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Compliance Monitoring Plan and Sampling and Analysis Plan

Cornet Bay Marina, Whidbey Island, Washington

January 2014

Prepared for

Washington State
Department of Ecology
Toxics Cleanup Program
3190 160th Avenue SE
Bellevue, Washington 98008-5452

K/J Project No. 1396010.00

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List of Acronyms

µg/L	microgram per liter
ARAR	applicable, relevant, and appropriate requirement
BTEX	benzene, toluene ethylbenzene, and xylene
CAP	Cleanup Action Plan
CMP	Compliance Monitoring Plan
COC	constituent of concern
CUL	cleanup level
CWA	Clean Water Act
DOT	U.S. Department of Transportation
DQO	data quality objective
DRO	diesel-range organics
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EPA	United States Environmental Protection Agency
Fe^{+2}	ferrous iron
GAC	granular-activated carbon
GRO	gasoline-range organics
HASP	Health and Safety Plan
IDW	investigation-derived waste
mg/kg	milligram per kilogram
mg/L	milligram per liter
MTCA	Model Toxics Control Act
NO_3	nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric turbidity unit
NWTPH-Dx	Northwest Total Petroleum Hydrocarbons as Diesel Extended
NWTPH-G	Northwest Total Petroleum Hydrocarbons as Gasoline
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCS	petroleum contaminated soil
PID	photoionization detector
PPE	personal protection equipment
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
SIM	select ion monitoring
SO_4^{-2}	sulfate
SQUIRT	Screening Quick Reference Tables (NOAA)
TCLP	Toxicity Characterization Leaching Procedure
UST	underground storage tank
VOC	volatile organic compound
WAC	Washington Administrative Code

Section 1: Introduction and Background

This Compliance Monitoring Plan (CMP) and Sampling and Analysis Plan (SAP) describes specific activities and requirements for compliance monitoring and sampling and analysis of environmental media associated with the cleanup action planned for the Cornet Bay Marina property located at 200 Cornet Bay Road in Oak Harbor, Washington (site) (refer to Figure 1). This document also provides a Quality Assurance Project Plan (QAPP) for the cleanup action.

This document is intended to be used in conjunction with other project documents including the Project Manual (i.e., bid specifications) (Ecology 2013), Cleanup Action Plan (CAP) (Kennedy/Jenks Consultants 2013b), Engineering Design Report (EDR) (Kennedy/Jenks Consultants 2013c), and site Health and Safety Plan (HASP) (to be prepared under separate cover). Therefore, detailed descriptions of all construction tasks are not included in this document. Refer to the above-referenced documents for complete descriptions of project tasks.

This CMP/SAP has been prepared to satisfy the requirements of the Model Toxics Control Act (MTCA) regulations published in Washington Administrative Code (WAC) 173-340-410 and 173-340-820 (Ecology 2007). The site is listed on the Washington State Department of Ecology's (Ecology's) Confirmed or Suspected Contaminated Sites List (CSCSL) and Hazardous Sites List as Deception Bay Marina (also known as Cornet Bay Marina). Ecology has assigned the site a hazard ranking of 5 (Ecology 2002).

1.1 Project Description

A remedial action is planned to address petroleum hydrocarbon-affected soil and groundwater at the Cornet Bay Marina site. Hydrocarbons detected in soil and groundwater are attributed to a release from ruptured underground fuel lines at the marina in January 1989.

In January 1993, Ecology entered into Consent Decree No. 93-2-00018-3 with Mr. Milton A. Woods, owner of Cornet Bay Marina, to perform a remedial investigation and feasibility study (RI/FS) and cleanup action at the site. The RI/FS was finalized in July 2013 (Kennedy/Jenks Consultants 2013a), and the remedial action is expected to begin in the late 2013 to early 2014).

The site history and planned cleanup action are described in detail in the RI/FS, CAP, and EDR. A general summary overview is provided below.

1.2 Site Background and Cleanup Action Overview

The site is an active marina (including docks, a wooden bulkhead, fueling facilities, and supporting facilities including a general store) that was constructed in the early 1960s. Four underground storage tanks (USTs) containing gasoline and diesel fuel were installed at the site in 1964, including associated underground piping.

In January 1989, a release from ruptured underground piping associated with the USTs resulted in impacts to soil and groundwater across most of the site. The primary constituents of concern (COCs) associated with the release include gasoline-range organics (GRO); diesel-range organics (DRO); and benzene, toluene, ethylbenzene, and xylenes (BTEX).

A series of investigations were performed at the site between 1990 and 2011 to identify the nature and extent of impacts to environmental media related to the release from the USTs. Characterization of COC impacts at the site was completed in the RI performed in 2011. Based on the results of the RI, a FS was performed and a cleanup alternative was selected. Details of the 2011 RI/FS including site investigation history, nature, and extent of impacts to environmental media, and evaluation of cleanup alternatives are included in the RI/FS report (Kennedy/Jenks Consultants 2013a).

The selected cleanup alternative includes replacement of a wooded bulkhead along the northern property boundary with Cornet Bay, excavation and offsite disposal of affected soil materials, and confirmational groundwater monitoring. Detailed requirements and specifications for the cleanup action are presented in the CAP, EDR, and Project Manual documents referenced above.

The anticipated excavation area, monitoring well locations, and general site layout are shown on Figure 2.

1.3 Purpose of the CMP

The purpose of this CMP is to satisfy the requirements of WAC 173-340-410 and those established under the 1993 Consent Decree.

The CMP provides a description of the compliance monitoring requirements for the cleanup action, including protection monitoring, performance monitoring, and confirmational monitoring as described in WAC 173-340-410:

- Protection Monitoring. Protection monitoring is performed during the cleanup action to confirm that human health and the environment are adequately protected during the construction and maintenance period of the cleanup action. Protection monitoring for the Cornet Bay Marina site is addressed in the site HASP prepared under separate cover.

- Performance Monitoring. Performance monitoring is performed during the cleanup action and includes sampling and analysis of environmental media to ensure that cleanup standards have been attained during the cleanup action (*in situ* and stockpile samples), and includes monitoring for construction quality control (i.e., testing of imported fill materials) and permit compliance (i.e., testing of water treatment system discharge to Cornet Bay).

- Confirmational Monitoring. Confirmational monitoring is performed following the cleanup action to confirm the long-term effectiveness of the cleanup action. This includes monitoring of groundwater at the site following completion of the remedial action.

The CMP is presented in Section 3, and includes a summary of the required compliance monitoring sampling during and after the cleanup action.

1.4 Purpose of the SAP

The purpose of this SAP is to satisfy the requirements of WAC 173-340-820 and those established under the 1993 Consent Decree. The SAP provides a description of the sample collection, handling, and analysis procedures to be used to implement the CMP at the site, including quality assurance and quality control (QA/QC) requirements (i.e., the QAPP).

Specific information required by WAC 173-340-820 and provided in this document includes:

- Purpose and objectives of the data collection including QA/QC.
- Organization and responsibilities for sampling and analysis activities.
- Requirements for sampling activities:
    - Project schedule
    - Rationale for location and frequency of sampling and parameters to be analyzed
    - Procedures for installation of sampling devices
    - Procedures for sample collection and handling including decontamination for equipment and personnel
    - Procedures for management of waste materials generated by sampling activities
    - Description of QA/QC samples
    - Sample labeling, packaging, and chain-of-custody protocols
    - Procedures for splitting samples.
- Procedures for sample analyses and reporting including laboratory detection/reporting limits, analytical methods, QA/QC procedures, data reporting, and data validation.

The SAP is presented in Section 4, and includes a discussion of the rationale and requirements (number of samples and analyses) for sampling of environmental media during and after the cleanup action. Organization and responsibilities for sampling and analysis activities, and the project schedule, are discussed in Section 2.

1.5 Document Organization

This document consists of five sections and three appendices:

Section 1– Introduction and Background

Section 2 – Organization and Responsibilities

Section 3 – Compliance Monitoring Plan

Section 4 – Sampling and Analysis Plan

Section 5 – References

Appendix A –Administrative Order 10404 for Water Treatment System Discharge issued by Ecology 11 December 2013.

Appendix B – Standard Operating Guidelines (SOGs).

- Environmental Data Collection
- Borehole Logging
- Surface and Shallow Soil Sampling
- Boring and Subsurface Soil Sampling
- Test Pit / Excavation Sampling
- Well Construction and Development
- Measuring Groundwater Levels
- Groundwater Sampling
- Sample Packaging and Shipping
- Equipment Decontamination
- Personnel Decontamination
- Handling and Disposal of Investigation-Derived Waste

Appendix C – Quality Assurance Project Plan (QAPP)

Section 2: Organization and Responsibilities

As previously discussed, the cleanup action at the site is being performed under a Consent Decree and managed by Ecology. The primary parties responsible for implementation of the cleanup action and compliance monitoring include the following:

Ecology: Project Coordinator
Jing Liu
Northwest Regional Office, Bellevue, Washington
425-649-4310

Consultant: Kennedy/Jenks Consultants
Ty Schreiner
Federal Way, Washington
253-835-6400

Contractor: Glacier Environmental Services, Inc.
Lauren Miles Golembiewski
Mukilteo, Washington
425-355-2826

2.1 Compliance Monitoring Responsibilities

The general areas of responsibility for the primary parties that will be involved with implementation of the cleanup action, with respect to compliance monitoring, are summarized below:

- **Ecology.** The cleanup action is being managed by Ecology under a Consent Decree. Ecology is also the primary regulatory agency providing oversight of the project. Ecology will provide review and approval of planned sampling frequency and analytical tests, and review of analytical results (during the cleanup action) for the onsite water treatment system and imported fill materials.

- **Consultant.** The consultant is responsible for field screening of excavated soil materials to identify the necessary extent of soil excavation and segregation of suspected clean (overburden) soil from that affected by contaminants. The consultant will also perform collection and analysis of performance monitoring and confirmational monitoring samples, and provide oversight for construction activities and sampling performed by the contractor.

- **Contractor.** The remediation contractor is responsible for performing construction-related activities at the site as described in the EDR and Project Manual. Sampling performed by the contractor is anticipated to include daily and weekly sampling from the onsite water treatment system and chemical sampling of imported fill materials.

Note: This document only describes responsibilities related to sampling and analysis of soil and water samples. Other project responsibilities for each party are discussed in greater detail in other project documents (EDR, CAP, Project Manual, etc.).

2.2 Project Schedule

The remedial action is anticipated to start in late 2013 to early 2014, pending approval of required permits and selection of a remediation contractor. The construction phase of the remedial action is expected to be completed in 5 months of continuous work as outlined below.

Estimated Project Schedule

Project Phases	Estimated Duration
Phase 1. Mobilization, Building Relocation, and Utility Demolition	2 to 3 weeks
Phase 2. Construction of Steel Pile Bulkhead	2 to 4 weeks
Phase 3. Excavation, Removal of Timber Bulkhead, Backfill	6 to 8 weeks
Phase 4. Site Restoration	2 to 3 weeks

Each phase will be completed consecutively. The actual time required to complete the remedial action may vary depending on site conditions, weather conditions, and the volume of soil requiring removal and disposal.

Confirmational groundwater monitoring will be performed following completion of the construction phase of the remedial action. Following the first round of the monitoring event, decisions will be made regarding the need for further monitoring activities to assess site groundwater conditions.

Section 3: Compliance Monitoring Plan

This section describes the compliance monitoring activities that will be performed at the site as part of the remedial action. Compliance monitoring activities identified in this section will fulfill requirements for ongoing monitoring of this remedial action in accordance with MTCA (WAC 173-340-410).

3.1 Protection Monitoring

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

The remediation contractor will have primary responsibility for implementation of the HASP during the construction phase of the cleanup action, including protection monitoring for its personnel, including subcontractors, visitors, and the general public (the marina will remain open during the remedial action). Protection monitoring by the contractor will also include measures, as necessary, for protection of surrounding communities and the environment during construction and will be specified in their site HASP.

Some protection monitoring tasks for the construction phase of the cleanup action (such as breathing space monitoring, for example) may also be performed by the consultant and will be specified in the HASP.

In addition, the consultant will prepare a separate HASP for compliance monitoring tasks to be performed by its personnel during the construction phase and subsequent conformational monitoring phase.

3.2 Performance Monitoring

Performance monitoring tasks associated with the cleanup action are summarized below and are described in greater detail in the SAP presented in Section 4.

- Field screening and collection and laboratory analysis of soil samples from excavation areas to verify that soil with COC concentrations above site cleanup levels has been removed from the site.

- Collection of samples from the water treatment system to be installed and operated onsite during the construction phase of the remedial action. Discharge limits are specified by Ecology in an Administrative Order issued on December 11, 2013. A copy of the Administrative Order is provided in Appendix A. [Note: This sampling is the Contractor’s responsibility; however, to ensure accuracy of the results, the consultant will also perform periodic independent monitoring.]

- Collection and laboratory analysis of soil samples from overburden soil stockpiles to verify that COC concentrations are below the site cleanup levels prior to reuse of the overburden soils as backfill.

- Collection and laboratory analysis of soil samples from impacted soil stockpiles for waste characterization, if required (i.e., if waste cannot be profiled using existing RI data).
- Collection and laboratory analysis of representative samples of imported fill materials for chemical analysis. [Note: This is the contractor's responsibility; however, this sampling may also be performed by the consultant for verification purposes.]

3.3 Confirmational Monitoring

Confirmational monitoring will include collection and laboratory analysis of groundwater samples following completion of the construction phase of the remedial action. Groundwater samples will be collected from existing monitoring wells and new wells to be installed at the end of the construction phase.

Eight of the 10 currently existing monitoring wells are located within the planned excavation area and will be decommissioned prior to soil excavation. Wells MW-7 and MW-9 are located outside the anticipated excavation area and will be decommissioned only if the excavation area is expanded toward the well locations. Following completion of the cleanup action, five new wells will be installed [Note: MW-7 would also be replaced if decommissioned]. Well locations are shown on Figure 2.

Groundwater monitoring events will be performed following completion of the construction phase of the remedial action. Based on the results of the initial groundwater monitoring event, additional monitoring may be needed. The specific wells, analytes, and sampling frequency may be modified for subsequent monitoring events as determined by Ecology.

Confirmational groundwater monitoring is described in greater detail in the SAP presented in Section 4.

3.4 Cleanup Levels

The soil cleanup levels (CULs) for site COCs are based on MTCA Method A/B values for unrestricted land use. For gasoline and diesel, MTCA Method A cleanup levels were used for the protection of direct contact pathway. Because the Method A soil CULs for BTEX were established for protection of potable groundwater and not for direct contact, the MTCA Method B values were appropriately used for BTEX compounds. The Method B soil CULs for direct contact (ingestion only) are protective of onsite workers and patrons at the marina. In addition to the Method B soil CULs, compliance with soil cleanup standards will also be evaluated during future confirmational groundwater monitoring to confirm that groundwater standards, including applicable values based on protection of surface water in Cornet Bay, are achieved [e.g., Clean Water Act (CWA) and National Oceanic and Atmospheric Administration's (NOAA) *Screening Quick Reference Tables* (SQUIRT) values]. If the groundwater standards are met, compliance with soil cleanup standards will be considered to be achieved. If groundwater cleanup standards are not achieved, additional remedial action might be conducted and additional monitoring will be performed until groundwater concentrations are below the groundwater CULs/applicable, relevant, and appropriate requirements (ARARs) identified above.

As groundwater discharges to surface water directly adjacent to the site, the groundwater CUL is based protection of surface water. As surface water is saline and cannot be used as potable water, the primary exposure pathways are consumption of organisms by humans and protection of aquatic organisms. Therefore, groundwater (surface water) cleanup standards for BTEX are based on the CWA (Section 304) values, which are protective of human consumption of aquatic organisms.

To evaluate potential chronic effects to aquatic organisms, NOAA SQUIRT values were used to provide comparison values for site groundwater concentrations. While not promulgated by the EPA or Ecology, the NOAA SQUIRT values provide conservative screening values to evaluate potential ecological effects to organisms in marine environments. The CULs, ARARs, and available screening levels for site COCs are summarized below.

Analyte	Method A/B Soil CUL [milligrams per kilogram (mg/kg)]	Method A Groundwater CUL and Surface Water ARARs [micrograms per liter (µg/L)]	NOAA(a) SQUIRT Values Marine Chronic Effects (µg/L)
GRO	30(b)	800(b)	NA
DRO	2,000(b)	500(b)	NA
Benzene	18(c)	51(d)	110
Ethylbenzene	8,000(c)	2,100(d)	25
Toluene	6,400(c)	15,000(d)	215
Total Xylenes	16,000(c)	1,000(d)	NA

Notes:

(a) Value based on NOAA *Screening Quick Reference Tables* (SQUIRT).
(b) Method A CUL. The GRO value is based on the presence of benzene.
(c) CUL is based on Method B standard for direct contact (ingestion only).
(d) Value based on Clean Water Act - CWA 304.

Section 4: Sampling and Analysis Plan

This section presents the compliance monitoring SAP for the Cornet Bay Marina remedial action including analytical methods, sampling frequencies and analyses, sampling methodologies, waste materials handling, sampling QA/QC, decontamination procedures, and discussion of other field activities and methodologies.

The anticipated excavation areas, monitoring well locations, and overall site layout are shown on Figure 2.

4.1 Analytical Methods and Laboratories

This section provides a description of the anticipated analytical testing that will be performed during the remedial action and subsequent monitoring, and the analytical testing facilities that will be used.

4.1.1 Analytical Methods

The following analytical methods will be used for soil, groundwater, and water treatment system discharge samples. Information regarding the specific analyses and sampling frequency for different media is presented in the following sections. Sample container, preservative, and holding time requirements for the analyses listed below are provided in Table 1. Additional information regarding the analytical method reporting limit requirements and laboratory QA/QC is provided in the QAPP presented in Appendix C.

Most samples will be analyzed for the primary COCs including:

- GRO using Ecology Method Northwest Total Petroleum Hydrocarbons as Gasoline (NWTPH-G).
- BTEX using United State Environmental Protection Agency (EPA) Method 8260B or 8021B.
- DRO using Ecology Method Northwest Total Petroleum Hydrocarbons as Diesel Extended (NWTPH-Dx) with silica gel cleanup.

Additional analyses will be required for evaluation of water treatment system discharge including the following [based on National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit Benchmarks as specified in the example Administrative Order in Appendix A]:

- Turbidity using analytical method SM1230 or a portable field meter.
- pH using an onsite pH Meter.

Additional analyses may be required for characterization of waste materials and imported fill materials (to confirm the contractor's results) including the following:

- Resource Conservation and Recovery Act (RCRA) Eight metals using EPA Method 6000/7000 series.

- Polychlorinated biphenyls (PCBs) using EPA Method 8082B.
- Volatile organic compounds (VOCs) using EPA Method 8260C.
- Polycyclic aromatic hydrocarbons (PAHs) using EPA Method 8270C in select ion monitoring (SIM) mode where appropriate.
- Dioxins and furans using EPA Method 1613B.
- Toxicity Characteristic Leaching Procedure (TCLP) RCRA Eight metals extracted using EPA Method 1311 and analyzed using EPA Method 6000/7000 series (if required by the waste disposal facility).

Some groundwater samples will also be analyzed for natural attenuation parameters including the following (based on Ecology's *Guidance on Remediation of Petroleum-Contaminated Ground Water by Natural Attenuation* dated July 2005):

- Nitrate (NO_3^-) using EPA Method 353.2 / SM 4500.
- Sulfate (SO_4^{-2}) using EPA Method 375.2 / SM 4500.
- Sulfide by EPA Method 376.2 / SM 4500.
- Dissolved manganese and iron using EPA Method 6000 series.
- Alkalinity using EPA Method 310.1.
- Methane (dissolved) using EPA Method RSK-175.
- Ferrous iron (Fe^{+2}) using a field colorimeter (e.g., HACH or similar).
- Field parameters including dissolved oxygen, redox potential, pH, specific conductivity, and temperature measured in the field using portable meter(s) equipped with appropriate probes either down-well or with a flow-through cell.

4.1.2 Analytical Laboratories

Most of the soil sample analyses for the construction phase of the cleanup action will be performed by an onsite mobile laboratory. Using an onsite laboratory will provide for rapid turn-around of performance monitoring samples for evaluation of the effectiveness of the cleanup action. Some soil samples (split samples) will also be submitted to an offsite fixed laboratory for QA/QC purposes (refer to Section 4.7). Other QA/QC samples such as filed duplicates and blanks (rinsate, field, trip, or others as appropriate) may be submitted to either the onsite mobile laboratory or offsite laboratory depending on required turn-around and capacity of the onsite laboratory.

Soil samples collected from stockpiles for characterization as waste or backfill (overburden soil) may be submitted to either the onsite mobile laboratory or offsite laboratory depending on required turn-around and capacity of the onsite laboratory.

Water samples collected from the onsite water treatment system will be submitted to the mobile laboratory for rapid turn-around.

Groundwater samples collected from onsite wells for conformational monitoring will be submitted to an offsite laboratory.

All laboratories (mobile and offsite) will be accredited by Ecology for the analyses being performed. Qualifications for the selected laboratories will be submitted to Ecology for review and approval prior to the start of onsite work.

Field measurements will be made using portable instruments appropriate for the parameters being measured and will be calibrated daily (refer to Section 4.3.3).

4.2 Frequency of Sampling and Sampling Methodologies

This section presents the anticipated sampling frequency for sampling of environmental media for compliance monitoring during the remedial action, and provides an overview of sampling methodologies.

Specific sampling methodologies for various sample types are described in detail in the SOGs provided in Appendix B and referenced below where applicable.

4.2.1 Excavation Soil Sampling

Soil samples for performance monitoring will be collected from the excavation floor and sidewalls once contaminated soil has been removed based on field screening results and observations (described in Section 4.3).

Sidewall samples will be collected at a maximum spacing of 30 feet between sample locations. The lateral spacing of adjacent sidewall samples may be reduced for areas where contaminant impacts are greatest (i.e., areas of greatest impact) based on field screening observations.

Sidewall sample collection depths will be based on the observed depth of contaminated soil removed from the excavation, and will be collected at the approximate middle of the depth interval that corresponds to the contaminated soil removed in proximity to the sidewall. If the sequence of contaminated soil is greater than approximately 8 feet at a sidewall sample location, sidewall samples may be collected from multiple depths at those locations.

Sidewall samples will not be collected where impacted soil abuts the bulkhead since this material will have been removed and the new bulkhead will act as the sidewall. In lieu of sidewall sampling, excavation bottom samples will be collected from within 5 feet of the bulkhead at these locations.

Excavation bottom samples will be collected on a maximum 30-foot by 30-foot grid (i.e. up to 900 square feet per sample). Additional bottom samples may be collected based on field observations and degree of contaminant impacts to overlying soil. As indicated above, bottom samples will be collected within 5 feet of the bulkhead where soil sidewalls are not present.

Based on the size of the planned excavation area, we anticipate sidewall samples will be collected at approximately 30 locations initially. If cleanup levels are not met at any sidewall locations, additional samples will be collected following excavation of additional soil material.

Based on the size of the planned excavation area, we anticipate bottom samples will be collected at approximately 50 locations initially. If cleanup levels are not met at any bottom locations, additional samples will be collected following excavation of additional soil material.

4.2.2 Water Treatment System Sampling

Samples will be collected from an onsite water treatment system during the construction phase of the cleanup actions. The treatment system will discharge treated water directly to Cornet Bay under an Administrative Order to be issued by Ecology to the selected remediation contractor (the Administrative Order issued is provided in Appendix A). The contractor will have responsibility for compliance with the Administrative Order during construction. The contractor will also secure a Construction Stormwater General NPDES permit.

Design requirements for the water treatment system are included in the Project Manual (Division 31 Earthwork; Section 31 23 19). In general, water primarily derived from excavation dewatering will be passed through a bag filter and then through two canisters of granular activated carbon (GAC) to remove contaminants prior to discharge to Cornet Bay.

Each work day, one water sample will be collected from a sampling port installed between the two GAC canisters. In addition, one sample will be collected from the final effluent discharge point on a weekly basis.

Water treatment system samples will be submitted for laboratory analysis of DRO, GRO, and BTEX. Turbidity and pH will also be measured during each sampling event using calibrated portable field meters. Effluent limits based on the example Administrative Order (Appendix A) include the following:

Analyte / Parameter	Indicator Level (i.e., Discharge Limit)
GRO	250 µg/L
DRO	250 µg/L
BTEX (sum of all)	2 µg/L
Turbidity	25 NTU
pH	6.5 to 8.5 (standard units)

Notes

µg/L = micrograms per liter
NTU = Nephelometric turbidity unit

Additional samples may be collected from the sampling ports or holding tanks to characterize the waste water if effluent limits are exceeded.

A separate binder will be maintained to document all monitoring samples and results (field measurements, laboratory analytical reports, and daily inspection reports).

4.2.3 Overburden Soil Characterization

During excavation activities, overburden soil which does not appear to be impacted by COCs will be stockpiled separately from soil suspected to be contaminated by COCs. Soil samples will be collected from overburden soils and submitted for laboratory analysis to determine if the material is suitable for reuse as backfill onsite based on COC concentrations. Determination of suitability for reuse as backfill will also be based on physical properties as described in the EDR.

We anticipate that excavation will be performed in stages and will include multiple smaller excavation areas within the larger area. The locations and sizes of the smaller excavation areas will be determined by the Contractor. Figure 3 shows the anticipated approximate thickness of overburden soils within the larger planned excavation area. [Note: The overburden thickness areas do not necessarily correspond to the separate excavation areas described above.]

Prior to the start of excavation activities, separate main stockpile areas will be established by the Contractor for onsite storage of overburden soil to be considered for reuse as backfill, and for onsite storage of contaminated soil pending transport offsite for disposal. These stockpile areas will be constructed and maintained as described in the EDR and Project Manual for the duration of the project (i.e., until all excavated soil is transported offsite or reused as backfill).

In addition to the main stockpiles described above, overburden soil will be initially placed in interim stockpiles that will be located within or near each separate excavation area. The interim stockpiles will be situated to facilitate drainage of the soil material back into the excavation (excavation water will be subsequently transferred to the onsite water treatment system). Soil samples will be collected from each interim overburden stockpile for characterization as described in the following sections. Based on the analytical results, interim overburden stockpiles will be moved to either the main overburden stockpile or the contaminated soil stockpile.

The overburden soil excavation and evaluation process is described in greater detail in the following sections.

4.2.3.1 Overburden Soil Excavation and Stockpiling

The general process for assessment, excavation, stockpiling, and characterization sampling of overburden soils at each separate excavation area is described below:

- Existing data will be used as general guidance for overburden soil thickness. The anticipated overburden soil thickness varies based on location, but typically increases toward Cornet Bay. The anticipated overburden thickness in the planned excavation area is shown on Figure 3.

- Field screening of overburden soil will be performed during excavation. Field screening may include visual and olfactory observation, water sheen testing, and photoionization detector (PID) headspace measurements.

- Overburden soil that does not exhibit field indications of COC impacts (i.e., soil that is expected to be chemically suitable for reuse as backfill onsite) will be placed in an interim stockpile area located within or adjacent to the excavation. Other soils (i.e., contaminated soils) will be placed directly into the contaminated soil stockpile area pending transport offsite for disposal.

- Each interim overburden stockpile will be numbered consecutively (i.e., SP1, SP2, etc., or similar) and the location will be documented in field notes and maps. The area of the site from which each interim stockpile was derived will also be documented.

- Soil samples will be collected from each interim stockpile as described below in Section 4.2.3.2.
- Interim stockpile soil samples will be analyzed for GRO, DRO, and BTEX using the analytical methods described in Section 4.1 on an expedited turn-around basis.
- Interim overburden soil stockpiles will be underlain and covered with plastic sheeting pending receipt of analytical results.
- Overburden soils which meet the chemical criteria for reuse as backfill onsite (see Section 4.2.3.3) will be moved to a designated clean overburden soil stockpile area.
- Overburden soils which do not meet the chemical criteria for reuse as backfill onsite will be moved to the designated stockpile area for contaminated soil.

4.2.3.2 Overburden Stockpile Sampling Frequency

The number of samples recommended by Ecology for stockpile characterization, based on the guidelines presented in Ecology's *Guidance for Remediation of Petroleum Contaminated Sites* dated September 2011, is summarized below:

Cubic Yards of Soil	Number of Samples for Chemical Analysis
0 - 100	3
101 - 500	5
501 - 1,000	7
1,001 - 2,000	10
>200	10 + 1 for each additional 500 cubic yards

The quantity of overburden material is estimated to be approximately 6,700 cubic yards based on the size of the excavation area and anticipated thickness of overburden material (refer to Figure 3). Based on Ecology's recommended sampling frequency, a 6,700 cubic yard stockpile would require 20 samples for characterization. However, overburden soil excavation, stockpiling, and sampling will be performed in stages as described above (i.e., it will not be contained in a single, large stockpile). Application of the recommended sampling frequency for each interim overburden soil stockpile could result in a very large number of samples [for example, if each stockpile is 250 cubic yards and is sampled based on the recommended frequency (five samples per stockpile), up to 135 samples could be required].

The typical interim stockpile size is anticipated to be less than 400 cubic yards, but the actual sizes will vary based on the size of each excavation area and field conditions encountered. The sampling frequency for interim stockpiles is as follows:

- For stockpiles less than 50 cubic yards, collect one discrete sample.
- For stockpiles of 50 to 250 cubic yards, divide into two equal sections and collect discrete samples from the center of each section (two samples total).
- For stockpiles of 250 to 400 cubic yards, divide into three equal sections and collect discrete samples from the center of each section (three samples total).

- For stockpiles over 400 cubic yards, add one sample for each additional 150 cubic yards.

Based on the sampling frequencies listed above, a total of approximately 50 to 60 samples would be collected from overburden soil for characterization of potential reuse as backfill material. Based on the estimated total of 6,700 cubic yards of overburden soil, the average sampling rate would be approximately one sample per 125 cubic yards.

4.2.3.3 Overburden Soil Backfill Criteria

Overburden soil will be reused as backfill onsite if chemical and physical properties are suitable. Ecology's *Guidance for Remediation of Petroleum Contaminated Sites* provides guidelines for reuse of petroleum-contaminated soil based on contaminant concentrations. Soil may be reused as backfill onsite anywhere (assuming it is otherwise suitable) if it qualifies as Category 1 Soil, or onsite only above the water table if it qualifies as Category 2 Soil. Petroleum hydrocarbon concentration ranges for Category 1 and Category 2 soils are summarized below:

Analyte	Category 1 Soil (mg/kg)	Category 2 Soil (mg/kg)
GRO	<5	5 to 30
DRO	<25	25 to 200
Benzene	<0.005	0.005 to 0.03
Ethylbenzene	<0.005	0.005 to 6
Toluene	<0.005	0.005 to 7
Total Xylenes	<0.015	0.015 to 9

Note

mg/kg = milligrams per kilogram

Category 1 and Category 2 soils will be placed in separate locations within the main overburden stockpile area (if both are encountered), and the location of each soil type within the main stockpile area will be documented in a field notebook.

Soils that qualify for reuse as backfill onsite (based on chemical composition) may be amended with imported fill to achieve engineering design specifications (grain size distribution, compaction, etc. as indicated in the EDR; imported fill will not be used as a means to "dilute" overburden soil materials).

Soils that do not qualify as Category 1 or 2, or do not meet engineering specifications for backfill, will be disposed offsite in the same manner as the contaminated soils. Because groundwater is shallow at the Site, some Category 2 soil (if any is encountered) may also be transported offsite for disposal.

4.2.4 Waste Characterization Sampling

Sampling for waste characterization may be performed during the remedial action based on the requirements of the selected waste disposal facilities. Ideally, the profiles for disposal waste materials will be established using existing data from RI sampling prior to the start of field activities.

Existing data will be submitted to the waste disposal facilities prior to the start of onsite work; however, it is possible that the facilities will require additional data (i.e., data for additional analytes or for verification of contaminant concentrations). In this case, the number of samples and analytes would be based on the requirements of the disposal facility and could include any of the analyses listed in Section 4.1.1.

Media possibly requiring additional waste characterization sampling are anticipated to include the following:

- Petroleum-contaminated soil (PCS). PCS would initially be stockpiled onsite and soil samples would be collected from the stockpile(s). The characterization samples would be submitted for laboratory analysis on an expedited turn-around basis based on the requirements of the disposal facility. If the profile for PCS disposal is established using prior site data, additional sampling of PCS during the remedial action may not be necessary.

- Excavation water. If effluent from the onsite treatment system does not meet the permit standards (refer to Section 4.2.2), offsite disposal may be required. In this case, samples would be collected from onsite holding tanks for laboratory analysis as required by the disposal facility.

- Drill cuttings. Soil cuttings from monitoring well installation, if not included in the profile for excavated soil, would be sampled for waste characterization as required by the disposal facility.

- Purge water. Well development and sampling purge water may be sampled for waste characterization if analytical data from conformational monitoring is insufficient to establish a waste disposal profile. Samples would be collected from purge water stored temporarily onsite in 55-gallon drums as required by the disposal facility.

- Overburden soil. As indicated in Section 4.2.3, if any overburden soil does not meet the requirements for reuse as backfill onsite, it will be disposed using the profile for PCS.

Sampling and general handing of waste materials are described in the SOGs included in Appendix B.

4.2.5 Imported Fill Materials Sampling

The remediation contractor will request analytical data for all backfill materials being imported to the site and will submit the data, if any is provided, to Ecology for review and approval as described in the EDR and bid specifications. The Consultant will also review analytical data for backfill materials and provide an assessment of the suitability of the material for use as backfill onsite to Ecology.

If the data provided by the supplier is determined by Ecology to be inadequate, or is not available, the contractor shall collect samples of proposed backfill materials for chemical analysis. Analyses performed for each proposed backfill material will be based on data needs identified by Ecology and may include one or more of GRO, DRO, RCRA metals, PCBs, PAHs, and dioxins/furans using the analytical methods specified in Section 4.1.1. The consultant may also independently collect and analyze a limited number of samples to verity the contractor’s results.

For each proposed backfill material, the sampling frequency will be five samples for first 5,000 yards and one for each additional for every 2,000 yards.

For fill materials being used in small quantities (such as pipe bedding) the five samples may be composited, or samples from fill materials that are substantively similar (i.e., derived from the same source but with different processing) may be combined.

4.2.6 Groundwater Monitoring

Following completion of the construction phase of the remedial action, groundwater monitoring will be performed. Groundwater monitoring will include collection of samples for laboratory analysis at six onsite wells including one existing well (MW-7) and five wells to be installed as replacements for existing wells in the excavation area (MW-1R, MW-2R, MW-4R, MW-8R, and MW-10R). [Note: MW-7 may be decommissioned and replaced if the excavation area is expanded to the well location.]

Groundwater monitoring will also include measurement of groundwater levels at all site wells including the six wells to be sampled plus well MW-9 (if it does not need to be abandoned during construction).

Groundwater samples will be collected using low-flow methodology described in the *Groundwater Sampling* SOG and water levels will be measured using an electronic water level meter as described in the *Measuring Groundwater Levels* SOG provided in Appendix B.

4.2.6.1 Primary Contaminants of Concern

Groundwater samples will be analyzed for the primary COCs. The primary COCs include GRO, DRO, and BTEX and will be submitted for laboratory analysis using the analytical methods described in Section 4.1.1.

Field parameters (see Section 4.3) will also be measured during monitoring.

4.2.6.2 Natural Attenuation Parameters

Groundwater samples will be analyzed for natural attenuation parameters. The natural attenuation parameters are based on Ecology's *Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation,* dated July 2005, and will include measurement of field parameters (dissolved oxygen, redox potential, pH, specific conductivity, temperature, and ferrous iron) (see Section 4.3) and collection of samples for laboratory analysis.

Natural attenuation samples submitted for laboratory analysis will include nitrate, sulfate, sulfide, dissolved manganese and iron, alkalinity, and methane (dissolved) using the analytical methods described in Section 4.1.1.

4.3 Field Screening and Field Parameter Measurement

This section provides a summary of the field screening (soil) and field parameter measurement (groundwater) anticipated for compliance monitoring during the remedial action, including the types of field observations and measurements and methodologies.

4.3.1 Soil

Field screening will be performed to monitor the progress of excavation activities including segregation of suspect contaminated versus suspect clean overburden soil, and determination of the extent of excavation required prior to collection of performance monitoring samples for laboratory analysis.

Field screening of soil materials will typically include the following:

- Visual observation of staining and other discoloration.
- Olfactory observation of petroleum hydrocarbon odors.
- Water-sheen testing for the presence of hydrocarbon sheen.
- Headspace analysis for organic vapors using a portable PID and headspace technique.

Field screening methodologies for soil are described in the SOGs presented in Appendix B. In addition, soil logging as described in the *Borehole Logging* SOG presented in Appendix B will be performed.

4.3.2 Groundwater

Field parameter monitoring for groundwater will be conducted during the purging process prior to sample collection at each well location. Field parameters will be measured using a portable meter (YSI) equipped with separate probes for temperature, pH, specific conductivity, redox potential, and dissolved oxygen. The probe will be installed down-well or in an in-line flow-through cell during the purging process. Turbidity will also be measured using a separate field meter.

Meter readings will be recorded at minimum 10-minute intervals during the purging process, including a final reading taken at the completion of purging for each well location. Purging will continue until stabilization criteria (listed in the *Groundwater Sampling* SOG in Appendix B) for each parameter have been met.

For groundwater monitoring events in which natural attenuation parameters are to be analyzed, ferrous iron will be measured using a field colorimeter. Ferrous iron will be measured at the end of the purging process for each well using a field-filtered (45 micron inline filter) sample.

Methods for measurement of groundwater field parameters are described in the *Groundwater Sampling* SOG presented in Appendix B.

4.3.3 Instrument Calibration

Field instruments and meters will be calibrated, at a minimum, on a daily basis, and as needed to maintain calibration during each field day. Instruments and meters will be calibrated using the manufacturer’s recommended procedures and appropriate calibration standards. A field log will be maintained with calibration dates, times, and results (as appropriate) for each instrument and meter. For instruments and meters that are factory-calibrated (i.e., not intended for daily calibration), a reference standard will be measured daily.

Field instruments and meters anticipated to be used for compliance monitoring during the remedial action include:

- PID calibrated daily using 100 parts per million (ppm) isobutylene gas and as needed to maintain calibration.
- Multi-parameter YSI probe for temperature, specific conductivity, pH, redox potential, and dissolved oxygen calibrated daily and as needed to maintain calibration (no calibration required for temperature).
- Turbidity meter field checked daily and as needed.

Instrument calibration procedures are described in the SOGs provided in Appendix B.

4.4 Monitoring Wells

During the remedial action, existing monitoring wells that are located in planned excavation areas will be abandoned and replacement wells will be installed at select locations (after final backfilling). Locations of the anticipated wells that will be abandoned and replaced are shown on Figure 2 (Note: Not all of the abandoned wells will be replaced). Additional wells may need to be abandoned if the excavation margin extends southward towards Cornet Bay Road.

Wells will be abandoned and installed by licensed well drillers using methods that are in accordance with Ecology's *Minimum Standards for the Construction and Maintenance of Wells* (WAC 173-160) dated December 2008.

We anticipate wells will be abandoned by removing the well casings and backfilling the well borings with granular bentonite, or removed during excavation activities. Wells located within the initial excavation area will be abandoned prior to the start of excavation activities using a hollow-stem auger drill rig. If additional wells need to be abandoned, they may be abandoned using a drill rig or by excavation (under supervision of a licensed driller).

New (replacement) wells will be installed and developed using a hollow-stem auger drill rig following the procedures described in the *Well Construction and Development* SOG presented in Appendix B.

New replacement wells will be installed at the same approximate locations as the abandoned wells (see Figure 2 for locations) and will be constructed of 2-inch polyvinyl chloride (PVC) well casing and screen (0.010-inch slots) with screen intervals similar to those of the original wells. The final locations, depths, and screen intervals will be submitted to Ecology for approval prior to installation of the wells.

4.5 Equipment and Personnel Decontamination

Decontamination of equipment and personnel will be performed as described in the SOGs provided in Appendix B and site HASP (prepared under separate cover).

Equipment requiring decontamination is anticipated to include non-disposable sampling equipment (i.e., spoons, bowls, etc.) and field meters. Decontamination will be performed between each sample location. Rinsate blanks (see Section 4.7) will be collected as a QA/QC measure for the decontamination procedures on a daily basis when non-disposable equipment is used.

4.6 Investigation Derived Waste Handling

Investigation-derived waste (IDW) generated during compliance monitoring activities at the site are anticipated to include well purge water, equipment decontamination water, and soil cuttings from well installations.

Because these IDW materials may be contaminated, each IDW type will be containerized separately pending characterization for disposal. 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 to indicate contents and the date and origin/location of collection. All IDW derived from compliance monitoring during the remedial action is anticipated to be non-hazardous.

Final disposal of IDW will be completed by Kennedy/Jenks Consultants on behalf of Ecology. Handling and disposal of IDW procedures that will be followed by Kennedy/Jenks Consultants personnel and its subcontractors are described in the *Handling and Disposal of Investigation Derived Waste* SOG presented in Appendix B.

Personal protection equipment (PPE) (i.e., gloves, etc.) and sampling materials (i.e., tubing) will be disposed as municipal waste.

4.7 Field QA/QC Sampling

Field QA/QC samples will be collected for excavation soil samples, overburden stockpile samples, and confirmational groundwater samples. QA/QC samples are not anticipated for contaminated soil stockpiles, waste characterization, water treatment system discharge, or imported fill materials.

The anticipated types and collection frequencies of QA/QC samples for soil and groundwater are summarized in Table 2 and described below.

Data quality objectives (DQOs) and measures necessary to achieve adequate data for the remedial action are summarized in the QAPP provided in Appendix C.

4.7.1 Soil

QA/QC sampling for soil samples includes the following:

- One field duplicate for every 20 soil samples collected from excavation areas and overburden stockpiles submitted blind to the mobile analytical laboratory (or fixed laboratory based on the capacity of the mobile laboratory).

- One field split sample for every 30 soil samples. Field split samples will be submitted to both the onsite mobile laboratory and the fixed-base laboratory to provide additional QA/QC for performance monitoring samples.

- Rinsate blanks will be collected when non-disposable sampling equipment is used. If disposable (i.e., single-use) sampling equipment is used, a field blank will be collected.

Blanks will be collected daily (when samples are collected) for the first 2 weeks of sampling. If COCs are not detected in blank samples during the first 2 weeks, the collection frequency will be reduced to a rate of two blank samples per week.

- Trip blanks will be included in each cooler which contains samples for which volatile (e.g., BTEX) analyses are to be performed.

4.7.2 Groundwater

One field duplicate sample for each of the primary COC analytes (GRO, DRO, BTEX) will be collected during monitoring from well MW-1R, which will be located downgradient of the UST vault (and former UST location). Duplicates will not be collected for natural attenuation monitoring parameters.

Trip blanks will be included with each sample shipment to the analytical laboratory.

One rinsate blank (if reusable sampling equipment is used) or field blank will be collected for each groundwater monitoring event.

4.8 Sample Documentation and Handling

Samples for chemical analysis will be stored in a cooled ice chest pending transportation to a certified analytical laboratory under chain-of-custody protocol as described in the SOGs provided in Appendix B.

Samples being analyzed by the onsite mobile laboratory will be submitted to the laboratory immediately after sample collection.

Samples being submitted to the offsite laboratory will be packaged in coolers with ice and shipped overnight as described in as described in the *Sample Packaging and Shipping* SOG in Appendix B.

4.9 Laboratory QA/QC and Data Validation

Laboratory QA/QC and data review/validation requirements are summarized in the QAPP provided in Appendix C. Certifications for the selected laboratories will be submitted to Ecology for review and approval prior to the start of sampling activities.

References

Kennedy/Jenks Consultants. 2013a. Remedial Investigation and Feasibility Study, Cornet Bay Marina, Whidbey Island, Washington, Kennedy/Jenks Consultants, July 2013.

Kennedy/Jenks Consultants. 2013b. Cleanup Action Plan, Cornet Bay Marina, Whidbey Island, Washington, Kennedy/Jenks Consultants, July 2013.

Kennedy/Jenks Consultants. 2013c. Engineering Design Report, Cornet Bay Marina, Whidbey Island, Washington, Kennedy/Jenks Consultants, September 2013.

Washington State Department of Ecology. 1993. Consent Decree between State of Washington Department of Ecology and Milton Woods. Consent Decree No. 93-2-00018-3. Dated February 1993.

Washington State Department of Ecology. 2005. Guidance on Remediation of Petroleum-Contaminated Groundwater by Natural Attenuation. Washington State Department of Ecology. Publication No. 05-09-091. July 2005.

Washington State Department of Ecology. 2007. Model Toxics Control Act Statute and Regulation, Chapter 173-340 WAC. Washington State Department of Ecology. 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. Washington State Department of Ecology. Publication No. 08-11-051, 19 December 2008.

Washington State Department of Ecology. 2011. Guidance for Remediation of Petroleum Contaminated Sites. Washington State Department of Ecology. Publication No. 10-09-057, September 2011.

Washington State Department of Ecology. 2013. Project Manual, Invitation for Bids IFB 1415 TCP, Cornet Bay Marina Remediation. Washington State Department of Ecology, September 2013.

Tables

Table 1: Summary of Sample Containers, Preservatives, and Holding Times(a)

Analyte	Method	Soil Samples			Water Samples		
		Container	Preservative	Holding Time	Container	Preservative	Holding Time
Gasoline Range Organics	NWTPH-G	2-40mL GV / 1-2oz.WMGS	Methanol; Cool≤6ºC	14 Days	2-40mL GV (b)	HCl; Cool≤6ºC	7 Days (c)/ 14 Days
Diesel Range Organics	NWTPH-Dx	8oz.WMG	Cool≤6ºC	14 Days	2-500mL AG	Cool≤6ºC	7 Days
VOCs (BTEX)	USEPA 8260C/8021	4-40mL GV / 1-2oz WMGS	2xSodium Bisulfate, 2xMethanol; Cool≤6ºC	2 Days (c)/ 14 Days	3-40mL GV (b)	HCl; Cool≤6ºC	7 Days (c)/ 14 Days
Total/Dissolved RCRA Metals	USEPA 6010/6020/200 Series	4oz.WMG	Cool≤6ºC	6 Months	500mL HDPE	HNO_3; Cool≤6ºC	6 Months
Total/Dissolved Mercury	USEPA 7470A/7471A	4oz.WMG	Cool≤6ºC	28 Days	500mL HDPE	HNO_3; Cool≤6ºC	28 Days
PAHs	USEPA 8270C/D-SIM	8oz.WMG	Cool≤6ºC	14 Days	2-500mL AG	Cool≤6ºC	7 Days
Dioxins/Furans	USEPA 1613B	8oz. AWMG	Frozen	1 year			
PCB Aroclors	USEPA 8082B	8oz.WMG	Cool≤6ºC	14 Days			
Nitrate	USEPA 353.2/SM 4500				500mL HDPE	H_2SO_4; Cool≤6ºC	48 hours (c) / 28 Days
Sulfate	USEPA 375.2/SM 4500				500mL HDPE	Cool≤6ºC	28 Days
Sulfide	USEPA 376.2/SM 4500				500mL HDPE	Zinc Acetate+NaOH; Cool≤6ºC	7 Days
Alkalinity	USEPA 310.1				500mL HDPE	Cool≤6ºC	14 Days
Methane (dissolved)	USEPA RSK-175				3-40mL GV (b)	Cool≤6ºC	14 Days

Notes:
(a) All sampling requirements and holding times to be verified by the selected analytical laboratories prior to collection of samples.
(b) No headspace in sample container.
(c) Holding time if unpreserved.

Abbreviations:

ºC = degrees Celsius
AG = Amber Glass Boston Round Bottle
AWMG = Amber Wide Mouth Glass Jar
BTEX = benzene, toluene, ethylbenzene, xylenes
H_2SO_4 = sulfuric acid
HCl = hydrochloric acid
HDPE = high density polypropylene
HNO_3 = nitric acid
mL = milliliters
NaOH = sodium hydroxide
oz = ounce
PCB = polychlorinated biphenyl
SM = Standard Method
USEPA = United States Environmental Protection Agency Method
VOCs = volatile organic compounds
SIM = select ion monitoring
WMG = Wide Mouth Glass Jar
WMGS = Wide Mouth Glass Jar with Septa

Grayed cells indicate that analyte will not be sampled for that matrix.

Table 2: Summary of Estimated QA/QC Samples (a)

		Primary COC Analyses			Natural Attenuation Parameters
Sample Type	**QA/QC Sampling Frequency**	**DRO (NWTPH-Dx)**	**GRO (NWTPH-G)**	**BTEX (USEPA 8260B/8021)**	**Nitrate, Sulfate, Sulfide, Dissolved Manganese and Iron, Alkalinity, Methane (b)**
Soil Samples					
Excavation Soil Samples (c)					
Standard Samples	As required for performance monitoring (refer to SAP text)	80 - 100	80 - 100	80 - 100	na
Duplicate Samples	One for every 20 standard samples	4 - 5	4 - 5	4 - 5	na
Split Samples	One for every 30 standard samples	2 - 3	2 - 3	2 - 3	na
Blank (field or rinsate) (d, e)	Daily for 2 weeks, then 2 per week (if COCs are not detected)	approximately 20	approximately 20	approximately 20	na
Trip Blank	One per cooler containing volatile (BTEX) samples	0	0	1 per batch	na
Overburden Soil Stockpiles (f)					
Standard Samples	As required for overburden soil characterization (refer to SAP text)	50 - 60	50 - 60	50 - 60	na
Duplicate Samples	One for every 20 standard samples	2 - 3	2 - 3	2 - 3	na
Split Samples	One for every 30 standard samples	1 - 2	1 - 2	1 - 2	na
Blank (field or rinsate) (d, e)	Daily for 2 weeks, then 2 per week (if COCs are not detected)	approximately 20	approximately 20	approximately 20	na
Trip Blank	One per cooler containing volatile (BTEX) samples	0	0	1 per batch	na
Groundwater Samples					
Monitoring Well Samples (per event) (e, f)					
Standard Samples	As required for confirmational monitiorng (assumed 6 wells per event)	6	6	6	6
Duplicate Samples	One for each monitoring event from one well location	1	1	1	0
Blank (field or rinsate)	One for each monitoring event	1	1	1	0
Trip Blank	One per cooler containing volatile (BTEX) samples	0	0	1	0

Notes:

(a) The actual number of quality assurance/quality control (QA/QC) samples may vary and will be based on the number of standard samples collected and the QA/QC sampling frequencies listed for each QA/QC sample type.

(b) Analytical methods for natural attenuation parameters are listed in Section 4.1.1.

(c) Excavation soil samples include bottom and sidewall samples collected for performance monitoring.

(d) Rinsate blanks will be collected when reusable equipment is used; otherwise, field blanks will be collected.

(e) If both excavation and stockpile samples are collected on the same day, only one blank will be collected.

(f) Overburden soil stockpile samples collected to evaluate the suitibility of overburden soil for reuse onsite as backfill material.

(g) Groundwater samples collected from onsite monitoring wells for confirmational monitoring.

(h) Primary constituents of concern (COCs) to be sampled quarterly; natural attenuation parameters to be samples semi-annually.

na = Not applicable
DRO = Diesel-range organics
GRO = Gasoline-range organics
BTEX = Benzene, toluene, ethylbenzene, and total xylenes
NWTPH = Northwest Total Petroleum Hydrocarbons Method
USEPA = United States Environmental Protection Agency

Figures

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Kennedy/Jenks Consultants

SAP/CMP
Cornet Bay, Washington

Site Location Map

1396010*00
January 2014

Figure 1

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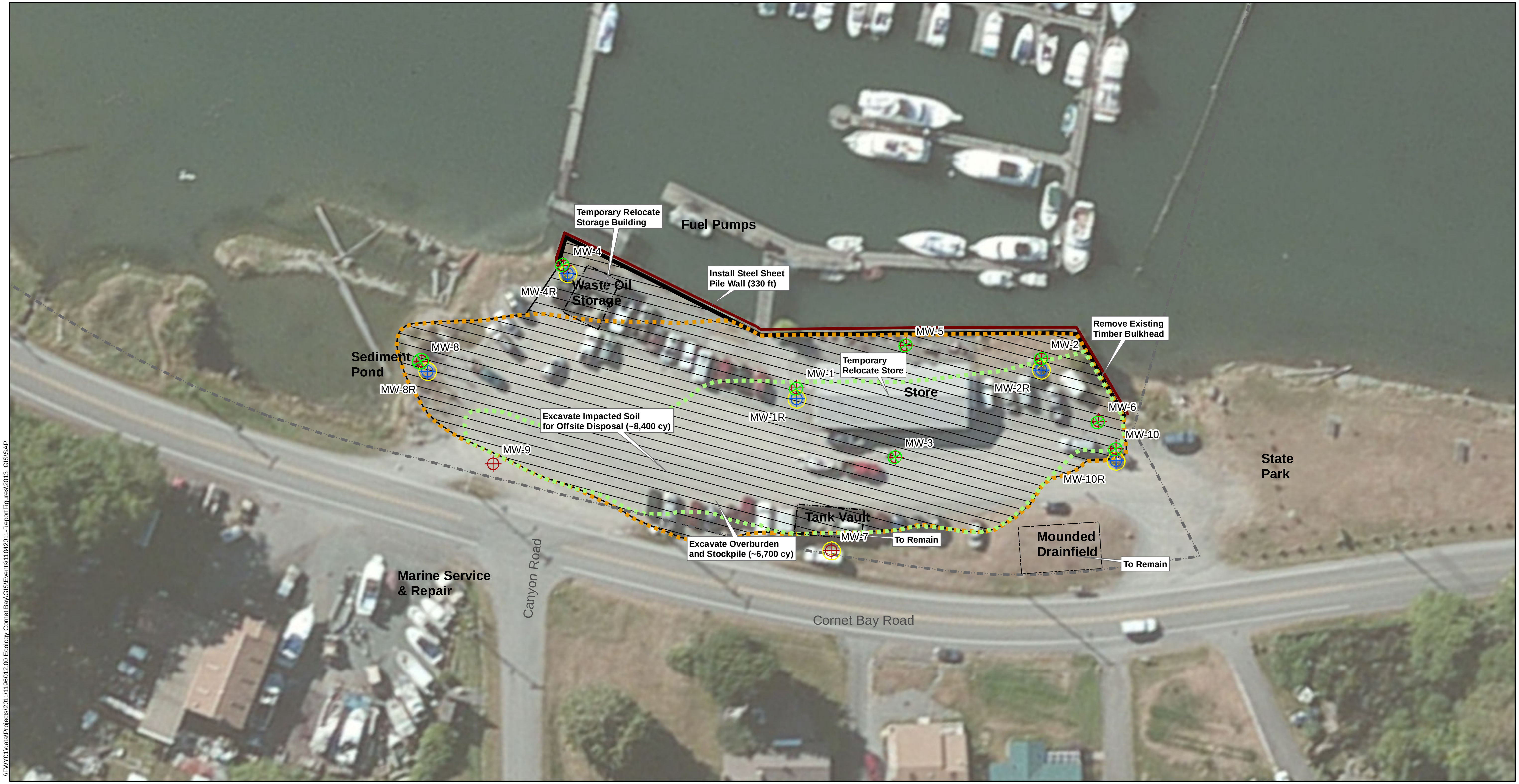
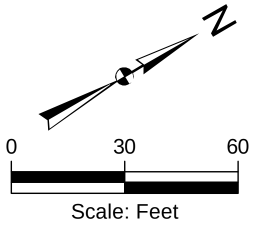


Imagery Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

⊕	Existing Monitoring Wells (Total of 10)	▨	Excavation Area
⊕	Abandon Monitoring Wells (Total of 8)	—	New Steel Sheet Pile Wall
⊕	Proposed New Monitoring Well (Total of 5)	-·-·-	Approximate Property Boundary
○	Wells to be Included in Quarterly Confirmtaional Monitoring (Total of 6)	━	Existing Timber Bulkhead
┅	Gas and Benzene Area Exceeding MTCA Method A Soil Cleanup Levels		
┅	Benzene Area Exceeding MTCA Method A Soil Cleanup Levels		

NOTE:
All locations are approximate.
Approximate property boundary obtained from Survery performed on 17 November 2011.Boundary located on east portion of site is identified as right-of-way.
Aerials Express 0.3 to 0.6m resolution imagery for metropolitan areas and the best available United States Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP) imagery and enhanced versions of United States Geological Survey (USGS) Digital Ortho Quarter Quad (DOQQ) imagery for other areas. For more information on this map, visit us online at http://goto.arcgisonline.com/maps/World_Imagery



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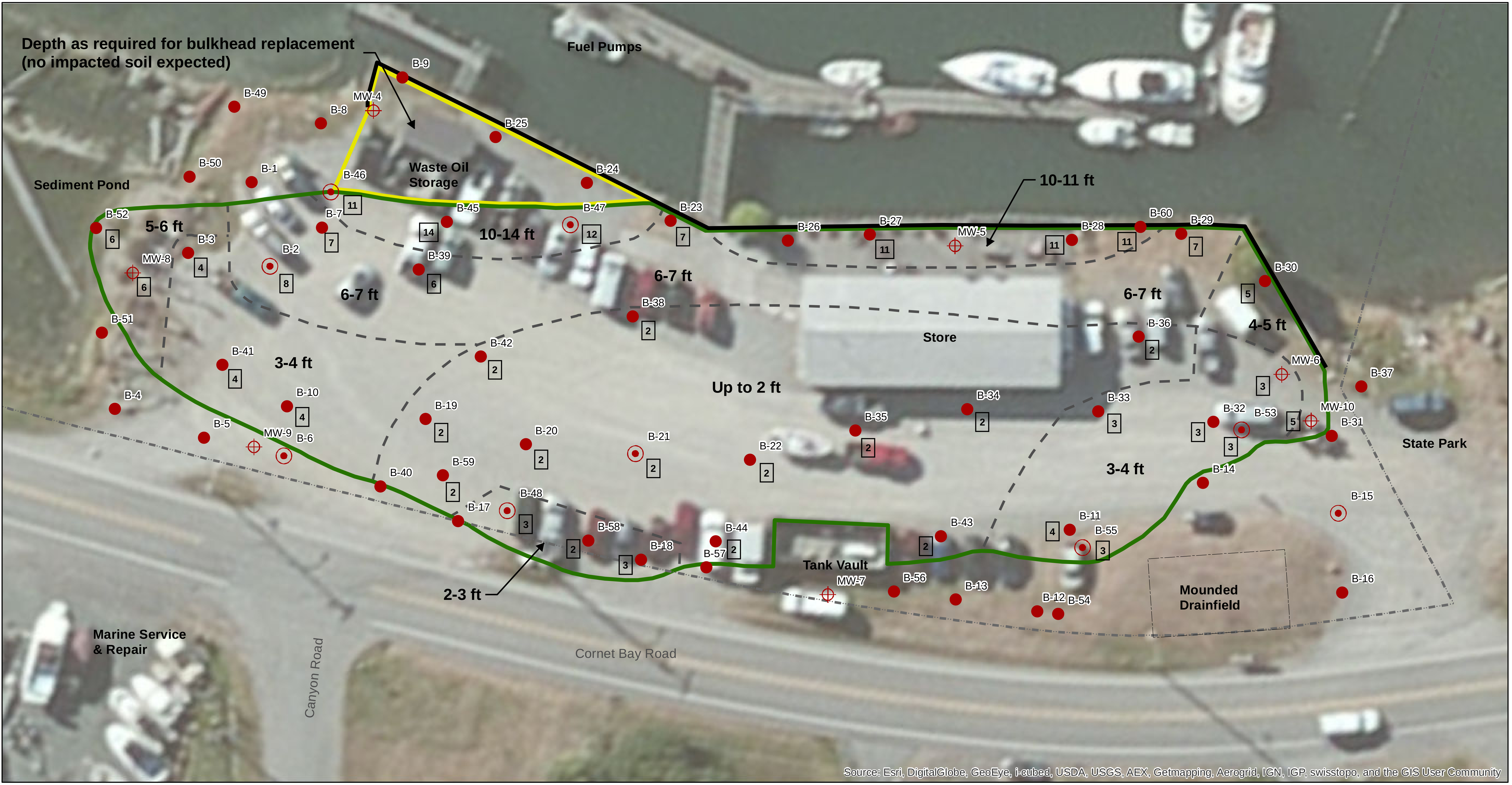
Cornet Bay, Washington

Site Plan, Excavation Areas, and Monitoring Well Locations

1396010*00
January 2014

Figure 2



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Legend

- ● 2011 Soil Boring
- ⊙ 2011 Soil Boring and Groundwater
- ⊕ 2011 Monitoring Well
- 🟩 Approximate Excavation Area for Removal of Impacted Soil
- 🟨 Approximate Additional Excavation Area for Replacement of Bulkhead
- ━ Timber Bulkhead
- ╌ Approximate boundary between areas with differing overburden soil thickness
- ┄ Approximate Property Boundary
- 2 Approximate anticipated overburden soil thickness (feet) at previous sampling locations based on RI sample analyses and field observations.
- **6-7 ft** Approximate anticipated overburden soil thickness (feet) in separate areas shown on map

NOTE:
1. All locations and areas are approximate.
2. Actual overburden soil removal thickness will be based on field observations and may vary from that shown on this map.
3. Overburden thickness areas do not necessarily correspond to specific excavation areas or stockpiles.

N

0 30 60

Scale: Feet

1 inch = 30 feet

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Cornet Bay, Washington

Approximate Thickness of Overburden Soil

1396010*00
January 2014

Figure 3

Appendix A

Administrative Order 10404 issued by Ecology 11 December 2013

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Northwest Regional Office • 3190 160th Ave SE • Bellevue, WA 98008-5452 • 425-649-7000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

December 11, 2013

Ms. Lauren Miles-Golembiewski
Glacier Environmental Services, Inc
3415 121st Street SW
Lynnwood, WA 98087

Order Docket No.	10404
Site Location	Cornet Bay Marina, 200 Cornet Bay Road, Oak Harbor, WA

Re: Administrative Order

Dear Ms. Miles-Golembiewski:

The Department of Ecology (Ecology) has issued the enclosed Administrative Order (Order) requiring Glacier Environmental Services to comply with:

- Chapter 90.48 Revised Code of Washington (RCW) – Water Pollution Control.
- Chapter 173-201A Washington Administrative Code (WAC) Water Quality Standards for Surface Waters of the State of Washington.
- Permit: National Pollution Discharge Elimination System (NPDES) Construction Stormwater General Permit WAR301251.

If you have questions please contact Tracie Walters at (425) 649-4484 or twal461@ecy.wa.gov.

Sincerely,

Gerald Shervey for...

Kevin C. Fitzpatrick
Water Quality Section Manager
Northwest Regional Office

Enclosure: Administrative Order No. 10401

By Certified Mail No.: 7008 1140 0000 2359 8763

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

IN THE MATTER OF AN ADMINISTRATIVE ORDER AGAINST Lauren Miles-Golembiewski Glacier Environmental Services, Inc	)))))	ADMINISTRATIVE ORDER DOCKET NO. 10404

To: Glacier Environmental Services, Inc
3415 121st Street SW
Lynnwood, WA 98087

Order Docket No.	10404
Site Location	Cornet Bay Marina, 200 Cornet Bay Road, Oak Harbor, WA

The Department of Ecology (Ecology) has issued this Administrative Order (Order) requiring Glacier Environmental Services, Inc (Glacier Environmental Services) to comply with:

- Chapter 90.48 Revised Code of Washington (RCW) – Water Pollution Control.
- Chapter 173-201A Washington Administrative Code (WAC) Water Quality Standards for Surface Waters of the State of Washington.
- Permit: National Pollution Discharge Elimination System (NPDES) Construction Stormwater General Permit WAR301251.

This is an Administrative Order in association with General Condition G13 (Additional Monitoring) as set forth in the Construction Stormwater General Permit. RCW 90.48.120(2) authorizes Ecology to issue Administrative Orders to accomplish the purposes of Chapter 90.48 RCW.

ORDER TO COMPLY

Description:

Glacier Environmental has applied for coverage under the Construction Stormwater General Permit (Permit) for construction activities associated with the construction site known as Cornet Bay Marina. Glacier Environmental Services reported that the construction site contains contaminated soil and groundwater which may be discharged due to the proposed construction activity. The Construction Stormwater General Permit does not have water quality sampling or benchmarks for gasoline-range hydrocarbons (NWTPH-Gx), diesel and heavy oil-range hydrocarbons (NWTPH-Dx), or benzene, toluene, ethyl benzene and xylenes (BTEX) (see Table 1); however, the permit requires compliance with the Water Quality Standards for Surface Water of the State of Washington (Water Quality Standards).

This Order establishes Indicator Levels for the Cornet Bay Marina. Indicator Levels express a pollutant concentration used as a threshold, below which a pollutant is considered unlikely to

cause a water quality violation, and above which it may. Indicator Levels in this Administrative Order were derived from practical quantitation levels for the cited analytical method.
Glacier Environmental Services must take the following actions to remain in compliance with NPDES Permit WAR301251.

- Glacier Environmental Services shall use storage tanks and/or weir tanks, media filtration, and granular-activated carbon columns to treat any contaminated dewatering water or stormwater comingled with dewatering water (dewatering water) prior to discharge to surface water.
- All dewatering water, stormwater, and stormwater comingled with dewatering water (water) must be sampled weekly and tested for the parameters listed in Table 1. If all parameters are equal to or below the benchmarks or Indicator Levels in Table 1, the water may be discharged to waters of the state. If any of the Indicator Levels listed in Table 1 are exceeded, the water must not be discharged to waters of the state until the water has been treated and retested to determine that all parameters are equal to or below the Indicator Levels in Table 1. If the indicator levels for turbidity or pH listed in Table 1 are exceeded, Construction Stormwater General Permit (Permit) condition S4.C.5 and S4.D.5 applies.
- Have all pre-treatment and treatment systems in place prior to any discharge of dewatering water to surface water.
- Sampling for gasoline-range hydrocarbons (NWTPH-Gx), diesel-range hydrocarbons (NWTPH-Dx), and benzene, toluene, ethylbenzene and xylene (BTEX) must be reported on the required Discharge Monitoring Report (DMR).
- All sampling data must be reported monthly on Discharge Monitoring Reports (DMRs) using Ecology's electronic secure online system WQWebDMR, in accordance to permit condition S5.B. If the measured concentration is below the detection level, then Glacier Environmental Services shall report single analytical values below detection as "less than the detection level (DL)" by entering "<" followed by the numeric value of the detection level (e.g. "<0.1"). All other values above DL must be reported as the numeric value.
- If Glacier Environmental Services conducts sampling for the above parameters more frequently than required by this Order, then Glacier Environmental Services must include the results of this monitoring in the calculation and reporting of the data submitted in the monitoring reports.
- All monitoring data must be prepared by a laboratory registered or accredited under the provisions of Chapter 137-50 WAC, *Accreditation of Environmental Laboratories*.
- If a modification of this Order is desired, a written request shall be submitted to Ecology; and if approved, Ecology will issue an approval letter or an amendment to this Order.
- The sampling dates of any two consecutive weekly dewatering monitoring samples should be at least six days apart and no more than eight days apart, unless directed by Ecology. If the dewatering discharge is intermittent rather than continuous, sampling should take place at the beginning of each discharge cycle.
- Any discharge to waters of the state in exceedance of the contaminant Indicator Level in Table 1, except for turbidity and pH criteria, shall be reported according to Permit condition S5.F, Noncompliance Notification.

If any monitoring result exceeds a benchmark listed on Table 1, immediately notify Tracie Walters (425) 649-4484, twal461@ecy.wa.gov and Raman Iyer (425) 649-4424, riye461@ecy.wa.gov.

Ecology retains the right to make modifications to this Order through supplemental order, or amendment to this Order, if it appears necessary to further protect the public interest. Transfer of NPDES WAR301251 may require an additional and/or separate Administrative Order.

This Order does not exempt Glacier Environmental Services from any Construction Stormwater General Permit requirement.

Table 1.

Parameter	Indicator Level	Unit	Analytical Method	Detection Level	Quantitation Level
TOTAL PETROLEUM HYDROCARBONS AND BTEX					
Gasoline-Range Hydrocarbons (NWTPH-Gx)	250[a]	µg/L	Ecology NWTPH-Gx	250	250
Diesel and Heavy Oil-Range Hydrocarbons (NWTPH-Dx)	250[a]	µg/L	Ecology NWTPH-Dx	250	250
BTEX (benzene +toluene + ethylbenzene + m,o,p xylenes)	2[a]	µg/L	EPA SW 846 8021/8260	1	2
NPDES CONSTRUCTION STORMWATER GENERAL PERMIT BENCHMARKS					
Turbidity	25	NTU	SM2130*	NA	NA
pH	6.5-8.5	SU	pH Meter	NA	NA

a: No surface water standard, value is laboratory quantitation level.
NWTPH-Gx: Northwest Total Petroleum Hydrocarbons Gasoline Extended Range
NWTPH-Dx: Northwest Total Petroleum Hydrocarbons Diesel Extended Range
*: Or equivalent.

FAILURE TO COMPLY WITH THIS ORDER

Failure to comply with this Order may result in the issuance of civil penalties or other actions, whether administrative or judicial, to enforce the terms of this Order.

YOUR RIGHT TO APPEAL

You have a right to appeal this Order to the Pollution Control Hearing Board (PCHB) within 30 days of the date of receipt of this Order. The appeal process is governed by Chapter 43.21B RCW and Chapter 371-08 WAC. "Date of receipt" is defined in RCW 43.21B.001(2).

To appeal you must do both of the following within 30 days of the date of receipt of this Order:

- File your appeal and a copy of this Order with the PCHB (see addresses below). Filing means actual receipt by the PCHB during regular business hours.
- Serve a copy of your appeal and this Order on Ecology in paper form - by mail or in person. (See addresses below.) E-mail is not accepted.

You must also comply with other applicable requirements in Chapter 43.21B RCW and Chapter 371-08 WAC.

Your appeal alone will not stay the effectiveness of this Order. Stay requests must be submitted in accordance with RCW 43.21B.320.

ADDRESS AND LOCATION INFORMATION

Street Addresses	Mailing Addresses
Department of Ecology Attn: Appeals Processing Desk 300 Desmond Drive SE Lacey, WA 98503	**Department of Ecology** Attn: Appeals Processing Desk PO Box 47608 Olympia, WA 98504-7608
Pollution Control Hearings Board 1111 Israel Road SW STE 301 Tumwater, WA 98501	**Pollution Control Hearings Board** PO Box 40903 Olympia, WA 98504-0903

CONTACT INFORMATION

Please direct all questions about this Order to:

Tracie Walters
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, WA 98008-5452

Phone: (425) 649-4484
Email: twal461@ecy.wa.gov

MORE INFORMATION

- Pollution Control Hearings Board Website: www.eho.wa.gov/Boards_PCHB.aspx
- Chapter 43.21B RCW – Environmental and Land Use Hearings Office – Pollution Control Hearings Board: http://apps.leg.wa.gov/RCW/default.aspx?cite=43.21B
- **Chapter 371-08 WAC – Practice And Procedure**
  http://apps.leg.wa.gov/WAC/default.aspx?cite=371-08
- **Chapter 34.05 RCW – Administrative Procedure Act**
  http://apps.leg.wa.gov/RCW/default.aspx?cite=34.05
- **Laws:** www.ecy.wa.gov/laws-rules/ecyrcw.html
- **Rules:** www.ecy.wa.gov/laws-rules/ecywac.html

SIGNATURE

Gerald Shervey for ...
Kevin C. Fitzpatrick
Water Quality Section Manager
Northwest Regional Office

Dec. 11, 2013
Date

Appendix B

Standard Operating Guidelines (SOGs)

Standard Operating Guidelines
Data Quality - Environmental Data Collection

Introduction

This guideline describes recommended procedures to be followed by Kennedy/Jenks Consultants when collecting environmental data. The guideline is divided into Pre-field Procedures and Field Procedures for ease of use.

Pre-Field Procedures

The following procedures represent the minimal effort appropriate for most environmental data collection projects. Refer to project-specific plans for additional data collection procedures.

1. Review the work plan or sampling plan prior to initiating fieldwork, and discuss any questions with project manager or field leader.
2. Review the Health and Safety Plan.
3. Set up subcontract with analytical laboratory for type and quantity of analyses, documentation and delivery format, both hard copy and electronic data deliverables (EDDs) and turnaround time requirements. Establish contacts at the laboratory, field and home office (Project Manager or person responsible) for all communications.
4. Notify the analytical laboratory of the upcoming fieldwork and advise about the following:
    a. Number of samples per medium
    b. Analyses needed
    c. Dates of sample delivery, coordinate for Saturday pick-up if necessary
    d. Means of delivery (e.g., courier, FedEx)
    e. Turnaround time required
    f. Level of quality control (QC) reporting required
    g. Delivery format, for both hard copy and EDDs. (If EDDs will be uploaded into a database, refer to the Database Use Data Quality SOG.)
5. Order the sample containers from the laboratory. Determine whether field personnel will preserve the samples in the field or if pre-preserved sample containers will be provided. It is preferable to order containers with appropriate preservatives.
6. Arrange for delivery or pickup of sample containers.
7. Request the laboratory fax or email you chain-of-custody forms and laboratory receipt documents immediately after receiving the samples.

8. Check the chain-of-custody form to verify the correct samples were collected and correct analyses were requested. Double check the laboratory receipt documents to verify there are no typographical errors for samples.

   If changes are required, request change in writing, via email, do not request over the phone. Request the laboratory to include all change request documentation in the laboratory summary report.

Field Procedures

1. At the beginning of each field day, identify planned work and document field conditions in the field notes.

2. Hold Tailgate Safety Meeting and have all present sign the form.

3. Complete sample identification labels for each sampling container using an indelible pen. Use the sample identification protocol described in the work plan or sampling plan. It is recommended that pre-printed labels be created at the office prior to going to the field site, if possible.

4. Complete the chain-of-custody form, accounting for each sample. Verify that sample identifications, sampling times, and requested analyses on the chain-of-custody form match the sample identifications, sampling times, and requested analyses on the sample labels.

5. Verify that the appropriate QC samples (field duplicate samples, trip blanks samples, etc.) required in the work plan or sampling plan were collected. If applicable, document blind duplicate parents in field notes, and if using a database, supply a summary table of your parent and duplicate samples to your database coordinator.

6. Verify, where applicable, that the appropriate sample volume was collected to enable the analytical laboratory to perform QC analyses (e.g., matrix spike and matrix spike duplicate analysis). (For example, if a water sample is being analyzed for polynuclear aromatic hydrocarbons, 1 liter of sample is required for the analysis, and another 2 liters are required for the matrix spike and matrix spike duplicate analyses.)

7. Collect, preserve, and transport samples to the analytical laboratory in accordance with the work plan or sampling plan.

8. Provide adequate ice in coolers so that the coolers arrive at the laboratory at a temperature of 4 degrees C ± 2 degrees C.

9. Keep in contact with the project manager or other team member to report any problems, unusual observations, etc.

10. Verify that samples were received by the analytical laboratory and that the laboratory understands the chain-of-custody and requested analyses prior to beginning analyses.

11. If samples are sent by overnight delivery, be sure to include the tracking number and time released to the delivery service on the chain-of-custody form.

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.).

- 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:
    1. 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.
    2. Moisture content: dry, damp, moist, wet.
    3. State of decomposition: highly decomposed, moderately decomposed, slightly decomposed, etc.
    4. Color: obvious mottling included.
    5. Texture: spongy, plastic (cohesive), friable.
    6. Odor.
    7. Combustible gas indicator readings (measure downhole).
    8. 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
Surface and Shallow Soil Sampling

Introduction

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

Equipment

- Stainless steel or plastic scoops
- Hand auger
- Split-spoon drive sampler (2.5-inch or 2.0-inch I.D.) and associated drill rods, wrench and other tools needed to break down equipment
- Slide hammer
- 2.5-inch or 2.0-inch brass liners and sealing materials (plastic end caps, Teflon seals, silicon tape, zip-lock plastic bags)
- Shovel
- Post hole digger
- Pick
- Breaker bar
- Foxboro FID-Organic Vapor Analyzer (OVA)
- HNU PID-Organic Vapor Analyzer
- OVM
- Measuring tape or measuring wheel
- Stakes or spray paint for sampling grid
- Sampler cleaning equipment
    Steamcleaner (if available)
    Generator (if available)
    Stiff-bristle brushes
    Buckets
    High priority phosphate-free liquid soap, such as Liquinox
    Trisodium phosphate (TSD) for use if samples are oily
    Methanol (if necessary)
    0.1N nitric acid (if necessary)
    Deionized water
    Potable water

- Insulated sample storage and shipping containers
- Personal protective equipment (as specified in site safety plan)

Typical Procedure

1. Obtain applicable drilling and well construction permits, prior to mobilization, if necessary.

2. Clear locations for underground utilities and structures by Underground Service Alert (USA) and subcontractors, if necessary.

3. Measure and mark sampling locations prior to initiation of the sampling program, as specified in the sampling and analysis plan. If sampling locations are based on a grid pattern, stakes can be used to define the grid layout.

4. Collect soil samples for chemical analysis by using precleaned scoops or a hand auger, or by driving a split-spoon drive sampler.

5. If overlying soil is to be removed (as specified in the sampling and analysis plan), use shovels, picks, or post-hole diggers, as needed.

6. Collect soil samples for lithologic logging purposes.

7. If applicable, as described in the site safety plan, use an OVA to analyze *in situ* air samples from the breathing zone and other locations as necessary.

8. 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 (refer to SOG 21).

9. Prior to each sampling event, wash sampling equipment (scoops, hand auger, split-spoon drive sampler, and brass liners) with high purity phosphate-free soap. Double-rinse it with deionized water and methanol, and/or 0.1N nitric acid, as appropriate.

10. At each sampling interval, collect soil and place it in the appropriate sampling container. Fill the sample container and compact the soil to minimize air space. Minimize handling of the soil, especially if it is being collected for analysis of volatile compounds.

11. If a split-spoon drive sampler is being used, select one brass liner for potential laboratory analysis. Cover the ends of this sample in Teflon sheets, seal it with plastic caps, and wrap it with silicon or Teflon tape. Place a completed sample label on the brass liner.

12. Place the selected samples in appropriate containers and store them at approximately 4 °C.

13. As a field screening procedure (if applicable), for each sampling interval, place soil not selected for chemical analysis in an airtight container (e.g., plastic bag or jar) and allow it to equilibrate. After this, monitor the headspace in the container using either a HNU, OVM or OVA. Record the headspace concentration in the field notes (refer to SOGs 4 and 5).

14. Complete chain-of-custody forms in the field and transport the selected samples in insulated containers, at an internal temperature of approximately 4°C, to the analytical laboratory (refer to SOGs 3).

Equipment Cleaning

Prior to collection of each soil sample, the sampling equipment should be either steamcleaned or hand washed. If the sampling equipment is hand washed, wash excavation equipment 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 (refer to SOG 11).

Investigation-Derived Residuals

If sufficient volumes of soil cuttings and other residuals are generated, contain the material in appropriately labeled containers for disposition by the client. All soil samples transported to the laboratory must be returned to the client for disposition if required by the laboratory. Kennedy/Jenks Consultants is available to assist the client with options for disposition of residuals (refer to SOG 20B).

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
Test Pit / Excavation Sampling

Introduction

This guideline describes the equipment and procedures typically used by Kennedy/Jenks Consultants personnel for collecting samples from test pits and excavations.

Equipment

- Backhoe, excavator, or other excavation equipment (supplied by contractor)
- Stainless steel scoop
- Split spoon drive sampler with brass liners, drive rod and sliding hammer.
- Rubber mallet
- Stakes
- Measuring tape
- Appropriate sample containers with labels
- Field Notebook

Typical Procedures

1. Identify and delineate test pit or excavation location(s) and area(s).

2. Identify overhead obstructions and underground utilities which may interfere with excavation activities.

3. The decontaminated excavation equipment will be used excavate soil to the desired depth and extent. The excavated material will be placed on plastic sheeting adjacent to the excavation, transferred to designated stockpile areas, or loaded directly into trucks.

4. Actual sampling depths and locations will vary by site based on the specific objectives. Refer to the appropriate project-specific documents for sampling requirements.

5. Relatively undisturbed material will be removed by the excavation equipment and brought to the surface for sampling (i.e. material from the excavation floor or sidewall will be collected in the excavator bucket at locations determined by the consultant). The sample will be collected from the excavator bucket by either driving a split spoon sampler into the unearthed material, driving a brass liner with a rubber mallet into the material, or by collecting a representative sample using a stainless steel scoop. Regardless of the specific methodology, samples will be collected from material that is not in contact with the excavator bucket. Under no circumstances will the excavation be entered by site personnel performing sample collection. Sample handling procedures will be the same as those outlined in the Boring and Subsurface Soil Sampling SOG.

6. The physical and lithologic conditions of the test pit or excavation will be logged in the field notebook.

7. If buried objects are encountered (such as tanks or drums) which could result in a release of contaminated material, the excavation will be left open and secured to warn of the potential danger. A specific remedial action plan will be developed which will address the specific concerns at that location.

8. If no potential contamination sources (drums or tanks) are identified and there are no visible indications of contamination, the excavation will be backfilled as specified in the project-specific documents.

9. The excavation equipment will be decontaminated prior to reuse (refer to Equipment Decontamination SOG).

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.

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
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
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
Personnel Decontamination

Introduction

This guideline describes field procedures typically followed by Kennedy/Jenks Consultants for personnel decontamination. Decontamination of personnel is critical to health and safety during and after environmental fieldwork. It protects personnel from hazardous substances that can contaminate and eventually permeate protective clothing, respiratory equipment, tools, vehicles, and other equipment used onsite. Decontamination reduces exposure of site personnel to such substances by minimizing the transfer of harmful materials into clean areas and preventing the mixing of incompatible chemicals. It also protects the community by preventing uncontrolled transportation of contaminants from the site.

Equipment

The materials, equipment, and facilities described in the following list are not required in every case of personnel decontamination. However, they represent all that might be required for sites where maximum decontamination procedures are necessary.

- Drop cloths (plastic or other suitable material) on which heavily contaminated equipment and outer protective clothing can be deposited.
- Collection containers, such as drums or suitably lined trash cans, for storing disposable clothing, heavily contaminated personal protective clothing, or equipment that must be discarded.
- Lined box with absorbent for wiping or rinsing off gross contaminants and liquid contaminants.
- Large tubs to hold wash and rinse solutions; tubs should be at least large enough to hold a worker's booted foot and allow full access for washing.
- Non-phosphate wash solutions (e.g., Alconox, Liquinox) to wash off debris and chemicals and reduce hazards associated with any contaminants.
- Rinse solutions (e.g., potable or distilled water) to remove contaminants and contaminated wash solutions.
- Long-handled soft-bristled brushes to wash and rinse off contaminants.
- Paper or cloth towels for drying protective clothing and equipment.
- Lockers or containers for storage of decontaminated non-disposable clothing (e.g., hard hat, boots) and equipment.
- Department of Transportation (DOT)-approved containers for contaminated wash and rinse solutions.
- Plastic sheeting, sealed pads with drains, or other appropriate means of secondary containment of contaminated wash and rinse solutions that might be spilled during decontamination.

- Shower facilities for full body wash or, at a minimum, wash sinks available to personnel.

- Soap or wash solution, wash cloths, and towels for personnel.

- Lockers or containers for clean clothing and personal item storage.

Decontamination Procedures

Level C

At a minimum, the following procedures apply when operating in a Level C exclusion zone:

1. Deposit items used onsite on plastic drop cloth. Segregation at the drop site reduces the probability of cross-contamination.

2. Scrub outer boots, gloves, and splash suit with decontamination solution or detergent water. Rinse items with generous amounts of water. Follow this step scrupulously for protective clothing that is not disposable.

3. Remove outer boots and gloves; deposit or discard them in container with plastic liner.

4. To continue decontamination outside the exclusion zone, change canister or mask when leaving the zone. Upon re-entering, remember to gear up again.

5. Remove boots, chemical-resistant splash suit, and inner gloves and deposit them in separate containers lined with plastic.

6. Remove respirator by taking off facepiece. Avoid touching the face with the fingers. Deposit the facepiece on a plastic sheet.

7. As a field wash, clean hands and face thoroughly and shower as soon as possible. Wash respirator facepiece with respirator cleaning solution.

8. Ensure that all decontamination procedures are in accordance with the project sampling and analysis plan and Kennedy/Jenks Consultants Standard Operating Guideline, Investigation-Derived Residuals (Unit 9.0).

Level D

If operating in a Level D area, perform the following procedures before leaving the site:

1. Wash and rinse all reusable equipment and garments. If gear is to be used elsewhere, wash it with detergent and then rinse with generous amounts of water.

2. If grossly contaminated, discard disposable protective clothing in appropriate container.

3. Wash hands and face thoroughly, and shower as soon as possible.

Special Notes

When working in an exclusion zone, be sure that the decontamination area is placed in an upwind direction (plus or minus 20 degrees) from the site.

Investigation-Derived Wastes

Refer to the specific project sampling and analysis plan for details of disposition of investigation-derived wastes.

Emergency Decontamination Procedures

1. If the decontamination procedure is essential to the life saving process, decontamination must be performed immediately.
2. If a heat-related illness develops, protective clothing should be removed as soon as possible. Protective clothing and equipment should be washed, rinsed, and/or cut off.
3. If medical treatment is required to save a life, decontamination should be delayed until the victim is stabilized or until decontamination will not interfere with medical treatment.
4. Dispose of contaminated clothing and equipment properly.
5. Alert medical personnel to the emergency.
6. Instruct medical personnel about potential contamination.
7. Instruct medical personnel about specific decontamination procedures.

References

NIOSH/OSHA/USCG/EPA. 1985. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*. Washington, DC. Federal Way.

U.S. Environmental Protection Agency. 1988. *Standard Operating Safety Guidelines*. United States Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

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.

Appendix C

Quality Assurance Project Plan (QAPP)

Kennedy/Jenks Consultants

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Quality Assurance Project Plan Cornet Bay Marina Remedial Action and Compliance Monitoring Sampling

January 2014

Washington State Department of Ecology
Toxics Cleanup Program
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K/J Project No. 1396010.00

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List of Tables

Section 1: Introduction

The purpose of this Quality Assurance Project Plan (QAPP) is to identify the quality assurance and quality control (QA/QC) protocols necessary to achieve the project-specific data quality objectives for sample collection and analysis during the remedial investigation at the Cornet Bay Marina site located at 200 Cornet Bay Road on Whidbey Island, Washington (site). The objectives for the remedial action as well as the background, project description, project organization and schedule, and sampling procedures are described in the Project Manual (i.e., bid specifications) (Ecology 2013), Cleanup Action Plan (CAP) (Kennedy/Jenks Consultants 2013a), Engineering Design Report (EDR) (Kennedy/Jenks Consultants 2013b), and Compliance Monitoring Plan and Sampling and Analysis Plan (CMP/SAP) (Kennedy/Jenks Consultants 2013c).

Section 2: Quality Objectives

The data quality objectives (DQOs) for this project are to describe and implement field and laboratory procedures that ensure: 1) data will be representative of actual environmental conditions, and 2) data are of known and acceptable quality. Measurements will be made to yield accurate and precise results representative of the media and conditions measured. Data will be calculated and reported in units consistent with those used by regulatory agencies to allow for comparability of data.

Accuracy, precision, completeness, representativeness, comparability, and sensitivity are terms used to describe the quality of analytical data. Routine procedures for measuring precision and accuracy include use of quality control samples (i.e., replicate analyses, check or laboratory control samples, matrix spikes, and procedural blanks). These indictors of data quality are discussed below.

2.1 Precision

Precision is an appraisal 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 will be evaluated by the analyses of matrix spike duplicate and laboratory duplicate samples, which can be mathematically expressed as the relative percent difference (RPD) between duplicate sample analyses. RPD is calculated using the following equation:

$$RPD = \frac{C_1 - C_2}{\overline{\overline{C}}} \; x \; 100$$

where:

C1 = First concentration value or recovery value measured for a variable

C2 = Second concentration value or recovery value measured for a variable

The frequency of the performance of matrix spike duplicate and laboratory duplicate samples, where applicable, is usually one per batch (which typically consists of up to 20 samples) for each sample matrix received.

Field duplicate samples will be submitted blind to the laboratory as a means to determine field variability. Frequency of field duplicate samples is discussed in the CMP/SAP.

Precision quantities will be calculated for analyses with method reporting limits of the same order of magnitude and with detected concentrations greater than or equal to five times the method reporting limits. In instances where no criteria have been established (e.g., field duplicates), relative percent difference project goals will be 50 percent for well-homogenized soil samples and 30 percent for water samples.

2.2 Bias and Accuracy

Bias is the systematic or persistent distortion of a measurement process that causes error in one direction. Accuracy refers to how close a measurement is to the true value. Bias and accuracy will be evaluated by the analysis of matrix spike samples and laboratory control samples and can be mathematically expressed as the percent recovery of an analyte that has been used to fortify a field sample or clean laboratory matrix sample at a known concentration prior to analysis. The percent recovery (R) for a matrix spike sample is calculated as follows:

$$R = \frac{(\mathrm{SSR} - \mathrm{SR})}{\mathrm{SA}} * 100$$

Where:

SSR = Spiked sample result

SR = Sample result

SA = Spike added.

The following calculation is used to determine R for a laboratory control sample or reference material:

$$R = \frac{RM}{RC} * 100$$

Where:

RM = Reference material result

RC = Known reference concentration

Results of matrix spike and laboratory control samples will be evaluated to the laboratory's control limits. Control limits are defined as the mean recovery, plus or minus three standard deviations, of the 20 data points, with the warning limits set as the mean, plus or minus two standard deviations. The laboratory will review the QC samples and surrogate standard recoveries for each analysis to ensure that internal QC data lie within the limits of acceptability. The laboratory will investigate any suspect trends and take appropriate corrective actions

Field blank samples and method blank samples will also be used to evaluate bias of the data. Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Analytes detected in field or method blank samples will be evaluated as potential indicators of bias.

2.3 Representativeness

Representativeness concerns the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Where appropriate, sampling locations will be selected on both systematic and biased (judgmental) sampling bases in an attempt to spatially cover the study area. Sampling locations and methods for selection of those sampling locations are presented in the EDR and SAP/CMP.

2.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system. Completeness will be measured for each set of data received by dividing the number of valid measurements actually obtained by the number of valid measurements that were planned. Although 100 percent is the goal for completeness, 90 percent is the minimum acceptable level.

2.5 Comparability

Comparability is a qualitative QA criterion that expresses the confidence in the ability to compare 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 as specified in the EDR and CMP/SAP. Analytical procedures will be conducted according to the methods discussed in this QAPP.

2.6 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest. The method detection limit (MDL) is defined as the statistically calculated minimum amount that can be measured with 99 percent confidence that the reported value is greater than zero. MDLs are specified in the individual methods and are developed by the laboratory for each analyte of interest representing the aqueous and solid matrices within the capability of an analytical method.

The method reporting limit (MRL) or practical quantitation limit (PQL) is the lowest value to which the laboratory will report an unqualified quantitative result for an analyte. The PQL is always greater than the statistically determined MDL. The PQLs required for this project are such that data can be compared to the lowest possible applicable, relevant, and appropriate requirements (ARARs) suitable for the site. PQLs are discussed in greater detail in Section 3.

Section 3: Analytical Procedures

The analytical laboratory(s) selected to analyze samples for this project will be certified by Washington State Department of Ecology (Ecology) for all the analytical methods required for the project. Both an onsite mobile laboratory and a fixed-based laboratory will be used as described in the CMP/SAP. Target PQLs are summarized in Table 1 of the QAPP.

Analysis of the soil and groundwater samples will be performed using the methods listed below and in the CMP/SAP. The analytical methods and applicable sample containers and holding times are summarized in the CMP/SAP Table 1.

Primary consituents of concern (COCs) for soil and groundwater samples include:

- Gasoline-range organics (GRO) using Ecology Method NWTPH-G.
- Benzene, toluene, ethylbenzene, and total xylenes (BTEX) using EPA Method 8260B or 8021B.
- Diesel-range organics (DRO) using Ecology Method NWTPH-Dx with silica gel cleanup.

Some groundwater samples will also be analyzed for natural attenuation parameters including:

- Nitrate (NO_3^-) using EPA Method 353.2 / SM 4500.
- Sulfate (SO_4^{-2}) using EPA Method 375.2 / SM 4500.
- Sulfide by EPA Method 376.2 / SM 4500.
- Dissolved manganese and iron using EPA Method 6000 series.
- Alkalinity using EPA Method 310.1.
- Methane (dissolved) using EPA Method RSK-175.

Additional laboratory analyses may be required for evaluation of waste materials and imported fill materials including:

- Resource Conservation and Recovery Act (RCRA) Eight metals using EPA Method 6000/7000 series.
- Polychlorinated biphenyls (PCBs) using EPA Method 8082B.
- Volatile organic compounds (VOCs) using EPA Method 8260C.
- Polycyclic aromatic hydrocarbons (PAHs) using EPA Method 8270C in select ion monitoring (SIM) mode where appropriate.
- Dioxins and furans using EPA Method 1613B.
- Toxicity Characterization Leaching Procedure (TCLP) RCRA Eight metals extracted using EPA Method 1311 and analyzed using EPA Method 6000/7000 series (if required by the waste disposal facility).

Any other analytical method employed will be determined with laboratory concurrence and submitted to Ecology for review and approval prior to beginning sample analysis. In addition, field parameters will be measured during groundwater sampling as outlined in the CMP/SAP.

Section 4: Quality Control

QC samples will be assessed for both field and laboratory operations to evaluate overall precision/bias and accuracy throughout the project. Field QC samples will include field duplicate, split, and blank samples as summarized in Table 2 of the CMP/SAP. The types and frequency of QC samples are discussed below.

4.1 Laboratory Quality Control

Laboratory QC parameters, criteria, and frequency will be performed in accordance with the analytical methods referenced in Section 3. Comparison of QC sample results against established criteria is performed during the data validation process as described in Section 7.3. Laboratory QC data may include:

- Laboratory control and laboratory duplicate samples
- Matrix spikes and matrix spike duplicate samples
- Laboratory duplicates
- Surrogate standards
- Internal standards
- Method and instrument blanks
- Post-digestion spikes.

The frequency of analysis for laboratory control samples, matrix spike samples, matrix spike duplicate samples, laboratory duplicate samples, and method blank samples will be one for every 20 samples or one per batch, where applicable, or as specified in the analytical methods. Surrogate spikes and internal standards will be added to samples as required by the methods. Laboratory control limits and performance-based criteria presented in the methods will be used to establish the acceptability of the data or the need for re-analysis of a sample. Analytical data will be evaluated by the laboratory based on the following criteria, where applicable:

- Performance of analytical method tests
    - Holding times
    - Matrix spike and matrix spike duplicate results
    - Calibration data using check compound and system performance check with compound analysis results
    - Laboratory blank sample analysis results
    - Interference check sample analysis results
    - Laboratory check sample analysis results

  - Comparison of calibration and sample analyses
  - Linearity of response and linear range.
- Analytical results of internal standards and the calculation of percent recoveries
- Reporting limits obtained
- Accuracy and precision of matrix spike/matrix spike duplicate analysis
- Comparison of the percentage of missing or undetected substances among duplicate samples.

During data validation, analytical results will be evaluated against the performance criteria noted in this QAPP and the individual analytical methods.

4.2 Field Quality Control Samples

Field duplicate samples are designed to monitor overall sampling and analytical precision. In general, duplicate samples will be collected at a frequency of approximately one duplicate sample per 20 samples (soil samples) or one duplicate sample per batch of samples (groundwater samples). In addition, split samples will be collected at a frequency of approximately one split sample per 30 samples to monitor performance of the mobile analytical laboratory (samples will be submitted to the mobile and fixed-base analytical laboratories).

Soil duplicate and split samples will consist of collecting a sample, homogenizing the sample, and splitting the sample into two equal aliquots. If the sample is to be analyzed for volatile organics the sample will not be homogenized before collection of primary or duplicate sample.

For duplicate water samples, sample containers will be alternately filled. The locations for duplicate sample collection will be determined in the field. Duplicate samples will be treated as separate samples from the originals (assigned unique sample numbers), and not identified to the laboratory as duplicate samples. Field duplicate samples will be documented on the daily field report, in the field logbook, or other appropriate field form.

Trip blank samples will also be collected. Volatile organic samples are susceptible to contamination by diffusion of organic contaminants through the sample vials. Therefore, trip blank samples will be submitted to monitor for possible sampling contamination during shipment if VOC analyses are performed. If samples for VOC analysis are not collected, a field blank will be collected each day

Trip blank samples will be prepared by the analytical laboratory by filling volatile organic analysis (VOA) vials with organic-free water and shipping the blank samples with the clean sample containers. Trip blank samples will accompany the sample containers through collection and shipment to the laboratory and will be stored with the samples. Field blanks will be collected by filling appropriate sample containers in the field with laboratory-prepared organic-free water.

Section 5: Data Management

5.1 Documentation and Records

Records will be maintained documenting activities performed and data generated during implementation of the remedial action. The types of documents that will be generated during implementation of the remedial action are discussed below.

5.1.1 Field Documentation

Field personnel will document their field activities on either a daily field log or in a field logbook and complete other field forms applicable to the field activities being performed. The daily field logs and field logbooks will document information regarding who was present during field activities (field personnel, subcontractors, visitors), weather conditions, work conducted that day, problems encountered and corrective actions, if any, etc. Field logs will be filed in the project files.

Field logbooks and other types of field forms (e.g., groundwater purge and sample forms, boring log/well construction logs, test pit excavation logs) will be used to record data obtained during various field activities. The individual field personnel will be responsible for maintaining these forms. Field daily logs, field logbooks, and other field forms will then be archived in the project files.

5.1.2 Laboratory Documentation

Records related to sample analysis will be documented by the laboratory. The laboratory will be required to submit data that are supported by sufficient backup information and QC results to enable reviewers to determine the quality of the data. The laboratory will submit the data in electronic and paper format. The paper format (i.e., hard copy) data packages from the laboratory will consist of the following information, where applicable:

- A cover letter for each sample batch will include a summary of any QC, sample, shipment, or analytical problems, and will document internal decisions. Problems will be outlined and final solutions documented. A copy of the signed chain-of-custody form for each batch of samples will be included in the deliverable.
- Sample concentrations will be reported on standard data sheets in proper units and to the appropriate number of significant figures. For undetected values, the lower limit of detection for each compound will be reported separately for each sample. Dates of sample extraction or preparation and analysis will be included.
- Method blank results.
- Surrogate percent recoveries.
- Laboratory duplicate results, where applicable.
- Laboratory control sample results, where applicable, with percent recoveries and spiking concentrations.

- Matrix spike/matrix spike duplicate percent recoveries, with spiking concentrations and calculated relative percent differences.
- A list of the detection limits calculated for laboratory instruments for all analytes.
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions.

Sample holding times will be calculated by comparing the date of sample collection (shown on the chain-of-custody form) with the date of sample extraction/analysis. Analytical laboratory deliverables will be validated as described in Section 7 of the QAPP.

The analytical laboratory will routinely archive raw laboratory data, including initial and continuing calibration data, chromatograms, and quantitation reports for at least 5 years.

5.2 Instrument/Equipment Calibration and Frequency

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 before use each day or more frequently as necessary. Calibration records will be recorded in the daily field log, field logbook, or other appropriate forms. Calibration of field instruments is discussed in the SAP/CMP Section 4.3.

Laboratory instruments will be calibrated and maintained in accordance with the requirements of analytical methods and normal operating standards associated with good laboratory practices. Calibration requirements are specified in each laboratory's QA manual. Calibration records are documented in laboratory logbooks.

5.3 Instrument/Equipment Testing, Inspection, and Maintenance

Sampling equipment that will be used during field activities is discussed in the SAP/CMP. Preventive maintenance of equipment is essential if project resources are to provide accurate results and are to be used cost-effectively. Preventive maintenance will take two forms: 1) implementation of a schedule of preventive maintenance activities to reduce downtime and maintain accuracy of measurement systems and 2) availability of critical spare parts and backup systems and equipment.

Qualified operators will perform routine inspections and maintenance for field instruments in accordance with manufacturers' recommendations. Field equipment will be inspected prior to the start of sampling activities. Maintenance activities, if performed, will be documented in the daily field log or field logbook. As most types of field equipment that will be used for this project are standard (i.e., used frequently in environmental sampling), replacement parts are readily available. The field personnel will be responsible for maintaining the field equipment.

The laboratory's QA manual discusses preventive maintenance for laboratory equipment and instruments. Maintenance and inspection records are documented in laboratory logbooks.

Section 6: Audits and Reports

6.1 Performance Evaluation Audits

Performance evaluation audits are an independent means of establishing the quality of measurement data by analysis of samples provided specifically for the evaluation.

During a performance evaluation audit, the performance of the laboratory technicians and the instrumentation or analytical systems on which they work are evaluated. A performance evaluation audit is accomplished by providing performance evaluation samples containing specific pollutants (in appropriate matrices) whose identities and/or concentrations are unknown to the technician. Laboratories participate in both internal and external performance testing to examine the overall laboratory performance as well as to qualify for various federal, state, and independent certification programs.

The laboratory will be responsible for implementing corrective action for analytical procedures. Corrective action procedures are described in the individual methods or are described in the laboratory's QA manual. If QC data are unacceptable, the cause will be determined and corrected. Corrective actions that affect the integrity of the project analytical data will require re-analysis of the affected sample or qualifying of these data in the final data report. If corrective actions are warranted by a laboratory, the laboratory will document and forward the corrective action(s).

6.2 System and Technical Laboratory Audits

System and technical audits are performed by the laboratory QA Manager according to a predetermined schedule and when requested by laboratory management. An independent audit may be conducted should corrective actions be needed during implementation of the Work Plan (e.g., a laboratory repeatedly does not meet QC criteria, or overall performance of the laboratory is questionable). This audit will be project-specific and will focus only on the performance of the laboratory for this project. A laboratory audit report will be prepared, if necessary.

6.3 Field Operations

A readiness review will be conducted prior to initiation of each field task requiring sampling to verify that the necessary preparations have been made for efficient and effective completion of the task-related field activities. The Project Manager will verify that the necessary field equipment has been assembled for the field activity and that the applicable subcontractors, if necessary, have been scheduled. Any deficiencies noted during this readiness review will be corrected prior to initiation of field activities.

Field personnel are required to maintain continual communication with project members during the duration of field activities. Thereby, should issues arise during field activities, corrective actions can be implemented.

Section 7: Data Tracking, Reduction, and Validation

7.1 Sample Data Tracking System

During field activities, field personnel will be responsible for overseeing field measurements and data recording. Information on field forms will be verified that the following conditions have been met:

- Samples are properly documented in daily field logs, field logbooks and/or other field forms appropriate to the field activities being conducted.
- Chain-of-custody forms are complete and accurate.
- Samples collected are properly documented and field forms are completed.
- Samples and analyses specified in the Work Plan have been collected.
- Correct number of field QC samples was collected.

In addition, upon receipt of samples at the laboratory, it will be verified that samples were received at the appropriate temperature and in good condition (i.e., no excessive headspace, broken sample containers, etc.). If a sample does not arrive at the laboratory at the appropriate temperature or the integrity of the sample is in question, the potential implication of the anomaly will be evaluated and a course of action will be determined.

7.2 Data Reduction

Both field and laboratory data will be collected during implementation of the cleanup action. Data obtained during sample collection will be manually entered onto daily field logs, field logs book, and other field forms.

The laboratory will provide analytical data in electronic and/or paper form. Electronic data will be loaded into project databases and verified with the paper copy.

Some data from these sources (such as sample location name and coordinates, water levels, and field parameters) may also be manually entered into project databases or various programs such as computer-aided drafting and design (CADD). Manually entered data will be reviewed by a second individual.

The central data management tool for the laboratory is the laboratory information management system (LIMS). The LIMS is used for sample processing, including sample log-in and tracking, instrument data storage and processing, generating data reports, and verifying results. Data collected from each laboratory instrument, either manually or electronically, are reviewed and confirmed by the analyst prior to reporting. Laboratory records including chain-of-custody forms, bench sheets, and analytical results, whether in electronic or hard copy format, are stored chronologically by batch or project.

7.3 Data Review, Verification, and Validation

Field and laboratory data generated during implementation of the cleanup action will be reviewed, verified, and validated. Field data entered into databases will be verified. Errors identified during the verification of data will be corrected prior to release of the final data.

The laboratory is responsible for verifying analytical results prior to the submittal of the final laboratory data report. Initially, all analytical data generated by the laboratory are verified by the laboratory. During the analysis process, the analyst and the laboratory QA Manager verify that the results have met various performance-based control limits (e.g., surrogate recoveries and continuing calibration). Non-conformance of various method QC requirements and control limits warrants the re-analysis and/or re-extraction of a sample.

Finally, the data will be verified and validated based on the quality objectives specified in this QAPP and performance-based criteria specified in the analytical methods in accordance with applicable portions of EPA's Contract Laboratory Program National Functional Guidelines for Organic and Inorganic Data Review (EPA 2004; 2008). If data do not meet required criteria, they will be flagged with data qualifiers as specified under the action portion of each requirement of the functional guidelines (EPA 2004; 2008).

Data verification and validation will be conducted to assess the laboratory's performance in meeting the quality objectives identified in the QAPP (e.g., reporting limits and control limits) and performance-based criteria specified in the analytical methods. The components to be evaluated during the data validation process are summarized below:

- Holding times
- Method blank results
- Surrogate recovery results for organic analyses
- Laboratory control sample results
- Field duplicate results
- Field blank results
- Laboratory duplicate results, where applicable
- Matrix spike/matrix spike duplicate (MS/MSD) results for all relevant analyses
- Completeness
- Reported detection limits for analyses.

If data do not meet the quality objectives and required criteria, they will be flagged with data qualifiers as specified under the action portion of each requirement of the functional guidelines (EPA 2004; 2008). Typical data qualifiers include, but are not limited to, "J," used to indicate an estimated value, "B," used to indicate blank contamination, and "R," used to indicate a rejected value. The findings of the data validation will be presented in the Remedial Investigation Report. Limitations to the usability of the data will also be discussed in the report.

References

Kennedy/Jenks Consultants. 2013a. Cleanup Action Plan, Cornet Bay Marina, Whidbey Island, Washington, Kennedy/Jenks Consultants. July 2013.

Kennedy/Jenks Consultants. 2013b. Engineering Design Report, Cornet Bay Marina, Whidbey Island, Washington, Kennedy/Jenks Consultants. September 2013.

Kennedy/Jenks Consultants. 2013c. Compliance Monitoring Plan and Sampling and Analysis Plan, Cornet Bay Marina, Whidbey Island, Washington, Kennedy/Jenks Consultants. September 2014.

U. S. Environmental Protection Agency (EPA). 1986, as amended through February 2007. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. SW-846.

U. S. Environmental Protection Agency (EPA) Office of Water. 1999. 821/R-99-017.

U. S. Environmental Protection Agency (EPA) Office of Water. 2002. 821/R-02-019.

U. S. Environmental Protection Agency (EPA). 2004. Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA 540-R-04-004. October 2004. .

U. S. Environmental Protection Agency (EPA). 2008. Contract Laboratory Program National Functional Guidelines for Superfund Organic Data Review. EPA 540-R-08-01. June 2008.

U. S. Environmental Protection Agency (EPA) Office of Water. 2009. 600/R-09-122. September 2009.

Washington Department of Ecology. 1997. Analytical Methods for Petroleum Hydrocarbons. Publication No. ECY 97-602. June 1997.

Washington State Department of Ecology. 2013. Project Manual, Invitation for Bids IFB 1415 TCP, Cornet Bay Marina Remediation. Washington State Department of Ecology, September 2013.

Table 1: Summary of Target PQLs[a]

Analyte	Soil Samples Target PQL[b]	Groundwater Samples Target PQL[b]
Metals	**µg/kg**	**µg/L**
Total/Dissolved Arsenic	200	0.2
Total/Dissolved Barium	500	0.5
Total/Dissolved Cadmium	100	0.1
Total/Dissolved Chromium (total)	500	0.5
Total/Dissolved Lead	100	0.1
Total/Dissolved Mercury	25	0.02
Total/Dissolved Selenium	500	0.5
Total/Dissolved Silver	200	0.2
Volatile Organic Compounds	**µg/kg**	**µg/L**
1,1,1,2-Tetrachloroethane	1.0	0.2
1,1,1-Trichloroethane	1.0	0.2
1,1,2,2-Tetrachloroethane	1.0	0.2
1,1,2-Trichloro-1,2,2-Trifluoroethane	2.0	0.2
1,1,2-Trichloroethane	1.0	0.2
1,1-Dichloroethane	1.0	0.2
1,1-Dichloroethene	1.0	0.2
1,1-Dichloropropene	1.0	0.2
1,2,3-Trichlorobenzene	5.0	0.5
1,2,3-Trichloropropane	2.0	0.5
1,2,4-Trichlorobenzene	5.0	0.5
1,2,4-Trimethylbenzene	1.0	0.2
1,2-Dibromo-3-Chloropropane	5.0	0.5
1,2-Dibromoethane	1.0	0.2
1,2-Dichlorobenzene	1.0	0.2
1,2-Dichloroethane	1.0	0.2
1,2-Dichloropropane	1.0	0.2
1,3,5-Trimethylbenzene	1.0	0.2
1,3-Dichlorobenzene	1.0	0.2
1,3-Dichloropropane	1.0	0.2
1,4-Dichlorobenzene	1.0	0.2
2,2-Dichloropropane	1.0	0.2
2-Butanone	5.0	5
2-Chloroethyl Vinyl Ether	5.0	1
2-Chlorotoluene	1.0	0.2
2-Hexanone	5.0	5
4-Chlorotoluene	1.0	0.2
4-Isopropyl Toluene	1.0	0.2
4-Methyl-2-Pentanone	5.0	5
Acetone	5.0	5
Acrolein	50	5
Acrylonitrile	5.0	1
Benzene	1.0	0.2
Bromobenzene	1.0	0.2
Bromochloromethane	1.0	0.2
Bromodichloromethane	1.0	0.2
Bromoethane	2.0	0.2
Bromoform	1.0	0.2
Bromomethane	1.0	1
Carbon Disulfide	1.0	0.2
Carbon Tetrachloride	1.0	0.2
Chlorobenzene	1.0	0.2
Chlorodibromomethane	1.0	0.2
Chloroethane	1.0	0.2

Table 1: Summary of Target PQLs[(a)]

Analyte	Soil Samples Target PQL[(b)]	Groundwater Samples Target PQL[(b)]
Volatile Organic Compounds, cont'd	**µg/kg**	**µg/L**
Chloroform	1.0	0.2
Chloromethane	1.0	0.5
cis-1,2-Dichloroethene	1.0	0.2
cis-1,3-Dichloropropene	1.0	0.2
Dibromomethane	1.0	0.2
Ethyl Benzene	1.0	0.2
Hexachloro-1,3-Butadiene	5.0	0.5
Iodomethane (Methyl Iodide)	1.0	1
Isopropyl Benzene	1.0	0.2
m,p-Xylene	1.0	0.4
Methylene Chloride	2.0	1
Methyl-t-butyl ether (MTBE)	1.0	0.5
Naphthalene	5.0	0.5
n-Butylbenzene	1.0	0.2
n-Propyl Benzene	1.0	0.2
o-Xylene	1.0	0.2
s-Butylbenzene	1.0	0.2
Styrene	1.0	0.2
t-Butylbenzene	1.0	0.2
Tetrachloroethene	1.0	0.2
Toluene	1.0	0.2
trans-1,2-Dichloroethene	1.0	0.2
trans-1,3-Dichloropropene	1.0	0.2
trans-1,4-Dichloro-2-Butene	5.0	1
Trichloroethene	1.0	0.2
Trichlorofluoromethane	1.0	0.2
Vinyl Acetate	5.0	0.2
Vinyl Chloride	1.0	0.2
Polycyclic Aromatic Hydrocarbons (SIM)	**µg/kg**	**µg/L**
1-Methylnaphthalene	5	0.1
2-Methylnaphthalene	5	0.1
Acenaphthene	5	0.1
Acenaphthylene	5	0.1
Anthracene	5	0.1
Benzo(a)anthracene	5	0.01
Benzo(a)Pyrene	5	0.01
Benzo(g,h,i)Perylene	5	0.1
Benzo(b)fluoranthene	5	0.01
Benzo(k)fluoranthene	5	0.01
Chrysene	5	0.01
Dibenz(a,h)Anthracene	5	0.01
Dibenzofuran	5	0.1
Fluoranthene	5	0.1
Fluorene	5	0.1
Indeno(1,2,3-cd)Pyrene	5	0.01
Naphthalene	5	0.1
Phenanthrene	5	0.1
Pyrene	5	0.1

Table 1: Summary of Target PQLs[(a)]

Analyte	Soil Samples Target PQL[(b)]	Groundwater Samples Target PQL[(b)]
Polychlorinated Biphenyl Aroclors	**mg/kg**	na
Aroclor 1016	4	na
Aroclor 1221	4	na
Aroclor 1232	4	na
Aroclor 1242	4	na
Aroclor 1248	4	na
Aroclor 1254	4	na
Aroclor 1260	4	na
Dioxins/Furans	**pg/g**	na
2,3,7,8-TCDD	1	na
1,2,3,7,8-PECDD	5	na
1,2,3,4,7,8-HXCDD	5	na
1,2,3,6,7,8-HXCDD	5	na
1,2,3,7,8,9-HXCDD	5	na
1,2,3,4,6,7,8-HPCDD	5	na
OCDD	10	na
2,3,7,8-TCDF	1	na
1,2,3,7,8-PECDF	5	na
2,3,4,7,8-PECDF	5	na
1,2,3,4,7,8-HXCDF	5	na
1,2,3,6,7,8-HXCDF	5	na
1,2,3,7,8,9-HXCDF	5	na
2,3,4,6,7,8-HXCDF	5	na
1,2,3,4,6,7,8-HPCDF	5	na
1,2,3,4,7,8,9-HPCDF	5	na
OCDF	10	na
Total Petroleum Hydrocarbons	**mg/kg**	**µg/L**
Gas Range	5	250
Oil Range	10	200
Diesel Range	5	100
Natural Attenuation Parameters	na	**µg/L**
Ntrate	na	100
Sulfate	na	100
Sulfide	na	50
Alkalinity	na	2000
Methane	na	0.70
Iron	na	20
Manganese	na	0.50

Notes:

(a) Target PQL values presented in this table are based on LOQ values from Analytical Resources, Inc. (ARI) of Seattle, Washington.

(b) PQLs from selected analytical laboratories to be verified prior to start of field sampling activities.

Abbreviations:

na = not applicable for matrix
µg/kg = micrograms per kilogram
µg/L = micrograms per liter
mg/kg = milligrams per kilogram
pg/g = picograms per gram
PQL = Practical Quantitation Limit
LOQ - Limit of Quantitation
SIM = Select Ion Monitoring