alternate sample location will be identified.
3. Permanent/semi-permanent sampling probes may be installed using a variety of drilling methods. Nested probes may be installed at one location to sample at various depths and may even be set near the groundwater table if diffusion from impacted groundwater is suspected. After installation of the probes, the location will be allowed to equilibrate before purging and sampling.
4. Some soil gas investigations may require a purge volume test be conducted before sampling can commence. During this test, typically three different volumes are tested (i.e. 1, 3, and 7 purge volumes).
5. Sampling of the soil vapor stream will be performed using a disposable syringe, Tedlar bag, glass bulb, or stainless steel evacuated canister.
6. The sample will be analyzed onsite by the subcontractor using a mobile gas chromatograph (GC-ECD or GC-FID) or submitted to a stationary analytical laboratory.

Quality Control Guidance

The following techniques and procedures will be used by the soil gas subcontractor to calibrate the analytical equipment and assure quality control.

- Standards will be prepared using ultra-pure grade chemical analytes. The GC will be calibrated to the analytes of concern using a three point standardization process. Standardization checks will be performed at the beginning of the day and throughout the day to assure the accuracy of the calibration.
- Equipment blank samples will be analyzed each morning prior to sampling to identify possible cross contamination.

Investigation-Derived Waste (IDW) Management

Any IDW, including personnel protective equipment (PPE) IDW, generated is to be contained onsite in an appropriate labeled container for disposition by the client unless other project-specific procedures are defined. Refer to the IDW SOG.

Standard Operating Guideline
Boring and Subsurface Soil Sampling

Introduction

This guideline describes the equipment and procedures that are used by Kennedy/Jenks Consultants personnel for drilling and collecting soil samples.

Equipment

- Drill rigs and associated drilling and sampling equipment as specified in work plan:
  - Hollow stem auger
  - Air-rotary casing hammer
  - Dual tube percussion hammer
  - Cable tool
  - Mud rotary
  - Reverse rotary
- CME, 5 ft x 94 mm continuous-core barrels (hollow-stem auger)
- 2.5-inch or 2.0-inch I.D. split-spoon drive sampler
- 2.5-inch or 2.0-inch brass liners and sealing materials (plastic end caps, Teflon seals, silicon tape, zip-lock plastic bags)
- Large capacity stainless steel borehole bailer
- Foxboro FID-Organic Vapor Analyzer (OVA)
- HNU PID-Organic Vapor Analyzer
- OVM
- Sampler cleaning equipment
  - Steamcleaner
  - Generator
  - Stiff-bristle brushes
  - Buckets
  - High purity phosphate-free liquid soap, such as Liquinox
  - Methanol (if necessary)
  - 0.1N nitric acid (if necessary)
  - Deionized water
  - Potable water
- Insulated sample storage and shipping containers
- Personal protective equipment (refer to project site safety plan)

Typical Procedure

1. Obtain applicable drilling and well construction permits prior to mobilization.
2. Clear drilling locations for underground utilities and structures by Underground Service Alert (USA) and subcontractors.
3. Have all downhole equipment steamcleaned prior to drilling each boring.
4. Ensure that soil borings not to be completed as monitoring wells are drilled with an auger drill rig, using hollow stem augers of appropriate size.

5. Make sure that borings not completed as monitoring wells are grouted to the surface, using a neat cement-bentonite grout (containing approximately 5 percent bentonite).
6. Ensure that borings made to construct shallow monitoring wells are drilled with an auger drill rig that uses hollow stem augers of appropriate size to provide an annular space of a minimum of 2 inches between borehole wall and well casing.
7. Verify that drill borings used to construct deeper monitoring wells are drilled with a dual tube percussion hammer or air-rotary casing hammer, using a steel drive casing of appropriate size, or with hollow stem augers through a steel conductor casing.
8. Collect soil samples for lithologic logging purposes with a CME continuous coring system in 5-foot increments.
9. Collect soil samples for lithologic logging and chemical and physical analyses by driving a split-spoon drive sampler, in 2.5- to 5-foot increments, below the depth of the auger bit with a rig-mounted hammer. Record the standard penetration resistance. If the sample is pushed rather than driven, be sure to record the push force.
10. When drilling with air-driven drill rigs, collect soil samples for lithologic logging purposes from the cyclone separator discharge on the dual tube percussion hammer, which separates air from formation cuttings as the drive casing is advanced.
11. Have the soils classified in the field in approximate accordance with the visual-manual procedure of the Unified Soil Classification System (ASTM D-2488-90) and the Munsell Color Classification.
12. Prior to each sampling event, wash the split-spoon drive sampler and brass liners with high purity phosphate-free soap, and double-rinse them with deionized water and methanol and/or 0.1N nitric acid, as appropriate.
13. At each sampling interval, collect soil in one brass liner for potential laboratory analysis. Cover this sample in Teflon sheets, seal it with plastic caps, and wrap it with silicon tape. Place a completed sample label on the brass liner. Then see that the samples are placed in appropriate containers and stored at approximately 4°C.
14. As a field screening procedure (if applicable), at each sampling interval put the soil from one of the brass liners into an airtight container and allow it to equilibrate. After this, use an OVA to monitor the headspace in the container. If significant organic vapors are detected with the OVA, save the appropriate brass sample liners for potential laboratory analysis.
15. Complete chain-of-custody forms in the field and transport the samples in insulated containers, at an internal temperature of approximately 4 °C, to the selected laboratory.
16. If applicable, as described in the site safety plan, use an OVA to analyze in situ air samples from the breathing zone, the inside of the augers or casing, and other locations as necessary.

Installation and Testing of Isolation Casing

1. Upon completion of the initial small-diameter boring, use a rotary drill bit of appropriate diameter to ream the boring to a depth (to be determined). Use a bentonite mud mixture, in accordance with standard drilling practice, to maintain hole stability and to minimize infiltration and development of a mud cake on the borehole wall.
2. When reaming is completed, install isolation casing in the boring. Use conductor casing of an appropriate grade of 14-inch diameter steel with a wall thickness of 0.25 inch, per the following specifications:

    Sections are 20, 10, or 5 feet in length.

    Casing sections are beveled or butt-jointed.

    Field joints are arc-welded with 70 percent weld penetration, having a minimum of two passes per circumference.

Welding rod is compatible with casing material.
Joints are watertight.
Casing centralizers are set on the bottom, middle, and top of the total casing length.
Centralizers are installed in sets of four, spaced at 90°, and attached at the bottom by a tack weld. They are flanged 2 inches at the top and bottom to contact the borehole wall.

3. Make volumetric calculations prior to grouting, to estimate the total volume of grout required to fill the annular space. The amount of grout actually used must be compared with this estimate. Ensure that the grout meets the following specifications:
   Volumes of grout used must be within 10 percent of estimated value.
   The grout consists of ASTM C150 Type II cement and water at a ratio of 5 gallons of water per 94 lb sack of cement, weighing approximately 118 lbs per foot. Approximately 5 lb of powdered bentonite for each sack of cement is mixed into the grout.
4. Note that leakage tests or a bond log might be required to validate the grout seal.
5. Grout conductor casing into place by one of the following methods:
   Pressure-grout from the bottom of the casing, using a packer or Braden-head to force the grout into the annular space between the conductor casing and the borehole wall.
   Fill the casing with grout and use a spacer plug apparatus to force the grout into the annular space between the conductor casing and the borehole wall. The spacer plug must be composed of a material that can be left in the boring and later drilled through to complete it.
6. After allowing the grout to set, continue drilling with an appropriate diameter hollow stem auger. A rotary bit can be used initially to drill through any grout that might have hardened in, or directly below, the casing.

Equipment Cleaning

1. Prior to drilling each boring, steamclean downhole equipment (augers, well casing, sampler).
2. Before collection of each drilling sample, steamclean or wash sampling equipment (sampler and brass liners) with a brush, in a solution of high purity phosphate-free soap and potable water. Rinse the equipment with potable water and methanol and/or 0.1N nitric acid, as appropriate. Follow this with double-rinsing using distilled water.
3. Before leaving the site at completion of drilling, steamclean downhole equipment and vehicles that require cleaning.

Investigation-Derived Residuals

Place soil cuttings and other residuals in appropriately labeled containers for disposition by the client. All soil samples transported to the laboratory must be returned to the client for disposition. Kennedy/Jenks Consultants is available to assist the client with options for disposition of residuals.

Standard Operating Guideline
Handling and Disposal of Investigation-Derived Waste

Introduction

Environmental site investigations usually result in generation of some regulated waste, particularly if the project involves drilling and construction of monitoring wells. Any potentially hazardous or dangerous material that is generated during a site investigation must be handled and disposed of in accordance with applicable regulations (22 CCR, Chapter 30). This guideline provides a procedure to be used for dealing with investigation-derived wastes that have the potential of being classified as hazardous or dangerous, including soil cuttings, well development water, and decontamination water.

Equipment

- DOT-approved packaging (typically DOT 17E or 17H drums)
- Funnel
- Bushing wrench
- 15/16-inch socket wrench
- Shovel
- Appropriate markers (spray paint, paint pen)
- Plastic sheeting
- Drip pans
- Pallets

Typical Procedures

Preparing Containers

1. Place each container on a pallet if it is to be moved with a fork lift after it is full.
2. Place plastic sheeting under containers for soil and drip pans under containers used to hold water.
3. Ensure that packaging materials are compatible with the wastes to be stored in them. Bung-type drums should be used to contain liquids. If a liquid is corrosive, a plastic or polymer drum should be used.
4. Solids should be placed in open-top drums. Liners are placed in the drums if the solid material is corrosive or contains free liquids. Gaskets are also used on open-top drums.

Storing Wastes

1. As waste materials are generated, place them directly into storage containers.
2. Do not fill storage drums completely. Provide sufficient outage so that the containers will not be overfull if their contents expand.
3. After filling a storage drum, seal it securely, using a bung wrench or socket wrench, for a bung-type or open-top drum, respectively.
4. Label drums or other packages containing hazardous or dangerous materials and mark them for storage or shipment. To comply with marking and labeling requirements, affix a properly filled out yellow hazardous waste marker and a DOT hazard class label to each waste container. Do

not mark drums with Kennedy/Jenks Consultants' name. All waste belongs to the client. Mark accumulation start date.

5. During an ongoing investigation, use a paint marker to mark the contents, station number, date, and quantity of material on each drum or other container. Do not mix investigation-derived wastes with one another or with other materials. Do not place items such as Tyvek, gloves, equipment, or trash into drums containing soils or liquids, and do not mix water and soil. Disposable protective clothing, trash, soil, and water materials should be disposed of in separate containers.
6. Upon completion of field work, or the portion of the project that generates wastes, notify the client as to the location, number, contents, and waste type of waste containers. Remind the client of the obligation to dispose of wastes in a timely manner and in accordance with applicable regulations.

Regulations

22 CCR, Chapter 30 *California Hazardous Waste Regulations*.

49 CFR 100-177, *Federal Transportation of Hazardous Materials Regulations*.

EPA Region X, Technical Assistance Team. 1984. *Manual for Sampling, Packaging, and Shipping Hazardous Materials*. Seattle, WA: EPA.

Standard Operating Guideline
Well Construction and Development

Introduction

This guideline describes procedures used by Kennedy/Jenks Consultants personnel for well construction and development following completion of boring and soil sampling procedures (described in Standard Operating Guideline, Boring and Subsurface Soil Sampling).

Well Construction Materials

- 2-inch or 4-inch Schedule 40 PVC blank casing
- 2-inch or 4-inch Schedule 40 PVC slotted casing, of appropriate slot size
- 2-inch or 4-inch Schedule 40 PVC threaded and slip caps
- 2-inch or 4-inch Schedule 40 stainless steel blank casing
- 2-inch or 4-inch Schedule 40 stainless steel wire wrapped casing, of appropriate slot size
- 2-inch or 4-inch stainless steel threaded and slip caps
- Stainless steel well centralizers
- 12-inch x 0.25-inch mild steel isolation casing with welded centralizers
- Hasp-locking standpipes
- Ground-level traffic-rated watertight well housing enclosure
- Locking expansion plugs
- Combination or key lock
- Filter pack sand (refer to Standard Operating Guideline, Design of Filter Packs and Selection of Well Screens for Monitoring Wells)
- Type I or II Portland cement
- Concrete
- Bentonite powder
- 0.25-inch bentonite pellets or chips.

Well Development Equipment

- 2-inch or 4-inch-diameter vented surge block
- 1-inch dedicated PVC hose for monitoring well development and purging
- Centrifugal surface pump
- Submersible pump (4-inch-diameter wells or larger)
- 55-gallon DOT-approved drums
- Teflon, stainless steel or PVC bailer
- Teflon-coated bailer retrieval wire
- Airlift pump with foot valve and compressor
- Bladder pump (2-inch diameter wells only)

Typical Procedure

1. Following completion of selected borings, install the monitoring well casing through the center of the hollow stem auger, drive casing, or open boring. The monitoring well consists of a PVC Schedule 40 slotted well casing of appropriate diameter and a blank casing with a threaded bottom cap and a slip or threaded top cap or watertight expansion plug. The casing string must be held in tension during initial installation.
2. Place clean, well graded sand around the slotted section of the monitoring well to serve as the filter pack. The grade of sand is chosen on the basis of aquifer units encountered (refer to Standard Operating Guideline, Design of Filter Packs and Selection of Well Screens for Monitoring Wells). The filter pack is emplaced as the auger or temporary casing is removed from the boring.
3. Ensure that filter pack sand for the well extends to approximately 3 feet above the top of the screened interval.
4. If required in the well construction permit, notify the appropriate inspector prior to placing the well seal.
5. Place a 2- to 3-foot thick bentonite pellet seal above the sand pack, as the auger and/or casing is removed from the boring. If the seal is placed above the water table, the bentonite pellets must be hydrated with potable water prior to placement of the annular seal.
6. Fill the remainder of the annulus between the well casing and the borehole wall with cement/bentonite grout (with approximately 5 percent bentonite), or a high-solids bentonite slurry (11 to 13 pounds per gallon), to a depth of approximately 1 foot below ground surface. If the water level is higher than the seal, use a tremie pipe to place the grout.
7. Install either a threaded cap or a locking watertight expansion plug on the monitoring well. Place a steel hasp-locking well housing over the top of the well and cement it into the annulus of the boring.
8. Place a traffic-rated precast concrete or steel well enclosure approximately 1 to 2 inches above grade, and cement it into place with concrete. Have a concrete apron constructed around the well housing enclosure to facilitate runoff.
9. For aboveground completion, ensure that the well casing extends approximately 3 feet above ground surface. An 8-inch diameter hasp-locking steel well housing surrounds the well casing. Traffic bollards can be installed around the well housing as necessary.
10. Repeat Steps 1 through 9 for all monitoring wells at site.
11. Following the curing of the grout (approximately 24 hours), each monitoring well is developed. Prior to development activities, measure the depth in each well to static water level and total casing depth.
12. Also prior to well development, if applicable, check the water interface of each monitoring well for the presence of floating product (NAPL). Use a clear bailer or color indicator paste for the inspection.
13. If a monitoring well has a water level of less than 25 feet, it may be developed by using a centrifugal surface pump with dedicated 1-inch I.D. clear flex suction hose, placed with the hose intake placed temporarily at all levels of the screened interval. If the well is greater than 25 feet deep, a submersible pump or airlift pump with air filter is used for development. In either case, a surge block of appropriate size can be moved up and down inside the screened section of the well casing to create a surging action that hydraulically stresses the filter pack.
14. During development of each well, ensure that field parameters and observations are recorded on a Kennedy/Jenks Consultants purge and sample form (attached). Information to be recorded includes, but is not limited to, the following items:
    - Depth to water
    - Development time and volume

Development (flow) rate
pH, temperature, specific conductivity, and turbidity
Other observations, as appropriate (e.g., color, presence of odors, or sheen)

15. Develop each monitoring well until water of relatively low turbidity is removed from the casing.
16. When development of each well is discontinued, record the following field parameters/observations:

Depth to water
Temperature
pH
Specific conductance
Turbidity
Color

Investigation-Derived Wastes

Place groundwater produced by well development in appropriately labeled containers for disposition by the client. Kennedy/Jenks Consultants is available to assist the client with options for disposition of groundwater.

Appendix C

Health and Safety Plan

Kennedy/Jenks Consultants

32001 32nd Avenue South
Federal Way, Washington 98001
253-835-6400
FAX: 253-952-3435

Health and Safety Plan (HASP)

Washington State Department of Ecology
Precision Engineering

1230 South Director Street
Seattle, Washington

25 March 2014

Prepared for

Washington State Department of Ecology
3190 160th Ave SE
Bellevue, Washington 98008

K/J Project No. 1396024*00

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Kennedy/Jenks Consultants

Health and Safety Plan (HASP) Summary

Project Name	Washington Department of Ecology, Precision Engineering	**Project No.**	1396024*00
Prepared by	John Jindra	**Date**	10/25/13
Project Manager	Ty Schreiner	**Office**	Federal Way

Field Services Description

Field Services Date(s)	Spring 2014 – to be determined
Site Name	Precision Engineering
Location	1230 S Director Street, Seattle, WA
Client Contact	Eugene Freeman
Site Telephone	425-649-7191

Type of Investigation:

Sampling Investigation:

- ☐ Hand Auger
- ☒ Drilling
- ☐ Trenching
- ☒ Well Installation
- ☒ Soil Sampling
- ☒ Groundwater Sampling
- ☒ Other: Indoor Air Sampling

Site Remediation:

- ☐ Excavation
- ☐ Treatment System Installation
- ☐ UST Removal

☒ Site Walk-through

☐ Other: ____________

Section 1: Introduction

This Site-Specific Health and Safety Plan (SSHSP), also referred to as a Health and Safety Plan (HASP), developed in accordance with Occupational Safety and Health Administration (OSHA) standards for hazardous waste operations (29 CFR 1910.120), and CAL/OSHA Standards (8 CCR 5192), establishes general health and safety protocols for Kennedy/Jenks Consultants (K/J) personnel at Washington State Department of Ecology's Site; Precision Engineering located at 1230 S. Director Street, Seattle, Washington. As needed, addenda containing activity-specific health and safety protocols will be prepared and attached to this HASP prior to the initiation of each additional field activity. The HASP and activity-specific addenda, as a minimum, contain the following information:

- Names of key personnel and alternates responsible for site health and safety and appointment of a Site Safety Officer (SSO).
- A Job Hazard Analysis (JHA) for each site task and operation.
- Personal protective equipment to be used by employees for each site task and operations being conducted.
- Medical surveillance requirements.
- Frequency and types of air monitoring, personal monitoring and environmental sampling techniques and instrumentation to be used. Methods of maintenance and calibration of monitoring and sampling equipment to be used.
- Site control measures.
- Decontamination procedures.
- Site's standard operating procedures.
- An Emergency Response Plan that addresses effective site response to emergencies.

For informational purposes only, this plan may be provided to subcontractors of K/J involved in activities at the site, interested regulatory agencies, or others. However, entities and personnel other than K/J shall be solely responsible for their own health and safety and shall independently assess onsite conditions and develop their own health and safety protocols. Entities or personnel that anticipate using health and safety measures which are less stringent than K/J's measures should immediately contact the K/J SSO.

K/J has developed a Corporate Health & Safety Manual (Kennedy/Jenks Consultants, Corporate Health and Safety Program, December 2010). The Corporate Health & Safety Program, upon which the manual is based, complies with current health and safety regulations, including OSHA 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response, and CalOSHA Standards (8 CCR 5192). Many of the protocols of the corporate program are conducted on a routine basis (general training, respirator fit testing, general medical record keeping, etc.) and are not repeated herein. The Corporate Health and Safety Program is available to K/J employees upon request during normal business hours. Questions regarding the program should be referred to the K/J Regional Safety Representative (RSR), John Gregg Bryden, Corporate Safety Specialist (CSS), Jim Barrios, or Corporate Health & Safety Manager (CHSM) Bert Drews.

A copy of this HASP, along with any addenda containing activity-specific health and safety information, will be kept in a conspicuous location at all times while work is being conducted at the site.

Section 2: Key Health and Safety Personnel

The K/J SSO is Jessica Faragalli. In the absence of the SSO during field activities, a member of the field investigation team will be designated as the K/J SSO. The SSO is responsible for the following.

- Observing field activities for compliance with this HASP, applicable addenda, and K/J's Corporate Health and Safety Program.
- Maintaining the onsite medical surveillance, if required, and emergency medical treatment programs, and assisting in onsite emergencies.
- Modifying health and safety protocols or terminating field work when unsafe work conditions exist.
- Assuring that all project team members participating in field activities have read and signed this HASP and have had the opportunity to ask safety-related questions regarding this project.
- Familiarizing personnel with health and safety protocols.
- Observing that field personnel wear appropriate personal protective equipment.
- Recording data from direct reading instruments and evaluating potential hazards.
- Monitoring decontamination procedures.
- Recording the occurrence of any site injury or illness.

If unsafe conditions are encountered, if illness or injury occurs, or if the level of protection needs to be changed, the SSO will consult in a timely manner with the Project Manager, Ty Schreiner, or the CHSM, Bert Drews.

Section 3: Site Description and History

The Site is a former manufacturing facility that specialized in the manufacturing and repair of large hydraulic cylinders, large rolls used in the manufacture of paper and metal sheet. The facility was in operation from 1968 through 2005. Services included precision grinding and polishing, honing, hard-chrome plating, milling, welding, and a large number of flame-and arc-applied metal coatings. Much of Precision Engineering's (Precision's) work involved the use of chromic acid. The facility also used other chemical compounds including trichloroethene (TCE).

West of the former Precision property is a business that repairs and sells refrigerators. East of the former Precision property is a towing and limousine service business (former KASPAC/Chiyoda property). According to former Precision personnel, the property to the east was used as a paint shop in the 1970s, and before that, it was a fiberglass-boat-manufacturing operation.

Contaminants of concern identified for this Site include oil- and diesel-range organics (ORO, DRO), TCE, and chromium (Cr III and Cr VI). However, additional contaminants should include Arsenic (As), 1,2-Dichloroethene (1,2-DCE), Vinyl Chloride, and Selenium (Se).

Ecology is concerned that contamination, particularly CrVI (hexavalent chromium) and chlorinated solvents may have migrated from the property and may pose a threat to the Duwamish River located approximately 1,000 feet to the east. Contamination has been found in groundwater in wells at the property. The aquifer at the Site is about 3 to 8 feet deep and slopes to the east, toward the Duwamish River. It is uncertain whether the aquifer is laterally continuous throughout the area, but an environmental report for the property suggests the aquifer unit has been observed in wells located to the east of the property. Additionally, contamination may persist at the property, particularly under the building. A vapor intrusion study indicated that TCE was detected in indoor air within the manufacturing building at a concentration of 0.2 micrograms per cubic meter ($\mu g/m^3$). Contaminated sediment excavation activities have been reported for this property.

Section 4: Planned Site Activities

Type of Investigation:

Sampling Investigation:
- ☐ Hand Auger
- ☒ Drilling
- ☐ Trenching
- ☒ Well Installation
- ☒ Soil Sampling
- ☒ Groundwater Sampling
- ☒ Other: Indoor Air Sampling

Site Remediation:
- ☐ Excavation
- ☐ Treatment System Installation
- ☐ UST Removal

☒ Site Walk-through ☐ Other: ________________

☐ Onsite Inspection or Construction-Related Services

☐ Entry into a Confined Space or Excavation[1]

☐ Work Along a Leading Edge Requiring Fall Protection

☐ Entry into an Excavation or Trench with a Depth of 5' or Greater (4' in Oregon and Washington)

☐ Field Investigation Requiring
- ☐ a. Entry into (potentially) hazardous area
- ☐ b. Interruption of vehicular traffic
- ☐ c. Interruption of plant processes
- ☐ d. Operation of pilot plant

☐ Chemical Use[2]

☐ Other - *specify*

[1] Completion of K/J Confined Space Pre-entry Checklist and Entry Authorization is required or review of Client's Confined Space Procedures.

[2] A Field Chemical Use Plan must be completed.

Potential Hazards:

- ☒ Organics
- ☒ Inorganics
- ☒ Metals
- ☐ Acids
- ☒ Solvents
- ☐ Pesticides
- ☐ Other: ________________
- ☐ Bases
- ☐ Fire/Explosion

Personal Protective Equipment:

- ☐ Level C
- ☒ Level D

The site is currently operated as a retail establishment providing construction/mechanical materials, with an outdoor yard along the western and southern periphery. Field investigation activities will require coordination with the current property owner/operator to consider appropriate means to protect facility operations and workers/customers.

Section 5: Hazard Assessment

5.1 Potential Physical & Environmental Hazards

Every job must be scrutinized for potential hazards which may cause an injury or an accident. The preferred method of assessing a job for hazards is to break down each job into smaller tasks. Each task may then be scrutinized by performing a Job Hazard Analysis (JHA).

While a documented JHA is not required, the K/J JHA Form provides examples to assist employees in performing their own JHA. The JHA process is intended to provide a brief, consistent means of identifying and addressing hazards which may injure employees.

Potential hazards may include, but are not limited to the following:

- Heavy Equipment
- Excavations and Trench work
- Confined Space Entry
- Tripping and Falling Hazards
- Heat Stress
- Cold Exposure

5.1.1 Heavy Equipment

Field personnel should be cognizant of potential physical hazards associated with use of heavy equipment and electrical equipment during field operations. Appropriate precautions include the following:

- ANSI-approved hardhats, Class II reflective safety vests, safety glasses or goggles, and safety-toe boots will be worn.
- Loose clothing that may catch in moving parts will not be worn.
- Hearing protection will be worn if a preliminary noise survey or past experience indicates that maximum noise levels will exceed 85 decibels at any time during site operations.

Prior to conducting drilling, a survey shall be conducted to identify overhead electrical hazards and potential ground hazards, such as hazardous agents in the soil or underground utilities.

5.1.2 Excavation

Field personnel should enter an excavation or trench only as a last resort. Any excavation or trench exceeding 5 feet in depth (4 feet in Oregon and Washington) must be properly shored, braced or sloped and a safety ladder must be provided for ready access or egress.

5.1.3 Confined Space Entry

K/J personnel will not enter any confined space without advanced specific preparation, planning, training, and supervision by the RSR, CSS, or CHSM. Training will include a thorough review of the K/J Confined Space Entry Program and completion of the K/J Pre-Entry Checklist and Entry Authorization forms.

A confined space is defined by OSHA as the concurrent existence of the following conditions.

- Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
- Is not designed for continuous employee occupancy.

5.1.4 Tripping and Falling Hazards

Other potential physical hazards include falling and tripping on slippery, uneven, or unpaved surfaces.

5.1.5 Heat Stress

Adverse climate conditions, primarily heat, are important considerations in planning and conducting site operations. Maximum daytime temperature may exceed 70 degrees F at the site and heat stress **is not** an associated concern. Provisions of the K/J Heat Illness Prevention Program will be applied to all projects when K/J employees are subjected to sustained temperatures of 85 degrees Fahrenheit or greater.

Preventative measures include the following:

- Water and/or commercial electrolyte solutions will be available and drinking of these fluids will be encouraged. When temperatures exceed 85 degrees Fahrenheit, sufficient water will be provided to accommodate each employee with one quart of water per hour. The water will be kept cool by means of a portable cooler with ice or similar means.
- Suitable acclimation periods will be provided for workers to gradually establish their resistance to heat stress.

Personnel exhibiting symptoms of heat stress (nausea, cramps, dizziness, clammy skin) will be removed from the work area, cooled, provided with water, and the personnel will be observed. Personnel exhibiting symptoms of heat stroke (hot dry skin, mental confusion, unconsciousness) will be immediately cooled and taken to the hospital.

5.1.6 Cold Exposure

Cold injury (e.g., frostbite and hypothermia) and impaired ability to work are dangers encountered at low temperatures and high wind-chill factors. To guard against these conditions, if cold weather is an important consideration at this site, field personnel should wear appropriate clothing, have access to readily available warm shelter, take carefully scheduled work and rest periods, and monitor the physical conditions of other workers.

5.2 Potential Chemical Hazards

Contaminants of concern (COC) identified for this Site include oil- and diesel-range organics (ORO, DRO), TCE, and chromium (Cr III, Cr VI). However, additional contaminants should include Arsenic (As), 1,2-Dichloroethene (1,2-DCE), Vinyl Chloride, and Selenium (Se). Field personnel could potentially be exposed to COC at the site by direct contact with soil or groundwater, through inhalation of dusts containing organic chemicals, or through inhalation of organic chemical vapors. Field personnel will minimize potential chemical hazards by (1) avoiding direct contact with groundwater and soil, (2) performing air monitoring to determine necessary level of personal protective equipment and (3) avoiding generation of dust. Ingestion of particulate matter containing chemicals is another general exposure route. However, for the site personnel, the potential for this type of exposure is minimal. Safe work practices, including restriction of eating, drinking, or smoking to certain times and places will be enforced at the work site.

5.2.1 Groundwater Samples

Chemicals detected in the groundwater from the site and the highest detected concentrations are listed in Table 1.

5.2.2 Soil Samples

COCs have been detected in subsurface soil samples collected at the site. The highest reported concentrations are listed in Table 2.

Available Threshold Limit Values (TLV) or Permissible Exposure Limits (PEL) published for the chemicals detected in soil and groundwater are listed in Table 3.

Section 6: Community Hazard Analysis

Generally, insignificant particulate and vapor emissions are generated during routine soil and groundwater sampling activities. During construction-related activities to include well installation and drilling, particulate and vapor emissions may increase above concentrations generated during routine soil and groundwater sampling activities. Therefore, activity-specific health and safety addenda will be developed for activities where elevated particulate and vapor emissions may develop. Onsite worker exposure to chemicals at concentrations of concern is not expected. Potential exposures to the surrounding community will likely be much less than potential onsite worker exposure, and is therefore also not expected to be of concern.

Section 7: Protective Actions

7.1 Personnel Protective Equipment

Field personnel will wear equipment to protect against the potential physical and chemical hazards which have been identified herein and those that become apparent in the field. Guidelines for Contaminants Commonly Encountered at K/J Sites provide guidance in assessing potential hazards and selecting the appropriate protection. Level D protection will be required at a minimum for field activities at the site. Level D personal protective equipment to be used may include all items on the following list which are denoted by an asterisk*.

Additional equipment will be readily available to upgrade to modified Level C protection, if necessary and approved by the CHSM or CSS. This equipment includes:

- Full-face or half-face air purifying respirator with high efficiency particulate/organic vapor cartridges
- Chemical resistant gloves; inner glove - disposable PVC and outer glove - NBR/Nitrile
- Boot covers
- Boots, chemical resistant, safety toe.
- Safety goggles or a face shield should be used when a foreseeable splash hazard exists

The level of protection employed may be upgraded, as deemed necessary by the SSO.If non-routine field activities are initiated, the level of protection will be specified in the activity-specific health and safety addenda.

Personal Protective Equipment (PPE)

☒ Eyes/face/glasses/shield*
☒ Gloves*: ☒ *Work* ☐ *Neoprene* ☐ *Rubber* ☒ *Nitrile*
☐ Suits*: ☐ *Cotton* ☐ *Tyvek* ☐ *Nylon* ☐ *Other*
☒ Hard hat*

☒ Ear muffs/plugs* (if noise level above 85 dB)
☒ Boots* (*type:Safety Toe*)
☐ Respirator (*cartridge type: specify*)

☒ First aid kit
☒ Eyewash/shower
☐ Spill kit
☐ Fire extinguisher
☐ Air horn
☐ Life jackets
☒ Camera/video
☐ Safety belt/harness/tripod
☒ Cell Phone

☐ Lockout tags and locks
☐ Ventilator/fan
☐ Volt/ampere meter
☐ Combust. gas, oxygen deficiency meter *(calib.: specify)*
☒ OVA *(calibration date: specify)*
☐ OVM *(calibration date: specify)*
☐ Hydrogen sulfide meter *(calibration date: specify)*
☐ Draeger detection tubes
☒ Soil sampling kit
☐ pH meter/paper
☐ Conductivity/temperature meter
☐ Metal detector
☐ Air sampling equipment
☐ Peristaltic pump (tank sampling)
☐ Lights *(type: specify)*
☒ Other: Orange reflective safety vest

7.2 Work Zones

Work zones including designation of an Exclusion Zone, a Contamination Reduction Zone, and a Support Zone will be established for any field activity which requires Level C protection or greater. Work zones will be clearly marked in the field. Work zones may vary depending on the proposed field activity and will be established in the activity-specific health and safety addenda.

7.3 Monitoring

7.3.1 Hazardous Substances

As appropriate, field personnel will perform air monitoring at least twice daily with a direct reading organic vapor analyzer (OVA, OVM or HNU) in the breathing zone at each work location. All readings shall be recorded in field logs. All direct reading instruments shall be calibrated according to the manufacturer's specifications. The following action levels will be used.

- If OVA readings for a particular work area consistently exceed 5 parts per million (ppm) above background, then sampling will cease and personnel will withdraw from the work area.

- If concentrations persist above 5 ppm, then Level C protection will be required if work is to continue.

- If OVA readings exceed 10 ppm in the breathing zone while workers are in Level C protection, then work will cease and the source of the emission will be determined and eliminated before work continues.

- Periodic measurements of the area will be taken before re-entry to ensure LEL has been reduced to safe working levels.

7.3.2 Explosive Limits

If conditions encountered during drilling, excavation, or confined space entry suggest that potentially explosive conditions may exists, the SSO will direct that explosimeter monitoring be conducted. The following explosimeter monitoring action levels will be used.

Outside a confined space:

- If a gas or vapor's concentrations are less than 10 percent of its lower explosive limit (LEL), continue investigation.

- If concentrations are between 10 and 25 percent of its LEL, continuously monitor site and continue the investigation with extreme caution.

- If concentrations are greater than 25 percent of LEL, withdraw from area immediately.

Inside a confined space:

- If a gas or vapor's concentration is less than 10 percent of its lower explosive limit (LEL), continue investigation and air monitoring.

- If a gas or vapor's concentration is10 percent or greater of its lower explosive limit (LEL), all personnel will immediately evacuate the space.

7.3.3 Oxygen Content

If site activities involve confined space entry, oxygen concentrations within the space will be measured with an oxygen concentration meter. The following oxygen monitoring action levels will be used.

- If concentrations are less than 19.5 percent, withdraw from area until a breathable atmosphere has been re-established.

- If concentrations are between 19.5 and 25 percent, continue investigation and monitoring.

- If concentrations are greater than 25 percent, withdraw from area immediately (fire hazard potential).

7.3.4 Noise

Field personnel will initially monitor noise levels associated with equipment and machinery with a direct reading portable noise level monitor unless based on experience, it is known that hearing protection is not necessary. Readings will be taken within the normal worker hearing zone. If maximum noise levels exceed 85 decibels at any time during site operations, hearing protection will be worn.

7.4 Site Control

Work zones will not be established for Level D activities. Individuals not directly involved in ongoing work will be requested to stay at least 50 feet away from Level D activities.

7.5 Decontamination

For activities requiring Level D protection and modified Level C protection without established work zones, it is unlikely that major decontamination will be necessary. At the conclusion of each day, disposable gloves and coveralls will be removed and disposed of in onsite containers.

If full Level C protection is required, minimum decontamination procedures associated with Level C protection will be followed and established within the Contamination Reduction Zone. These procedures are presented in Table 4.

7.6 Training

K/J personnel participating in field activities will have completed the Hazardous Waste Operations and Emergency Response 40-hour health and safety training course (29 CFR 1910.120) or have equivalent training, and have undergone annual 8-hour refresher training. Training requirements are discussed in K/J's Corporate Health and Safety Program. Prior to each day of work, a meeting will be held at the site to familiarize personnel with health and safety issues, protective equipment, emergency information and supplies, and to discuss special topics.

7.7 Medical Monitoring

K/J personnel participating in field activities that require Level C protection will be included in a medical monitoring program. The program includes a baseline physical examination, pulmonary function test, and blood and urine tests. Annual follow-up examinations are included. Details of the medical program are included in the K/J Corporate Health and Safety Program.

7.8 Sanitation and Illumination

The site does not have drinking water, washing water, or restroom facilities available. No eating, drinking, smoking, or gum chewing is allowed in restricted areas.

Activities will take place during daylight hours. Because natural illumination (approximately 50 to 200 foot candles) will be sufficient to meet the 5 foot candle requirement for general site areas, no additional illumination will be required.

Section 8: Emergency Response Plan

Hazard recognition is an essential part of the Emergency Response Plan. Initiation of the contingency plan relies on the employee's ability to recognize an emergency or potential for an emergency. The following is a list of events which will immediately initiate emergency procedures:

- Explosion
- Fire
- Release of organic vapors or particulate above the action levels
- Personal injury
- Failure or expected failure of runon/runoff control measures
- Natural occurrences (i.e., lightning, tornado, high winds, etc.)
- Spills

8.1 Emergency Communications

Emergency communications will consist of four methods.

8.1.1 Verbal Communication

Verbal communication will be the primary method of emergency communication between onsite personnel, distance permitting.

8.1.2 Hand Signals

- Hands clasped on wrists will indicate personnel to stop work and exit Exclusion Zone.
- Hands on throat indicate inability to breathe.
- Thumbs up indicates OK.
- Thumbs down indicates not OK.

8.1.3 Air Horn/Vehicle Horn

As appropriate, air horns will be carried by personnel entering any established Exclusion Zone and stationed in the Support Zone. If air horns fail or are lost, vehicle horns may be used as a substitute. Air horns will be the primary alarm system and used in the following manner:

One long blast: Evacuate Exclusion Zone by nearest exit. Proceed to assembly area.

Two short blasts: Localized problem. Avoid area, move to decontamination Reduction Zone for further instruction.

Three short blasts: All clear, resume work.

8.1.4 Telephones

Telephones are used for routine communication and to notify offsite agencies of incidents and request assistance. Emergency telephone numbers are provided in Section 9.

8.2 Emergency Protocol

When an event recognized as an emergency occurs, the alarm system will be used to notify personnel. As soon as the alarm system is activated, the SSO will be notified.

The SSO will take into account the following information:

- Nature of emergency
- Wind direction
- Location of personnel
- Monitoring results
- Emergency equipment available
- Offsite population

Based on this information, the SSO will direct appropriate emergency action and agency notification. After the emergency has been controlled and the site is considered safe to re-enter, the SSO, in coordination with the Project Manager, will direct remedial action to restore the site to full operating condition.

The SSO will investigate the nature and cause of the incident so that work procedures can be modified to minimize the likelihood of the incident's recurrence.

All incidents must be reported in a timely, appropriate manner to the CHSM or CSS. An incident is any unplanned event resulting in injury, damage, loss of assets, adverse publicity, or which requires notification of a regulatory agency, regardless of severity. All K/J personnel should report an incident to the SSO. The SSO will report to the project manager who is responsible for notifying the CHSM or CSS.

Each incident will be investigated and a Root Cause Analysis Report will be generated and forwarded to the project manager and the RSR.

If work zones are established, the Exclusion Zone will have several emergency exits which will allow safe egress in multiple directions from any point onsite. The exit selection will be based on the emergency location, type of emergency, and wind direction. Upon hearing the evacuation signal or otherwise being notified of an evacuation, employees will immediately travel to the assembly area located at the decontamination station.

Employees will follow a route that avoids locations downwind from the emergency. If emergency exits are used, employees will proceed to the assembly area by the quickest route possible, staying close to the perimeter of the Exclusion Zone. When the assembly area is reached, employees will immediately check in with the SSO. The site will remain evacuated until the all clear signal has been given.

8.3 Emergency Supplies

Onsite emergency equipment will include equipment used during operations (heavy equipment) and reserved items stored at the decontamination/ assembly area and at strategic areas onsite. The following is a list of emergency equipment available to take to the site.

- Portable emergency eye wash
- First Aid supplies
- Absorbent-spill control
- Extra batteries for radios, monitoring equipment, etc.

All personnel will have a thorough understanding of the Emergency Response Plan before starting work. It will be reviewed periodically to keep it current with new or changing site conditions or information.

8.4 Injury Response

In the event of an employee injury in a contaminated area, consideration must be given before moving the injured and contaminated employee to outside the restricted contamination area. The nature of the injury, hazards posing an immediate danger, and other factors must all be weighed before moving an injured employee who is wearing contaminated PPE. Initial responders should follow directions from 9-1-1 personnel or the CHSM or CSS.

Section 9: Emergency/Team Contacts & Approvals

Emergency Telephone Numbers

	Name	Phone
Site Contact	Eugene Freeman	425-649-7191
WorkCare (Non-Critical Injuries)	WorkCare	(888) 449-7787
Fire Department[1]	9-1-1	
Hospital:	Highline Medical Center 16251 Sylvester Rd SW Burien, WA 98166	206-244-9970
Directions to hospital[2]:	See map and directions on following page	
Ambulance		9-1-1
Police		9-1-1
Kennedy/Jenks Consultants:		
Project Manager	Ty Schreiner	253-835-6428 or 206-419-0048
Regional Safety Representative (RSR)	Gregg Bryden	503-259-4911 or 503-593-2662
Site Safety Officer (SSO)	Dean Malte	
Corporate Safety Officer	Bert Drews	415-243-2526

[1] The local fire department prefers the public use 911 to assure the proper assistance in case of accident or injury.
[2] Attach written directions and map showing route to hospital.

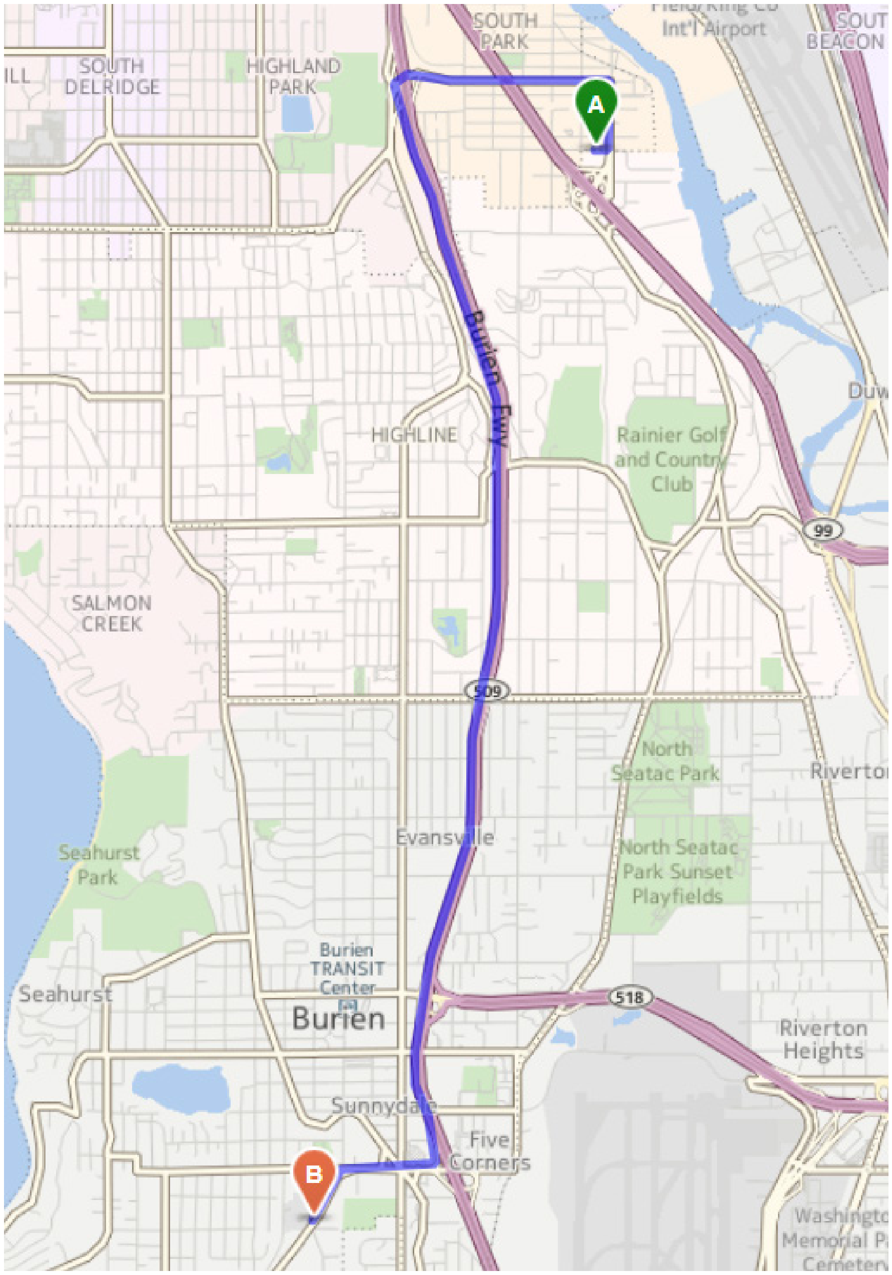
Project Team Members Participating in Field Activities

Name	Affiliation	Responsibility	Signature
Jessica Faragalli	Kennedy/Jenks	Fieldwork / SSO	
Dean Malte	Kennedy/Jenks	Fieldwork / SSO	

Approvals

	Name	Signature/Date
Project Manager	Ty Schreiner	
Regional Safety Representative (RSR)	Gregg Bryden	
Site Safety Officer (SSO)	Jessica Faragalli	

CC: Project File
Office Representative



Directions:
Head east on S. Director Street.
Left on 14th Ave S;
Left on S. Cloverdale St.;
Left onto WA-509 S toward Burien;
Exit S. 160th Street and turn right;
Left onto Sylvester Road SW;
driveway into hospital complex on the right

Tables

Table 1: Chemicals Detected In Groundwater Monitoring Samples

Chemical	Maximum Concentrations (µg/l)	Sample Location
TPH[a] (DRO)[b]	2,640	MW-6 (12/2005)
TPH (ORO)[c]	1,320	MW-6 (12/2005)
Arsenic	35.7	MW-6 (7/2010)
Total Chromium	497,000	MW-5 (12/2005)
Hexavalent Chromium (Cr VI)	450,000	MW-5 (12/2005)
Trivalent Chromium (Cr III)	61,000	MW-5 (12/2005)
cis-1,2-Dichloroethene	144	GP6 (6/2005)
Lead	57	MW-1 (3/1990)
Trichloroethene (TCE)	1,130	GP6 (6/2005)
Vinyl Chloride (VC)	16.5	GP13 (12/2005)

(a) Total petroleum hydrocarbon
(b) Diesel-range organics
(c) Heavy oil-range organics

µg/L = micrograms per liter

Table 2: Chemicals Detected in Soil Samples

Chemical	Maximum Concentrations (mg/kg)	Sample Location
TPH[a] (DRO)[b]	5,270	GP21 – 6.5 feet bgs[c] (2005)
TPH (ORO)[d]	19,900	GP21 – 6.5 feet bgs (2005)
Arsenic	9.45	GP13 – 1 foot bgs (2005)
Total Chromium	7,470	WP-8 – unknown depth (1993)
	6,750	GP32 – 1 foot bgs (2005)
Hexavalent Chromium (Cr VI)	3,500	GP32 – 1 foot bgs (2005)
Trivalent Chromium (Cr III)	3,250	GP32 – 1 foot bgs (2005)
Trichloroethene (TCE)	1.16	GP6 – 14.5 foot bgs (2005)

(a) Total petroleum hydrocarbon
(b) Diesel-range organics
(c) Below ground surface
(d) Heavy oil-range organics

mg/kg = milligrams per kilogram

Table 3: Chemical Allowable Exposure Values and Exposure Symptoms

Chemical	TLV-TWA[(a)]	PEL[(b)]	Acute Exposure Symptoms[(c)]	Target Organs[(c)]
Diesel and Oil Range Hydrocarbons	None Developed	None Developed	Eye irritation, pulmonary function changes; [potential occupational carcinogen]	Eyes, respiratory system
Trichloroethylene	100 ppm	100 ppm	irritation eyes, skin; headache, visual disturbance, lassitude (weakness, exhaustion), dizziness, tremor, drowsiness, nausea, vomiting; dermatitis; cardiac arrhythmias, paresthesia; liver injury; [potential occupational carcinogen]	Eyes, skin, respiratory system, heart, liver, kidneys, central nervous system
Chromium (Cr III, Cr VI)	0.5 mg/m^3	1 mg/m^3	irritation eyes, skin; lung fibrosis (histologic)	Eyes, skin, respiratory system
Arsenic	0.01 mg/m^3	0.01 mg/m^3	Ulceration of nasal septum, dermatitis, gastrointestinal disturbances, peripheral neuropathy, resp irritation, hyperpigmentation of skin, [potential occupational carcinogen]	Liver, kidneys, skin, lungs, lymphatic system
1.2-dichloroethene	200 ppm	200 ppm	irritation eyes, corneal opacity; central nervous system depression; nausea, vomiting; dermatitis; liver, kidney, cardiovascular system damage; [potential occupational carcinogen]	Eyes, skin, kidneys, liver, central nervous system, cardiovascular system
Vinyl Chloride	1 ppm	1 ppm	inhalation, skin and/or eye contact (liquid)	Liver, central nervous system, blood, respiratory system, lymphatic system
Selenium	0.2 mg/m^3	0.2 mg/m^3	Irritation eyes, skin, nose, throat; visual disturbance; headache; chills, fever; dyspnea (breathing difficulty), bronchitis; metallic taste, garlic breath, gastrointestinal disturbance; dermatitis; eye, skin burns; in animals: anemia; liver necrosis, cirrhosis; kidney, spleen damage	Eyes, skin, respiratory system, liver, kidneys, blood, spleen

(a) TLV - TWA = Threshold Limit Value - 8 hr. Time Weighted Average
American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLV) and Biological Exposure Indices for 1997.
TLV - TWA reported in ppm represents parts of vapor per million parts of air by volume at 25°C and 760 torr. TLV - TWA reported in mg/m^3 represents milligrams of substance per cubic meter of air.
(b) PEL = Federal OSHA (29 CFR 1910 Subpart Z) Permissible Exposure Level based on 8 hour time weighted average.
(c) Source: U.S. Department of Health and Human Services. NIOSH Pocket Guide to Chemical Hazards. June 1994. Sittig, Marshall. 1985. Handbook of Toxic and Hazardous Chemicals and Carcinogens. Park Ridge, New Jersey. Noyes Publications.
(d) "Skin" notation indicates route of exposure through cutaneous absorption.

Table 4: Decontamination Procedures to be Performed in Contamination Reduction Zone

Station	Description
1	**Equipment Drop** Deposit equipment used onsite (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, a cool down station may be set up within this area.
2	**Outer Garment, Boots, and Gloves Wash and Rinse** Scrub outer boots, outer gloves and splash suit with decon solution or detergent water. Rinse off using copious amounts of water.
3	**Outer Boot and Glove Removal** Remove outer boots and gloves. Deposit in container with plastic liner.
4	**Canister or Mask Change** If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
5	**Boot, Gloves and Outer Garment Removal** Boots, chemical-resistant splash suit, inner gloves removed and deposited in separate containers lined with plastic.
6	**Face Piece Removal** Facepiece is removed. Avoid touching face with fingers. Facepiece is deposited on plastic sheet.
7	**Field Wash** Hands and face are thoroughly washed. Shower as soon as possible.

Appendix D

Quality Assurance Project Plan

Appendix D: Quality Assurance Project Plan

The following quality assurance project plan (QAPP) describes the data quality objectives (DQOs) and measures necessary for sample collection and analysis conducted as part of the Remedial Investigation/Feasibility Study (RI/FS) at the former Precision Engineering facility (Site) located at 1230 South Director Street, Seattle, Washington.

D.1 Quality Assurance Objectives for Measurement Data

Quality assurance (QA) objectives are prescribed to provide reliability and accuracy of measurement data, and apply to all aspects of sample handling, analysis, data management, and reporting. QA objectives for accuracy, precision, completeness, representativeness, and comparability are presented in this section. In addition, detection limit requirements based on Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA) cleanup levels are outlined in this section.

Analytical methods and procedures referenced in MTCA will be used to provide consistent results of known and documented quality and to ensure that data are accurate, precise, comparable, and legally defensible. The following analyses/constituents will be conducted on samples collected at the site: volatile organic compounds (VOCs), Resource Conversation and Recovery Act (RCRA) metals (up to eight metal constituents), hexavalent chromium (CrVI), total petroleum hydrocarbons (TPH) as diesel-range organics, as well as aromatic and aliphatic hydrocarbon fractions (for soil gas samples).

D.1.1 Accuracy

Accuracy refers to how close a measurement is to the true value. It is represented by percent recovery of an analyte that has been used to spike a field sample at a known concentration prior to analysis. For spiked samples, the accuracy is defined as the percent recovery:

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

Where:

%R	=	Percent Recovery
SSR	=	Spiked Sample Result
SR	=	Sample Result
SA	=	Spike Added

Matrix spike/matrix spike duplicates, surrogate recoveries, and laboratory check samples will be used to monitor accuracy.

D.1.2 Precision

Precision is an evaluation of the reproducibility of a set of measurements. Precision can be better defined as the variability of a group of measurements compared to their average value. Variability for environmental monitoring programs contains both an analytical component and a field component. Analytical precision is evaluated by the analyses of laboratory duplicate samples and can be mathematically expressed as the relative percent difference (RPD) between the duplicate sample analyses (e.g., primary sample and laboratory duplicate, or matrix spike and matrix spike duplicate).

Field duplicate samples will be submitted to the laboratory as a means to determine field variability. These samples will be collected and analyzed at a frequency of 10 percent of the samples for each matrix, or one each per day, whichever is more frequent.

QA objectives (control limits) for laboratory duplicate RPDs are described in the specific analytical method and the laboratory's QA manual. RPD is calculated using the following equation:

$$RPD = \frac{(S - D)}{\left(\frac{(S + D)}{2}\right)} \times 100$$

Where:

S	=	First (primary) sample result
D	=	Second (duplicate) sample result

D.1.3 Completeness

Completeness describes the percentage of measurements that meet QA acceptance criteria for the requested determinations. Measurement completeness (C) can be defined as the ration of acceptable measurements obtained to the total number of planned measurements for an activity.

Percent completeness is defined as:

$$C = \frac{M_a}{M_t} \times 100$$

Where:

M_a	=	Number of acceptable data per target QC limits
M_t	=	Total number of data points.

The goal for measurement completeness is 100 percent.

D.1.4 Representativeness

Representativeness concerns the degree to which sample data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Sampling locations are selected on both a systematic and biased sampling basis in an attempt to spatially cover the site and to obtain more data in areas where historical data indicate the highest contaminant concentrations. Sampling locations and a discussion for selecting those sampling locations are presented in the work plan.

D.1.5 Comparability

Comparability is a qualitative QA criterion that expresses the confidence in comparing one data set with another. Comparability among data sets is achieved through the use of similar sampling procedures and analytical methods. Sampling procedures will be performed in accordance with those referenced in Section D.2. Analytical procedures will be conducted according to guideless contained in standard EPA (or equivalent) methods. Standard Operating Guidelines (SOGs) for collecting samples and recording field measurements are developed in accordance with EPA-accepted methods, where appropriated and referenced in the SOGs presented in Appendix B.

D.1.6 Reporting / Detection Limits

At a minimum, detection limit requirements are based on applicable Ecology MTCA cleanup levels (Ecology 2007). Detection limits for constituents not having cleanup levels are based on method or laboratory routine detection limits. Method reporting limits for soil gas samples will meet MTCA screening levels (Ecology 2009) to the extent practicable based on individual laboratory capabilities. MTCA cleanup levels for soil, groundwater, and soil gas are noted in the work plan and in Table 1.

D.2 Sampling Procedures

The work plan describes sampling locations, frequencies, and analytical methods for all sample matrices. Sample collection and field measurement procedures for subsurface soil, groundwater, and soil gas are also described in the work plan. In addition, SOGs for sample collection are presented in Appendix B. Pertinent field measurements will be presented in the RI/FS report.

D.3 Sample Handling

Sample handling and documentation are vital aspects of environmental investigations. Samples must be collected and placed in appropriate sample containers, properly preserved and stored, and be traceable from the time of sample collection until sample data are presented in the RI/FS report. Therefore, written records (e.g., chain-of-custody and field sampling forms, logbooks, etc.) must exist for each sample throughout sample collection, transport, storage, and analytical activities. SOGs for sample handling are included in Appendix B.

D.3.1 Sample Containers, Preservatives, and Holding Times

Sample analyses, matrices, method numbers, containers, preservation methods, and holding times associated with each analysis to be performed will be in accordance with MTCA regulations and the appropriate test method criteria. Samples will be preserved as specified in the applicable test method.

D.3.2 Sample Custody

The key aspect of documenting sample custody is recordkeeping. A field logbook will be maintained to document the collection of every sample. At the time of sampling, the appropriate sample container will be selected and the sample number for each sample will be recorded on the sample log form by the sampler. Any QA/QC samples collected at this time will also be noted in the field logbook.

Sample labels will be filled out with waterproof ink at the time of sample collection. Sample containers will be labeled with the following information:

- Source
- Sample location or sample identification
- Sample type (e.g., grab or composite)
- Sample depth
- Analyses
- Preservatives
- Sampling date and time
- Name (or initials) of the sampler.

After each sample container is filled, a custody seal may be placed over the container. The container will be placed immediately on ice in a cooler for temporary sample storage (soil gas samples will not be chilled, and will be handled in accordance with Kennedy/Jenks Consultants SOGs presented in Appendix B). At the end of each day, and prior to the transfer of the samples offsite, chain-of-custody entries will be made for all samples. The chain-of-custody form will include the sample identification, sample type, date and time of collection, the specific analytical requests for that sample, and the signature of the sample collector. When more than on chain-of-custody analysis request form is needed, the forms will be sequentially numbered.

All samples will be transmitted to the laboratory with completed chain-of-custody analysis request forms. Copies of all forms will be retained by Kennedy/Jenks Consultants. Original chain-of-custody forms will remain with the sample during storage and analysis.

D.3.3 Sample Packaging and Storage

Prior to shipment, sample containers will be securely packaged inside coolers or appropriate shipping containers. As appropriate, samples will be protected using suitable packing material. Ice will be placed in coolers to keep samples cold [approximately 4 degrees Celsius (°C).] Packing materials will be added to fill coolers completely and sample containers will be secured in an upright position.

The original chain-of-custody analysis request forms will be enclosed in plastic and placed inside the shipping container. The container will be closed and properly secured for transport or shipment to the analytical laboratory. A custody seal may be affixed and secured with tape over the cooler or appropriate shipping container in such a way that the custody seal must be broken to open the container. Use of custody seals will ensure that samples are not tampered with after collection.

All samples will be packaged and shipped (or transported) to the analytical laboratory according to U.S. Department of Transportation (DOT), commercial carrier regulations, and SOGs presented in Appendix B.

D.3.4 Laboratory Documentation

The sample custodian at the laboratory will sign the chain-of-custody form upon receipt of the samples and note the condition of each sample received upon entry of all samples into the laboratory data management system. The custody seals on coolers and sample containers will also be inspected. Any discrepancies will be promptly reported by the laboratory to Kennedy/Jenks Consultants.

D.4 Calibration Procedures

All field instruments will be operated, calibrated, and maintained by qualified personnel, according to manufacturer's guidelines and recommendations. At a minimum, instruments will be calibrated or calibration-checked before use each day, or more frequently as necessary. Field maintenance and calibration records will be recorded in the logbook designated for equipment calibrations and maintenance.

Laboratory instruments will be calibrated and maintained in accordance with requirements set forth in the test method(s), in the laboratory's QA manual, and in agreement with normal operating standards associated with good laboratory practices.

D.5 Analytical Procedures

Analytical methods and procedures will be conducted as specified under MTCA regulations and in accordance with the laboratory's QA manual.

D.6 Data Reduction, Validation, and Reporting

Field and laboratory analytical procedures and results must be documented in detail and contain sufficient QC results to allow reviewers and end users of data to determine its quality.

During implementation of the work plan, Kennedy/Jenks Consultants personnel will be responsible for maintaining records, including field logbooks, sample identification and documentation, and sample locations. Records should be sufficiently detailed so the field events and sample locations can be reconstructed. Kennedy/Jenks Consultants qualified personnel will oversee field measurements and data recording to ensure that results are valid.

The laboratory performing analyses for this project will be required to submit data that are supported by sufficient backup information and QA results to enable reviewers to determine the quality of the data. A data package will consist of the following information, where applicable:

- Environmental sample results (including dates of extraction/preparation and analysis)

- Method blank data results
- Spike and spike duplicate results (e.g., surrogate spike, matrix spike), concentrations of spiking compound(s), percent recovery, and control limits
- Duplicate result(s), relative percent difference, and control limits.

D.6.1 QA Review and Validation

Data generated by the laboratory will undergo a QA data validation by a Kennedy/Jenks Consultants QA officer. All data will be reviewed to evaluate procedural compliance to QA objectives (e.g., chain-of-custody records, sampling equipment, sample containers, and preservation methods). In addition, technical compliance will be reviewed to assess the laboratory's performance in meeting the QC specifications for detection limits, accuracy, precision, and completeness as outlined in the specific test methods.

A general overview of the QA objectives includes review of the following items:

- Sample tracking procedures
- Sample containers and preservation techniques
- Chain-of-custody forms.

A complete data validation as described in EPA's Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA 1999) may be conducted. Where applicable, a confirmatory data validation will be based only on selected requirements described in the functional guidelines. QC objectives identified in the guidelines and laboratory established control limits will be evaluated. The confirmatory data validation will consist of the following components:

- Verify holding times.
- Verify laboratory method blank samples [verify that analytes were not present in method blank samples and that a blank was analyzed every 20 samples (or more often) for each matrix].
- Verify that matrix spike(s) and matrix spike duplicate(s) were analyzed every 20 samples for each matrix, or at least for each batch of samples, where applicable, and that control limits were met.
- Verify that surrogate percent recoveries met laboratory established control limits.
- Verify that laboratory check samples, if analyzed, met control limits.
- Verify that laboratory duplicate samples were analyzed every 20 samples for each matrix, or at least for each batch of samples, where applicable, and that control limits were met.

If data do not meet required criteria, they will be flagged with data validation qualifiers as specified under the action portion of each requirement of the functional guidelines (EPA 1999). The findings from the confirmatory data validation for each analysis will be submitted with the RI/FS report in a Data Validation Summary Report.

D.7 Internal QC Checks

QC check samples will be assessed for both field and laboratory operations to ensure maximum overall precision and accuracy throughout the project. Field QC check samples will include field duplicate and blank samples. Comparison of QC samples against laboratory QC parameters and criteria will be completed during the data validation process.

D.7.1 Field Duplicate Samples

Field duplicate samples are designed to monitoring overall sampling and analytical precision. For a given matrix, approximately one field duplicate will be collected for every 10 samples. Field duplicate samples will be collected from randomly selected locations, and will be treated as a separate sample from the original (assigned a unique sample number) and not identified to the laboratory as a duplicate. Field duplicates will be documented as such in the field logbook.

D.7.2 Blank Samples

At least one type of blank sample (e.g., rinsate or trip) will be collected for each day that water samples are collected. Rinsate blanks will be collected when equipment will be reused. All blanks will be collected, preserved, labeled and treated like the other samples. They will be sent to the laboratory for analysis, and the type of blank sample(s) will be noted in the field logbook.

D.7.2.1Rinsate Blanks

Rinsate blanks are collected to monitor the effectiveness of decontamination procedures and to identify potential cross-contamination between sampling locations. Rinsate blanks will be collected when sampling equipment is being reused during a given sampling event. The rinsate blank will be collected after decontamination and before use at the subsequent sampling location. A rinsate blank is collected by rinsing decontaminated sampling equipment with distilled or deionized water and placing the collected water in an appropriate container with preservative, as necessary. Rinsate blanks will be analyzed for the same parameters as the environmental samples.

D.7.2.2Trip Blanks

Volatile organic samples are susceptible to contamination by diffusion of organic chemicals of concern through the septum of the sample vials. Therefore, trip blanks will be collected and analyzed to monitor for possible sampling contamination during shipment. Trip blanks will be prepared by the laboratory by filling volatile organic analysis (VOA) vials with organic-free water and shipping the blanks with sample containers. Trip blanks accompany the sample containers through collection and shipment to the laboratory and are stored with the samples. Trip blanks will be collected for VOCs whenever a sample (groundwater or soil) within a batch is being analyzed for VOCs.

D.7.3 Laboratory QC Evaluation

The analytical laboratory will generate sufficient documentation using recommended methods to permit a determination of data quality. Analytical data will be evaluated by the laboratory based on criteria set forth in the test method(s) and the laboratory's QA manual.

The laboratory will evaluate specified method or laboratory established control limits for surrogate analyses, matrix spike/matrix spike duplicate analyses, duplicate analyses, and other analyses with control limits. Laboratory control limits should be addressed in the laboratory QA manual.

During confirmatory data validation, analytical results will be evaluated by a Kennedy/Jenks Consultants QA officer against the data quality objectives specified in the selected analytical test methods.

D.8 Corrective Action

Deviations from established QA criteria or from procedures outlines in the QAPP may require corrective action for both field and laboratory activities.

Qualified Kennedy/Jenks Consultants personnel will be responsible for corrective actions during the field investigation(s). Any correct actions taken will be noted in the field logbook, and will be documented in a report to the Kennedy/Jenks Consultants project manager.

The laboratory will be responsible for implementing corrective action for analytical procedures. For the specific analytical method(s), corrective action procedures are described in the method or in the laboratory's QA manual. If the QC data are not acceptable, the cause will be determined and corrected. Corrective actions that affect the integrity of the analytical data will require reanalysis of the affected samples or flagging of these data in the final data report. A corrective action report will be requested from the laboratory describing the actions taken and the resolution.

References

U.S. Environmental Protection Agency. 1999. Contract Laboratory Program National Functional Guidelines for Organic Data Review. EPA 540/R-99/008. U.S. EPA, Office of Emergency and Remedial Response, Washington, DC.

Washington State Department of Ecology. 2007. Model Toxics Control Act Statute and Regulation. Publication No. 94-06. Revised November 2007.

Washington State Department of Ecology. 2009. Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action, Review Draft. Publication No. 09-09-047. October 2009.