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WORK PLAN ADDENDUM NUMBER 2 ADDITIONAL GROUNDWATER AND SOIL SAMPLING
SITE 19 ON SHORE DERECKTOR SHIPYARD OPERABLE UNIT 12 (OU 12) NS NEWPORT

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TETRA TECH

Work Plan Addendum No. 2

Additional Groundwater and Soil Sampling

**Site 19 – On-Shore Derecktor Shipyard
(Operable Unit 12)**

**Naval Station Newport
Newport, Rhode Island**



**Naval Facilities Engineering Command
Mid-Atlantic**

**Contract Number N62472-03-D-0057
Contract Task Order 165**

June 2014

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WORK PLAN ADDENDUM 2
ADDITIONAL GROUNDWATER AND SOIL SAMPLING
ON-SHORE DERECKTOR SHIPYARD, SITE 19
NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND
COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYMS

bgs	Below Ground Surface
B&RE	Brown and Root Environmental
CLEAN	Comprehensive Long-Term Environmental Action Navy
CSM	Conceptual Site Model
CTO	Contract Task Order
DEC	Direct Exposure Criteria
DoD	Department of Defense
DPT	Direct Push Technologies
DQO	Data Quality Objective
ELAP	Environmental Laboratory Accreditation Program
EPA	United States (U.S.) Environmental Protection Agency
FS	Feasibility Study
GIS	Geographic Information Systems
HASP	Health and Safety Plan
HI	Hazard Index
HHRA	Human Health Risk Assessment
IDW	Investigation Derived Waste
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MNA	Monitored Natural Attenuation
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAVSTA	Naval Station Newport
ORP	Oxygen Reduction Potential
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PQL	Project Quantitation Limit
PQOs	Project Quality Objectives
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RIDEM	Rhode Island Department of Environmental Management
ROD	Record of Decision
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SASE	Study Area Screening Evaluation
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leachate Procedure
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
Tetra Tech	Tetra Tech, Inc., formerly Tetra Tech NUS, Inc.
UFP	Uniform Federal Policy
U.S.	United States
VOCs	Volatile Organic Compounds

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1.0 INTRODUCTION

This Work Plan Addendum No. 2 was prepared by Tetra Tech, Inc., (Tetra Tech) for the U.S. Department of Navy (Navy) to conduct *additional groundwater and soil sampling* activities during *summer 2014* at Site 19 – On-Shore Derecktor Shipyard (Operable Unit [OU] 12) (the site) at Naval Station (NAVSTA) Newport, Rhode Island. Figure 1-1 provides a site location map. This second addendum is a supplement to the Work Plan for On-Shore Site Assessment Screening Evaluation (SASE), Former Derecktor Shipyard, Naval Education & Training Center, Newport, Rhode Island (Brown and Root Environmental [B&RE], 1996) and Work Plan Addendum No. 1 for the SASE (Data Gaps Investigation) (Tetra Tech, 2011). This Work Plan Addendum No. 2 will be used to guide Tetra Tech personnel in performing the additional sampling activities as agreed at the Tier 1 and Tier 2 levels of the Remedial Project Manager (RPM) Team. This work is being conducted by Tetra Tech for Navy under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-03-D-0057, Contract Task Order (CTO) 165.

As part of their review of the Feasibility Study (FS), the U.S. Environmental Protection Agency (EPA) and Rhode Island Department of Environmental Management (RIDEM) requested that additional groundwater and soil sampling be conducted to provide new information on potential natural attenuation conditions at the site and on contaminant leachability conditions at certain locations. The requested additional data will provide valuable information to support remedy selection and future monitoring evaluations.

This Work Plan Addendum No. 2 presents updates to the Work Plan Addendum No. 1 (Tetra Tech, 2011), provided in Appendix A. The sections in this Work Plan Addendum No. 2 correspond to sections in the above-named work plan, with section-specific text added only for those activities to be conducted as part of this additional fieldwork. As requested by the Navy Chemist, a Sampling and Analysis Plan (SAP) Crosswalk Table has been prepared (Table 1-1) to provide a guide to the Uniform Federal Policy (UFP) SAP elements presented in this unique-format work plan addendum. The UFP-SAP is the most recent project planning document format required by NAVFAC. For the sake of expediency and continuity with earlier documents, this Addendum No. 2 does not adhere to the UFP-SAP format. The cross-walk table helps locate the elements of a planning document as required by the UFP-SAP.

1.1 PROJECT OBJECTIVES

Section 1.1 is amended by addition of the following text.

The objectives of the field work described in this Work Plan Addendum No. 2 are as follows:

- Collect additional soil samples from previous sample locations with leachability criteria exceedances to confirm naphthalene concentrations and re-evaluate lead using the Synthetic Precipitation Leachate Procedure (SPLP) method instead of Toxicity Characteristic Leaching Procedure (TCLP).
- Collect additional groundwater samples from previously sampled wells where additional temporal data and natural attenuation data has been requested by the regulators.

As noted above, this Addendum No. 2 amends the Work Plan Addendum No. 1 (Tetra Tech, 2011), as described in the following sections.

1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

Section 1.2 has been updated for the purposes of the On-Shore groundwater and soil additional sampling effort in summer 2014 as follows:

Table 1-2 provides the updated project specific communication pathways and Table 1-3 outlines the personnel responsibilities. Figure 1-2 provides the updated project organizational chart.

1.3 PROJECT DELIVERABLES

Section 1.3 is amended by addition of the following text:

The project deliverable will be a data report in technical memorandum (tech memo) format. The purpose of the tech memo will be to present the results of the additional sampling; it will consist of only three sections: Introduction, Field Methods, and Results.

1.4 WORK PLAN ORGANIZATION

Section 1.4 has not been updated for the purposes of the purposes of this work plan addendum.

1.5 CHANGES TO THE WORK PLAN

Section 1.5 has not been updated for the purposes of the purposes of this work plan addendum.

1.6 SCHEDULE AND REGULATORY OVERSIGHT

Section 1.6 has not been updated for the purposes of the purposes of this work plan addendum.

2.0 BACKGROUND

Section 2.0 is amended by addition of the following text:

Information in this section has been augmented by adding the findings of the SASE Addendum Report.

2.1 ACTIVITY HISTORY

Section 2.1 has not been updated for the purposes of the purposes of this work plan addendum.

2.2 SURROUNDING LAND USE

Section 2.2 has not been updated for the purposes of the purposes of this work plan addendum.

2.3 GEOLOGY/HYDROGEOLOGY

Section 2.3 has not been updated for the purposes of the purposes of this work plan addendum.

2.4 FINDINGS OF THE PRELIMINARY SITE ASSESSMENT

Section 2.4 has not been updated for the purposes of the purposes of this work plan addendum.

2.5 RECENT ACTIVITY

Section 2.5 has not been updated for the purposes of the purposes of this work plan addendum.

2.6 RECOMMENDATIONS OF THE PRELIMINARY ASSESSMENT REPORT

Section 2.6 has not been updated for the purposes of the purposes of this work plan addendum.

2.7 FINDINGS OF THE SITE ASSESSMENT SCREENING EVALUATION REPORT

Section 2.7 has not been updated for the purposes of the purposes of this work plan addendum.

2.8 RECOMMENDATIONS OF THE SITE ASSESSMENT SCREENING EVALUATION REPORT

Section 2.8 has not been updated for the purposes of the purposes of this work plan addendum.

2.9 REMOVAL ACTIVITIES

Section 2.9 has not been updated for the purposes of the purposes of this work plan addendum.

2.10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

For the purposes of this expedited Work Plan Addendum 2, the following limited summary is provided for the RI/FS historical information. More detailed information will be provided in a new standalone UFP-SAP to be prepared for long-term monitoring purposes following the finalization of the Record of Decision (ROD). These details are available in the Final FS (Tetra Tech, May 2014).

A Data Gaps Investigation was conducted in 2011 after the original SASE and removal actions. Documented in the Tetra Tech (2013) *Final SASE Addendum Report*, this investigation included groundwater, soil, and soil gas sampling focused on specific locations and analytes as scoped by the Navy, EPA, and RIDEM. Laboratory analysis was sample-specific, but included volatile organic compounds (VOCs), TPH– diesel range organics (TPH-DRO) and gasoline range organics (-GRO), PAHs, PCBs, and metals. The SASE Addendum Report included a new baseline HHRA. The conclusions of the risk assessment determined that risk is present under the residential use scenario for soil and groundwater. Risk under the future industrial user scenario is present due to inadvertent ingestion of groundwater containing arsenic and manganese. In addition to risk-based contaminants, there are exceedances of state residential and industrial criteria. Figure 2-2 presents the current Conceptual Site Model (CSM) for Site 19.

Based on the risks estimated for the hypothetical residents (soil and groundwater) and industrial workers (groundwater), the report recommended an FS. The B&R (1997) SASE Report and Tetra Tech (2013) SASE Addendum Report serve as the Remedial Investigation (RI) component in the CERCLA process for the on-shore portion of Site 19 – Derecktor Shipyard. The FS and Proposed Plan were completed in May 2014. The proposed remedy for soil is covers, cover maintenance, and LUCs. The proposed remedy for groundwater is MNA and LUCs. During review and finalization of the FS, the RPM Team agreed to perform additional soil and groundwater sampling to support these remedy selections before finalizing the ROD.

3.0 FIELD INVESTIGATION AND SAMPLING PLAN

Section 3.0 was amended by the addition of the following text.

This section describes additional field tasks proposed as part of the summer 2014 additional sampling effort to be implemented under this Work Plan Addendum No. 2. The required number, locations, and depths of soil and groundwater samples were determined in advance by the RPM Team (i.e., agreed initially by Tier 2 managers and scoped by Tier 1 RPMs) and are described below.

3.1 OBJECTIVES

Section 3.1 is amended by addition of the following text.

The field tasks to be conducted during summer 2014 under this Work Plan Addendum No. 2 include:

- Mobilize and demobilize for field investigation
- Install and develop temporary wells
- Conduct soil sampling (utilizing Direct Push Technology [DPT] and hand augering methods)
- Measure groundwater levels
- Conduct groundwater sampling at existing monitoring wells and new temporary wells
- Manage investigation-derived waste (IDW)

3.2 VISUAL AND INSTRUMENT INSPECTIONS

No changes were made to Section 3.2 for the purposes of this work plan addendum.

3.2.1 Task 1: Mechanical Pits and Trenches Inspection

No changes were made to Section 3.2.1 for the purposes of this work plan addendum.

3.2.2 Task 2: Underground Drainage Systems Tracking and Clearing

No changes were made to Section 3.2.2 for the purposes of this work plan addendum.

3.2.2.1 Storm Drains/Catch Basins

No changes were made to Section 3.2.2.1 for the purposes of this work plan addendum.

3.2.2.2 Floor Drains

No changes were made to Section 3.2.2.2 for the purposes of this work plan addendum.

3.3 INTRUSIVE INVESTIGATIONS

Section 3.3 is amended by addition of the following text.

Intrusive field activities described in this work plan addendum include soil borings for the collection of soil samples, and installation of temporary monitoring wells. Groundwater samples will be collected from

existing monitoring wells and temporary monitoring wells. Table 3-1 provides a summary of construction and survey details of the monitoring wells. Temporary wells will be installed at locations where existing monitoring wells appear damaged, integrity is questionable, or are inaccessible. The proposed sample locations, with their associated sampling details, are summarized in Table 3-2. The sample locations for soil and groundwater are depicted on Figures 3-1 and 3-2, respectively.

3.3.1 Task 3: Test Pit Excavation and Sample Collection

No changes were made to Section 3.3.1 for the purposes of this work plan addendum.

3.3.1.1 Test Pit Excavation

No changes were made to Section 3.3.1.1 for the purposes of this work plan addendum.

3.3.1.2 Sample Collection

No changes were made to Section 3.3.1.2 for the purposes of this work plan addendum.

3.3.2 Task 4: Geologic/Hydrogeologic Investigation

Section 3.3.2 was amended by addition of the following text.

Soil borings will be advanced at seven locations and soil samples will be collected. Depending on the surface cover and target depth at each location, either a DPT rig or a hand auger will be used to collect the soil samples. A surface soil sample will be collected at each of 5 locations. Four locations will be sampled from 0 to 1 foot below ground surface (bgs) and one location will have soil collected from 0.5 to 1.5 feet bgs. A subsurface soil sample will be collected at each of 2 locations as deep as 13 feet bgs. Table 3-2 provides the sample location identifier, sampling depths, and analysis to be conducted at each location. Table 3-3 provides the sampling design and rationale for these soil samples. Figure 3-1 presents the soil boring locations.

Groundwater samples will be collected at 13 well locations. These 13 locations are associated with existing or previously installed monitoring wells. Table 3-1 provides the monitoring well construction details and Table 3-2 provides the sample nomenclature and required analysis. Table 3-3 provides the sampling design and rationale for each of the samples being collected.

Table 3-4 provides the necessary references calibrating, maintaining, testing, and inspecting the field equipment to be used as part of this investigation. Table 3-5 provides the referenced Standard Operating Procedures (SOPs) that will be used during this sampling effort and referred to in the text. Appendix B provides copies of the referenced SOPs.

3.3.2.1 Investigation of Target Areas

Section 3.3.2.1 is amended by addition of the following text.

The investigation covered by this Work Plan Addendum No. 2 includes soil borings and temporary wells to be installed/and or sampled in summer 2014 at Site 19 – On-Shore Derecktor Shipyard. Unlike during the previous investigations, the site is not subdivided into target areas / subareas for this particular effort. Sample locations and analyses are established from previous investigations and RPM Team agreement.

Soil borings will be advanced at seven locations and soil samples will be collected at depths that correspond with soil samples which exceeded the GA Leachability Criteria during the 1997 SASE field investigation. Groundwater samples will be collected from 13 locations, 12 of which were sampled during the 2011 field investigation. The soil and groundwater samples collected are meant to confirm previous analytical data, provide new leachability data, and provide data for future evaluation of natural attenuation at the Site. See Figures 3-1 and 3-2 for the locations of the soil and groundwater samples respectively.

3.3.2.2 Advancement of Overburden Borings

Section 3.3.2.2 is amended by addition of the following text.

DPT drilling will be performed by a subcontractor to Tetra Tech (applicable SOPs, including SA-2.5, are included in Appendix B). All down-hole drilling equipment will be cleaned before use at the site and after completion of each boring (Section 3.6 provides detailed decontamination procedures).

Based on observations recorded during the SASE investigations, the bedrock depth at the site ranges from approximately 18 feet in the north to 46 feet in the south, and most of the overburden is a dense glacial till. Soil borings will be advanced and sampled using DPT drilling techniques to the target depth interval where exceedances of RIDEM GA Leachability Criteria were identified during the original 1996 SASE effort. Continuous soil cores will be collected and logged according to Tetra Tech SOP GH-1.5.

3.3.2.3 Soil Samples Collected From Borings

Section 3.3.2.3 is amended by addition of the following text.

The investigation covered by this work plan includes the collection of soil samples, see Table 3-2. The locations of the soil sample locations are shown on Figure 3-1. Soil samples will be collected in accordance with Tetra Tech SOP SA-1.3 (Appendix B).

The sampling design is a biased design primarily targeting existing monitoring wells and former soil sample locations where new leachability data was requested. Table 3-3 provides additional detail regarding sampling design and rationale for sample collection. Soil samples will be collected at specific depth intervals from locations which during the 1997 SASE investigation had concentrations exceeding the GA Leachability Criteria. Soil samples will be analyzed for naphthalene and for Synthetic Precipitation Leachate Procedure (SPLP) lead. The sample locations, sampling intervals, and analysis to be conducted are as follows:

- SB301 (TP08) at 0 to 1 foot, to be analyzed for SPLP lead
- SB302 (TP10) at 0 to 1 foot, to be analyzed for SPLP lead
- SB303 (TP11) at 12 to 13 feet, to be analyzed for SPLP lead
- SB304 (TP16) at 0 to 1 foot, to be analyzed for naphthalene and SPLP lead
- SB305 (TP26) at 3 to 5 feet, to be analyzed for naphthalene
- SB306 (TP28) at 0 to 1 foot, to be analyzed for SPLP lead
- SB 307 (MW08) at 0.5 to 1.5 feet, to be analyzed for SPLP lead

In addition, quality assurance/quality control (QA/QC) samples including field duplicates, equipment rinsate blanks, and laboratory QA/QC will be collected for analysis as part of the groundwater investigation. No QA/QC samples will be collected for soil. QA/QC samples are summarized in Table 3-6 and are described further in Section 4.1.3. The required sample containers, preservatives, and holding times for each analytical group, and analytical methods are presented in Table 3-7.

The drill cuttings generated during investigative activities will be returned to the borehole with the remainder of the boring backfilled with bentonite and/or clean sand. See Section 3.4 for a more complete discussion of IDW handling.

3.3.2.4 Groundwater Monitoring Well Installation

Section 3.3.2.4 is amended by addition of the following text.

Temporary groundwater monitoring wells will be installed as necessary. The collection of groundwater levels and monitoring well inspections are more thoroughly discussed in Tetra Tech SOP GH-1.2 (Appendix B).

If any existing well is compromised, inaccessible, or cannot be located, a temporary monitoring well will be installed at the same depth and screen interval as the former or adjacent well. The one location which is known to need a temporary monitoring well is MW-11A, which will be installed from 5 to 10 feet bgs and labeled as MW-11B. Table 3-1 provides a summary of the construction details of the monitoring wells. During well installation, a 3.25-inch casing will be advanced to the target depth and the temporary monitoring wells will be installed through the casing. The wells will be constructed with 1-inch inner diameter schedule 40 polyvinyl chloride casing with a pre-packed 10-slot (0.010-inch) screen. After the well is in place the casing will be pulled out as sand is added as possible to approximately 2 feet above the top of the screen, and a bentonite seal will be placed on top and allowed to hydrate before the well is completed. The temporary wells will be completed with a concrete pad, protective steel casing or a flush mount well box, and locked until sample results are validated and confirmed acceptable. These wells will be abandoned in a separate field event.

3.3.2.5 Well Development

Section 3.3.2.5 is amended by addition of the following text.

Well development will be conducted at temporary wells installed. Development will consist of a brief surge with a check valve to clean out the fines accumulated during drilling. Water quality parameters for pH, specific conductance, temperature, dissolved oxygen, and turbidity will be periodically measured during development and recorded on well development data sheets (Appendix C). Purged groundwater will be containerized in drums and temporarily stored onsite for characterization and disposal as described in Section 3.4.

Groundwater level measurements and sampling activities in a new/temporary monitoring well will not be conducted until at least 24 hours after well development to allow water levels to stabilize.

3.3.2.6 Groundwater Elevation Survey

No changes were made to Section 3.3.2.6 for the purposes of this work plan addendum.

3.3.2.7 Hydraulic Conductivity Testing

No changes were made to Section 3.3.2.7 for the purposes of this work plan addendum.

3.3.2.8 Groundwater Sample Collection

Section 3.3.2.8 is amended by addition of the following text.

Groundwater samples will be collected from the same 12 locations that were sampled in 2011 (MW02A, MW03, MW08, MW11A, MW12, MW204, MW218, MW219, MW220, MW221, MW222, and MW223) plus well MW104(Figure 3-2). Each groundwater sample will be analyzed for target compound list (TCL) VOCs and monitored natural attenuation (MNA) parameters, while select locations also will be analyzed for PAHs and TAL metals (total and dissolved) (see Table 3-2). The dissolved metals samples will be field-filtered using a 0.45 micron in-line filter.

All monitoring wells will be sampled using low stress (low-flow) purging and sampling procedures according to Tetra Tech SOP SA-1.1 (Appendix B). Dedicated tubing will be used for each monitoring well to minimize cross-contamination between monitoring wells during well purging. Water level drawdown and flow rate will be recorded on low-flow groundwater sample log sheets (Appendix C). Groundwater will be pumped through a flow-through cell and groundwater quality parameters including pH, specific conductance, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and salinity will be measured and recorded on the purge data sheet. Turbidity will be measured separately with a turbidity meter. The instruments will be calibrated according to the manufacturer's specifications. Purging is considered complete and sampling may begin when all parameters have stabilized.

Salinity results for each sample will be noted on the chain-of-custody form (Appendix C) in order to aid the analytical laboratory in establishing dilution requirements for metals analysis, where salinity could present an interference concern.

The required sample containers, preservatives, and holding times for each analytical group, and analytical methods are presented in Table 3-7. In addition, QA/QC samples including field duplicates, equipment rinsate blanks, trip blanks, and laboratory QA/QC will be collected for analysis as part of the groundwater investigation. One rinsate blank for dissolved metals analysis will be collected using an in-line filter. QA/QC samples are summarized in Table 3-4 and are described further in Section 4.1.3. Purged groundwater will be containerized in drums and temporarily stored onsite for characterization and disposal as described in Section 3.4.

3.3.2.9 Soil-Gas Sample Collection

No changes were made to Section 3.3.2.9 for the purposes of this work plan addendum.

3.3.3 Tasks 5 and 6: Underground Drainage Systems Sampling

No changes were made to Section 3.3.3 for the purposes of this work plan addendum.

3.3.3.1 Task 5: Catch Basin and Sump Sampling

No changes were made to Section 3.3.3.1 for the purposes of this work plan addendum.

3.3.3.2 Task 6: Floor Drain Discharge Area Sampling

No changes were made to Section 3.3.3.2 for the purposes of this work plan addendum.

3.4 INVESTIGATION-DERIVED WASTE (IDW)

Section 3.4 is amended by addition of the following text.

It is anticipated that the following waste materials will be generated during the field investigation:

- Decontamination fluids
- Well purge water

IDW will be managed as described below, in accordance with RIDEM regulations.

Tetra Tech will be responsible for arranging the removal and proper disposal of all accumulated waste materials following completion of the field investigation. Manifests and shipping papers will be signed by a representative of the NAVSTA waste management office. Disposal will be arranged with licensed waste haulers and approved receiving facilities. Characterization analyses will be conducted by the waste disposal subcontractor.

3.4.1 Solid Wastes

Section 3.4.1 has not been updated for the purposes of this work plan addendum.

3.4.2 Soil Wastes

Section 3.4.2 has not been updated for the purposes of this work plan addendum.

3.4.3 Sandblast Material

No changes were made to Section 3.4.3 for the purposes of this work plan addendum.

3.4.4 Aqueous Wastes

Section 3.4.4 has not been updated for the purposes of this work plan addendum.

3.5 TASK 7: SURVEY

Section 3.5 is amended by addition of the following text.

After completion of sample collection activities the coordinates of all soil borings, temporary groundwater monitoring points and other pertinent features will be recorded by a handheld global positioning system (GPS) that is accurate to 1 meter or less. The coordinates of previously installed wells already have been incorporated into the NAVSTA Newport Geographic Information Systems (GIS) database.

3.6 DECONTAMINATION PROCEDURES

Section 3.6 is amended by addition of the following text.

All non-disposable equipment that comes in contact with sample media will be decontaminated to prevent cross-contamination between sampling points. This includes equipment such as stainless steel bowls and scoops, as well as heavy equipment. Personnel decontamination is discussed in the Health and Safety Plan (HASP).

Water level indicators will be sprayed with a liquid detergent solution, wiped with clean paper towels, and rinsed with deionized water in between every well.

SOPs for decontamination are addressed in the Tetra Tech SOP SA-7.1 (Appendix B).

All heavy equipment, including the drilling rig, rods, and other down-hole equipment used during site investigative activities will be decontaminated using a high-pressure steam wash prior to beginning work and between all boreholes. The water to be used during steam cleaning will be from a potable source.

3.7 TASK 8: EVALUATION OF CULTURAL AND ECOLOGICAL SETTINGS

No changes were made to Section 3.7 for the purposes of this work plan addendum.

3.7.1 Cultural Setting

No changes were made to Section 3.7.1 for the purposes of this work plan addendum.

3.7.2 Off-Shore Ecological Setting

No changes were made to Section 3.7.2 for the purposes of this work plan addendum.

3.7.3 On-Shore Ecological Setting

No changes were made to Section 3.7.3 for the purposes of this work plan addendum.

3.7.3.1 Characterization of Habitats

No changes were made to Section 3.7.3.1 for the purposes of this work plan addendum.

3.7.3.2 Literature Review

No changes were made to Section 3.7.3.2 for the purposes of this work plan addendum.

3.7.3.3 Review of Threatened And Endangered Species

No changes were made to Section 3.7.3.3 for the purposes of this work plan addendum.

3.7.3.4 Field Assessments

No changes were made to Section 3.7.3.4 for the purposes of this work plan addendum.

3.7.3.5 Data Products

No changes were made to Section 3.7.3.5 for the purposes of this work plan addendum.

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4.0 QUALITY ASSURANCE/QUALITY CONTROL

Section 4.0 has not been updated for the purposes of the On-Shore Pre-ROD Sampling effort.

4.1 QUALITY ASSURANCE OBJECTIVES

Section 4.1 is amended by addition of the following text.

The objectives of the additional groundwater and soil sampling effort in summer 2014 are to gather new leachability analytical soil data at former sample locations with results exceeding RIDEM GA Leachability Criteria during the 1996 SASE effort (Figure 3-1) and to collect another round of analytical groundwater data, including MNA parameter data, at wells sampled during the 2011 Data Gaps Investigation plus well MW104 (Figure 3-2). To accomplish these objectives, the following data are needed:

- Soil – naphthalene soil concentrations and lead soil SPLP leachate concentrations
- Groundwater – VOCs, metals, PAHs, and MNA parameter concentrations

Analyses are specific to selected locations and media as described in Table 3-2.

Historical data collected during the SASE efforts (B&RE, 1997; Tetra Tech, 2013) and the new data to be collected during summer 2014 under this Work Plan Addendum No. 2 will provide the data needed to meet project objectives. There are no limitations on the previously collected data.

4.1.1 Data Quality Objectives

Section 4.1.1 is amended by addition of the following text.

Project Quality Objectives (PQOs) define the type, quantity, and quality of data that are needed to answer specific environmental questions and support proper environmental decisions. To develop the PQOs for this investigation, the data quality objectives (DQOs) planning process described in the EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (U.S. EPA, 2006a) was used. The outputs of the DQO process for this project are presented in this section.

4.1.1.1 Define Problem and Establish a Decision Statement

During review of the Feasibility Study (FS), the RPM Team identified soil sample locations where RIDEM GA Leachability Criteria were exceeded for naphthalene and lead. The naphthalene GA Leachability Criterion is directly comparable to soil sample results (milligrams per kilogram [mg/kg]). The lead GA Leachability Criterion, however, is an aqueous value for comparison to soil leachate test results, either by EPA TCLP method or SPLP method.

Historical TCLP results were used for this leachability evaluation for metals in the FS. Acquisition of SPLP leachate results for lead will better support the remedy selection in the Record of Decision (ROD), because SPLP more closely mimics acid rain leaching conditions at this site rather than landfill conditions simulated by the TCLP. Naphthalene soil data also will confirm previous results to support the remedy selection in the ROD.

In addition, the RPM Team agreed to collect an additional round of groundwater data to aid in future MNA evaluations.

4.1.1.2 Inputs to the Decision

Inputs to the decision are chemical data. The reference limits for soil and groundwater are presented in Tables 4-1 and 4-2, respectively. The following groundwater data are needed to resolve the problem identified above:

- VOCs, PAHs, and metals (total and dissolved) concentrations in groundwater
- MNA parameter data to assess natural attenuation conditions at the site

These analytical groups were selected based on performing the same analytical suite testing as performed during the 2011 Data Gaps Investigation (reported in the 2013 SASE Addendum Report), per agreements by the RPM Team during review and finalization of the FS. Comparison criteria, the lower of: (1) the EPA MCLs for drinking water (EPA, 2010) or (2) the RIDEM Groundwater Quality Standards for GA aquifers (RIDEM, 2011), were used to establish groundwater analytical goals for this work plan addendum. Note groundwater analytes are not being limited to target contaminants (e.g., Chemicals of Concern) during the effort described herein; however, MNA performance monitoring efforts to be scoped in a new long-term monitoring SAP after the ROD will focus sample analysis on specific COCs and supporting parameters.

The following soil (and soil leachate test) data are needed to resolve the problem identified above by providing an indication of the potential for the selected target analytes to leach from soil to groundwater:

- Naphthalene soil concentrations at former test pit locations TP16 and TP26.
- Aqueous lead leachate concentrations from SPLP-tested soil samples at former test pits locations TP08, TP10, TP11, TP16, and TP28, and monitoring well location MW08.

These analytical groups were selected based on the exceedances of RIDEM GA Leachability Criteria during the 1996 and 2011 SASE investigation efforts. Comparison criteria, the RIDEM GA Leachability Criteria (RIDEM, 2011), were used to establish analytical sensitivity goals for this work plan addendum. These criteria are relatively low concentrations, so the data are expected to provide a high degree of utility in a wide range of future data uses, including temporal concentration monitoring.

4.1.1.3 Boundaries of the Study

The media to be investigated, as identified in the problem definition (groundwater and soil) are those media that were or could have been contaminated by a chemical release, or to which released chemicals may have migrated. To achieve a high degree of data comparability with past environmental investigations and to provide continuity for future monitoring, previously sampled locations or nearby areas are targeted for new data collection.

The groundwater population of interest is the overburden aquifer underlying the site. It is anticipated that groundwater samples will be collected primarily from previously installed wells that were sampled during the SASE Addendum investigation. It is possible that previously installed wells have been destroyed or are inaccessible and temporary groundwater monitoring wells will be installed to collect groundwater samples at or near those locations. Additionally, due to regulatory request, MW104, located downgradient of Building 7 (upgradient of the Building 234 area) will be sampled as part of this effort to provide a more comprehensive assessment of site conditions. Total and dissolved metals will be analyzed to evaluate possible high turbidity groundwater impacts on analytical results and to mimic the previous round of groundwater sampling conducted in 2011.

The soil population of interest is within several areas of the On-Shore Derecktor site area, which include TP08, TP10, TP11, TP16, TP26, TP28, and MW08. At TP08, TP10, TP16, TP28, and MW08 the soil of interest is the surficial soil. At TP11 and TP26 the soil of interest is subsurface soil.

4.1.1.4 Analytical Approach

The new chemical data will be used to support remedy selection and provide temporal and natural attenuation data for groundwater to help plan the anticipated LTM program. These evaluations and any associated decisions will be made outside the purview of this project / Work Plan Addendum No. 2.

4.1.1.5 Performance Criteria

The data acquired by implementing this SAP addendum will be provided to the project team for their use(s): Groundwater data will provide additional temporal data and preliminary baseline data for the MNA groundwater remedy, and the soil data will provide information on whether leaching issues exist for lead and naphthalene and whether the issues need to be addressed by the soil remedy. Language in the Final ROD can be adjusted accordingly pending these results.

If the targeted data are acquired and no significant data quality deficiencies or usability constraints are identified during data validation and usability assessment, the project will have attained its objectives; otherwise, the project team will need to revisit the data quality objectives to determine whether additional measures are required to attain or modify project objectives.

Results of data validation (i.e., data qualifications) will be considered in data evaluation and the data validation criteria are presented in Section 4.10.2. The data usability assessment process will follow the previously established process and is described in more detail in Section 4.1.2.

4.1.1.6 Sampling Design

The DQO process presented in the EPA QA/G-4 document describes the use of various approaches for developing a data set. These approaches are based on contaminant distributions and outputs of the previous steps. The sampling design for the efforts covered in this Work Plan Addendum number 2 was based on previous sample data and Navy/regulator agreements, as outlined in Table 3-3.

Specifics of the data collection design, rationale, and procedures are presented in Section 3.0.

4.1.2 PARCC Parameters

Section 4.1.2 has not been updated for the purposes of the On-Shore Pre-ROD Sampling effort. This evaluation requires a review of data quality indicators relative to measurement performance criteria (MPCs) to verify that precision, accuracy, representativeness, comparability, completeness, and sensitivity of analytical data are sufficient to support the project.

4.1.3 Quality Control Samples

Section 4.1.3 has been updated for the purposes of the On-Shore Pre-ROD Sampling effort.

Table 4-3 provides the Measurement Performance Criteria Table for the quality control samples to be collected.

4.1.3.1 Field Duplicates

Section 4.1.3.1 has not been updated for the purposes of the On-Shore Pre-ROD Sampling effort.

4.1.3.2 Equipment Rinsate Blanks

Section 4.1.3.2 has not been updated for the purposes of this work plan addendum.

4.1.3.3 Field Blanks

Section 4.1.3.3 has not been updated for the purposes of this work plan addendum.

4.1.3.4 Trip Blanks

Section 4.1.3.4 has not been updated for the purposes of this work plan addendum.

4.1.3.5 Matrix Spike/Matrix Spike Duplicates (MS/MSD)

Section 4.1.3.5 has not been updated for the purposes of this work plan addendum.

4.2 SAMPLING PROCEDURES

Section 4.2 has not been updated for the purposes of this work plan addendum.

4.3 SAMPLE DESIGNATION AND CUSTODY

Section 4.3 has not been updated for the purposes of this work plan addendum.

4.3.1 Sample Numbering

Section 4.3.1 is amended by addition of the following text.

Each sample to be collected will be assigned a unique sample-tracking number to be used to catalog the associated results. Table 3-2 details the samples to be collected and their respective sample ID. The sample-tracking number will consist of alpha-numeric characters identifying the site, sample medium, location, and depth or date. Any other pertinent information regarding sample identification will be recorded on the sample log sheets or in the field logbooks.

The alpha-numeric (A-N) coding to be used in the sample-tracking system is detailed below and in the subsequent definitions.

AAA	-	AANN (or AANN for some existing wells)	-	NNNN
(Site ID)	-	(Medium & Location)	-	(Depth or Date)

Site identifier: "DSY" for Derecktor Shipyard

Medium identifier: “MW” for groundwater samples and “SB” for soil samples

Sample location identifier: The sample location identifier will be numeric characters within the portion of the sample-tracking number that represent the assigned location number, either the monitoring well number, or soil boring number. The soil boring locations to be advanced during the work conducted under this Work Plan Addendum are assigned a “300-series” location number, beginning with “301”. If new temporary groundwater monitoring points need to be advanced those will be identified using the same identifier as the well they are replacing with an “A” after the well ID (in the case of MW11 a “B” will be used if MW11 cannot be located because it has already been sampled as “A” during the SASE Addendum).

Depth/Date: For soil sample locations, this portion of the sample-tracking number will represent the depth in feet below ground surface from which the sample was collected; e.g., for soil samples collected from 2 to 4 feet bgs, this portion of the sample tracking number will be “0204”.

For groundwater samples collected from monitoring wells, this portion of the sample-tracking number will represent the month and year (MMYY) the sample was collected.

For example, a soil sample from soil boring SB301 from the 10 to 12 feet interval will be labeled DSY-SB301-1012. A groundwater sample collected from MW204 collected in October 2014 will be labeled DSY-MW204-1014.

Quality Control Samples: QC samples collected during the field work program will use the same coding system as the environmental samples. Field QC sample types are presented in Section 3.4. Field QC designations will conform to the following formats:

Field Duplicates: Blind field duplicate samples will be designated such that the location designation will be replaced with a sequential “-DUP” label, followed by the date (MMDDYY). The sample log sheet will note which sample location the duplicate was collected from. For example the first groundwater field duplicate sample collected on October 17, 2014 will be labeled DSY-MW-DUP01-101714 and the second field duplicate will be DSY-MW-DUP02-101714. The first soil field duplicate collected will be labeled DSY-SB-DUP01-101714.

Rinsate Blanks: Rinsate blank sample identifiers will consist of the medium, a sequential “RB” label, and the date (MMDDYY). Example: DSY-MW-RB01-101714 and DSY-SB-RB01-101714.

Laboratory QC samples (matrix spike and laboratory duplicate samples) have no separate sample identifier codes, but are noted on the chain-of-custody record and sample log sheet.

Each sample will be handled as per the details in Table 4-4.

4.3.2 Sample Chain-of-Custody

Section 4.3.2 has not been updated for the purposes of this work plan addendum.

4.4 CALIBRATION PROCEDURES

Section 4.4 has not been updated for the purposes of this work plan addendum.

4.5 ANALYTICAL PROCEDURES

Section 4.5 has not been updated for the purposes of this work plan addendum.

4.5.1 Laboratory Analysis

Section 4.5.1 is amended by addition of the following text. Chemical analysis for all analytical groups will be performed by a subcontracted fixed-base laboratory. The laboratory is accredited under the Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP). Analyses will be performed in accordance with the analytical methods identified in Table 3-7 and the requirements of the technical specifications for laboratory services developed by Tetra Tech for this work (Appendix D).

The soil samples will be analyzed for all or a subset of the following: SPLP lead, naphthalene (as indicated in Table 3-2) according to the EPA SW-846 methods listed in Table 3-7. The groundwater samples will be analyzed for all or a subset of the following: VOCs, PAHs, TAL metals (total and dissolved), and MNA parameters; dissolved metals will be filtered at the site. The types of sample containers, preservatives, and holding times for each analytical group are presented in Table 3-7.

The laboratory technical specifications detail the analytical requirements, number of samples, matrix, methods to be used, sample containers, preservatives, holding times, the quantitation limits required for the project, and data deliverables. The laboratory will perform the chemical analyses following laboratory-specific SOPs listed in Table 4-5 and developed based on the methods listed in Table 3-7. The laboratory QC sample method/SOP acceptance limits to be met for each analysis are listed in Tables 4-6 through 4-13.

Tetra Tech will evaluate and track the technical performance of the laboratory.

4.5.2 Field Screening

Section 4.5.2 has not been updated for the purposes of this work plan addendum.

4.6 DATA REDUCTION, REVIEW, AND REPORTING

Section 4.6 has not been updated for the purposes of this work plan addendum.

4.7 INTERNAL QUALITY CONTROL

Section 4.7 has not been updated for the purposes of this work plan addendum.

4.8 PERFORMANCE AND SYSTEM AUDITS

Section 4.8 has not been updated for the purposes of this work plan addendum.

4.9 PREVENTATIVE MAINTENANCE

Section 4.9 has not been updated for the purposes of this work plan addendum.

4.10 DATA ASSESSMENT PROCEDURES

Section 4.10 has not been updated for the purposes of this work plan addendum.

4.10.1 Representativeness, Accuracy, and Precision

Section 4.10.1 has been updated for the purposes of this work plan addendum.

Table 4-14 provides the updated data verification procedures

4.10.2 Data Validation

Section 4.10.2 has been updated for the purposes of this work plan addendum.

Table 4-15 provides the updated data validation procedures

4.10.3 Data Evaluation

Section 4.10.3 has not been updated for the purposes of this work plan addendum.

4.11 CORRECTIVE ACTION

Section 4.11 has not been updated for the purposes of this work plan addendum.

4.12 QUALITY ASSURANCE REPORTS/DOCUMENTS

Section 4.12 has not been updated for the purposes of this work plan addendum.

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5.0 REPORTING

Section 5.0 is amended by the following text.

Following completion of the field and analytical work described in Section 3, the results of the information collected will be described in the form of a Technical Memorandum (Tech Memo) report.

The Tech Memo will contain three major sections. This outline has been selected because the data will not be used for production of a Remedial Investigation Report or any type of risk assessment.

5.1 BACKGROUND AND FINDINGS OF THE INVESTIGATIONS

No changes were made to Section 5.1 for the purposes of this work plan addendum.

5.2 PRELIMINARY HUMAN HEALTH RISK ASSESSMENTS

No changes were made to Section 5.2 for the purposes of this work plan addendum.

5.3 ECOLOGICAL ASSESSMENT

No changes were made to Section 5.3 for the purposes of this work plan addendum.

5.4 SASE ADDENDUM - ADDITIONAL INVESTIGATIONS

No changes were made to Section 5.4 for the purposes of this work plan addendum

5.5 TECHNICAL MEMORANDUM

Section 1 will provide a brief introduction with the purpose of this additional sampling effort in summer 2011. Section 2 will describe the field techniques utilized to obtain the samples, and will provide details regarding sampling dates and field observations. Section 3 will present the data collected and any quality issues encountered. Data tables and sample location figures will be provided.

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REFERENCES

B&RE (Brown and Root Environmental), 1996. *Work Plan For On-Shore Site Assessment and Screening Evaluation, Former Derecktor Shipyard, Naval Education & Training Center, Newport, Rhode Island*. April.

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Intergovernmental Data Quality Task Force (IDQTF), 2005. *Uniform Federal Policy for Quality Assurance Program Plans, Part 1: UFP-QAPP Manual, Final Version 1*. March.

RIDEM (Rhode Island Department of Environmental Management), 2011. *Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases*. Office of Waste Management. DEM-DSR-01-93. November.

Tetra Tech, 2011. *Work Plan Addendum Number 1. On-Shore Derecktor Shipyard, Naval Station Newport, Rhode Island*.

Tetra Tech, 2013. *SASE Addendum Report. Site 19 – On-Shore Derecktor Shipyard, Naval Station Newport, Rhode Island*. January.

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**TABLE 1-1
CROSSWALK TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVAL STATION NEWPORT, RHODE ISLAND
PAGE 1 OF 2**

UFP SAP Worksheet #	Required Information	Crosswalk to Related Information
A. Project Management and Objectives		
<i>Documentation</i>		
1	Title and Approval Page	See Signature Page
2	SAP Identifying Information	See Section 1.0 and Table 1-1 Crosswalk
3	Distribution List	Not required
4	Project Personnel Sign-Off Sheet	Not required
<i>Project Organization</i>		
5	Project Organizational Chart	See Figure 1-2
6	Communication Pathways	See Table 1-2
7	Personnel Responsibilities Table	See Table 1-3
8	Special Personnel Training Requirements Table	Presented in Site-Specific HASP and SOPs
<i>Project Planning/Problem Definition</i>		
9	Project Scoping Session Participants Sheet	No sheets created, scope consensus/agreement documented in emails and report comments
10	Conceptual Site Model	Section 2.10 and Figure 2-2
11	Project Quality Objectives/Systematic Planning Process Statements	Section 4.1.1
12	Field Quality Control Samples	See Table 4-3
13	Secondary Data Criteria and Limitations Table	No secondary criteria or limitations, See Section 4.1
14	Summary of Project Tasks	See Section 1.0 and associated Tables and Figures
15	Reference Limits and Evaluation Tables	See Tables 4-1 and 4-2
16	Project Schedule/Timeline Table	To be manage outside of SAP/TBD
B. Measurement/Data Acquisition		
<i>Sampling Tasks</i>		
17	Sampling Design and Rationale	See Table 3-3
18	Location-Specific Sampling Methods/ SOP Requirements Table	See Table 3-2
19	Field Sampling Requirements Table	See Table 3-7
20	Field QC Sample Summary Table	See Table 3-6
21	Project Sampling SOP References Table	See Table 3-5
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	See Table 3-4
<i>Analytical Tasks</i>		
23	Analytical SOP References Table	See Table 4-5
24	Analytical Instrument Calibration Table	Laboratory will comply with analytical method requirements and common laboratory practices.
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	Laboratory will comply with analytical method requirements and common laboratory practices.

**TABLE 1-1
CROSSWALK TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVAL STATION NEWPORT, RHODE ISLAND
PAGE 2 OF 2**

UFP SAP Worksheet #	Required Information	Crosswalk to Related Information
<i>Sample Collection</i>		
26	Sample Handling System	See Table 4-4
27	Sample Custody Requirements	Not required
<i>Quality Control Samples</i>		
28	Laboratory QC Samples Table	See Tables 4-6 through 4-13
<i>Data Management Tasks</i>		
29	Project Documents and Records Table	Documents will be maintained in project files and electronic database
30	Analytical Services Table	See Table 3-7
C. Assessment Oversight		
31	Planned Project Assessments Table	Not applicable for this project
32	Assessment Findings and Corrective Action Responses Table	Not applicable for this project
33	QA Management Reports Table	See Table 1-2 for communication requirements in case of analytical data deficiencies
D. Data Review		
34-36	Data Verification and Validation (Steps I and IIa/IIb) Process Table	See Tables 4-14 and 4-15
37	Usability Assessment	See Section 4.1.2.

COC : Chain of custody

QA : Quality Assurance

NA : Not Applicable

TBD : To be determined

UFP SAP : Uniform Federal Policy Sampling and Analysis Plan

**TABLE 1-2
COMMUNICATION PATHWAYS
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 1 OF 2**

Communication Drivers	Responsible Affiliation	Name	Phone Number	Procedure
Regulatory Agency Interface	Navy RPM	Jim Gravette	757-341-2014	The Navy RPM will contact the regulatory agency via phone and/or e-mail within 1 business day of recognizing the issue whenever issues arise.
	RIDEM RPM	Pam Crump	401-222-2797, Ext. 7020	
	USEPA Region 1 RPM	Kymberlee Keckler	617-918-1385	
Field Progress Reports	Tetra Tech FOL	Peter Seward	(978) 429-5052	The Tetra Tech FOL will contact the Tetra Tech PM on a daily basis via phone, and every 1-2 days summarizing progress via e-mail.
	Tetra Tech PM	Ed Corack	757-466-4908	
	Navy RPM	Jim Gravette	(757-341-2014	
SAP amendments	Tetra Tech FOL	Peter Seward	(978) 429-5052	The Tetra Tech FOL will verbally inform the Tetra Tech PM within 24 hours of realizing a need for an amendment.
	Tetra Tech PM	Ed Corack	757-466-4908	The Tetra Tech PM will document the proposed changes via a Field Task Modification Request (FTMR) form and submit it to the RPM.
	Navy RPM	Jim Gravette	757-341-2014	Upon receiving approval of the SAP amendment, the Tetra Tech PM will send the Navy RPM a concurrence letter within 7 days, if a contract scope change is necessary. The Tetra Tech PM will send scope changes to the Project Team via e-mail.
Changes in schedule	Tetra Tech PM	Ed Corack	757-466-4908	The Tetra Tech PM will verbally inform the Navy RPM and the Facility Point of Contact (POC) on the day that schedule change is known and document in the monthly report. If report deliverable date is expected to be delayed as a result, document via schedule impact letter as soon as impact is realized.
	Navy RPM	Jim Gravette	757-341-2014	
	RIDEM RPM	Pam Crump	401-222-2797, Ext. 7020	The Tetra Tech PM will notify the USEPA RPM and RIDEM RPM either verbally or via e-mail within 1 business day of when impact is realized.
	USEPA Region 1 RPM	Kymberlee Keckler	617-918-1385	
Issues in the field that result in changes in scope of field work	Tetra Tech FOL	Peter Seward	(978) 429-5052	The Tetra Tech FOL will verbally inform the Tetra Tech PM on the day that the issue is discovered.
		Peter Seward	(978) 429-5052	The Tetra Tech PM will inform the Navy RPM and the Facility POC (verbally or via e-mail) within 1 business day.
	Tetra Tech PM	Ed Corack	757-466-4908	The Navy RPM will issue a scope change (verbally or via e-mail), if warranted. The scope change is to be implemented before further work is executed.
	Navy RPM	Jim Gravette	757-341-2014	The Tetra Tech PM will document the change via an FTMR form within 2 days of identifying the need for change and will obtain required approvals within 5 days of initiating the form.
	RIDEM RPM	Pam Crump	401-222-2797, Ext. 7020	The Tetra Tech PM will notify the USEPA RPM and RIDEM RPM either verbally or via e-mail within 1 business day.
	USEPA Region 1 RPM	Kymberlee Keckler	617-918-1385	

**TABLE 1-2
COMMUNICATION PATHWAYS
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 2 OF 2**

Communication Drivers	Responsible Affiliation	Name	Phone Number	Procedure
Recommendations to stop work (for example, to protect workers from unsafe conditions/ situations or to prevent a degradation in quality of work) and initiate work upon corrective action	Tetra Tech FOL	Peter Seward	(978) 429-5052	If a subcontractor is the responsible party, the subcontractor PM must inform the Tetra Tech FOL within 15 minutes, and the Tetra Tech FOL will then follow the procedure listed above.
	Tetra Tech PM	Ed Corack	757-466-4908	
	Tetra Tech QAM	Tom Johnston	412-921-8615	If Tetra Tech is the responsible party for a stop work command, the Tetra Tech FOL will inform on-site personnel, subcontractor(s), the Facility POC, and the identified Project Team members within 1 hour (verbally or by e-mail).
	Tetra Tech HSM	Matt Soltis	412-921-8912	
	Tetra Tech Project Chemist	Kelly Carper	412-921-7273	If a subcontractor is the responsible party, the subcontractor PM must inform the Tetra Tech FOL within 15 minutes, and the Tetra Tech FOL will then follow the procedure listed above.
	Navy RPM	Jim Gravette	757-341-2014	
Corrective action for field program	Tetra Tech QAM	Tom Johnston	412-921-8615	The Tetra Tech QAM will notify the Tetra Tech PM verbally or by e-mail within 1 business day that the corrective action has been completed.
	Tetra Tech PM	Ed Corack	757-466-4908	The Tetra Tech PM will then notify the Navy RPM within 1 business day (verbally or via e-mail).
	Navy RPM	Jim Gravette	757-341-2014	
Analytical data quality issues	Spectrum Analytical Laboratory PM	Edward Lawler	401-732-3400	The Spectrum Laboratory PM will notify (verbally or via e-mail) the Tetra Tech Project Chemist within 1 business day of when an issue related to laboratory data quality is discovered.
	Tetra Tech Project Chemist	Kelly Carper	412-921-7273	The Tetra Tech Project Chemist will notify (verbally or via e-mail) the data validation manager (DVM) and the Tetra Tech PM within 1 business day.
	Tetra Tech DVM	Joseph Samchuck	412-921-8510	The Tetra Tech DVM or Project Chemist will notify the Tetra Tech PM verbally or via e-mail within 48 hours of validation completion that a non-routine and significant laboratory quality deficiency has been detected that could affect this project and/or other projects. The Tetra Tech PM will verbally advise the Navy RPM within 24 hours of notification from the Tetra Tech Project Chemist or DVM. The Navy RPM will take corrective action that is appropriate for the identified deficiency. Examples of significant laboratory deficiencies include data reported that has a corresponding failed tune or initial calibration verification. Corrective actions may include a consult with the Navy Quality Assurance Officer (QAO)/Chemist.
	Tetra Tech PM	Ed Corack	757-466-4908	
	Navy RPM	Jim Gravette	757-341-2014	

**TABLE 1-3
PERSONNEL RESPONSIBILITIES TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

Name	Title / Role	Organizational Affiliation	Responsibilities
Jim Gravette	NAVFAC MIDLANT Remedial Project Manager/ Manages project	Navy	Oversees project implementation, including scoping, data review, and evaluation.
Kymberlee Keckler	Remedial Project Manager / Manages project	EPA Region 1	Participates in scoping and data review.
Pam Crump	Remedial Project Manager / Manages project	RIDEM	Participates in scoping and data review.
Ed Corack	PM / Manages project on a daily basis	Tetra Tech	Oversees project, financial, schedule, and technical day to day management of the project
Steve Parker	Tetra Tech Base Coordinator/Coordinates all facility work for Tetra Tech	Tetra Tech	Coordinates all Tetra Tech project related work at the facility.
Tom Johnston	QAM / Oversees program and project quality assurance activities	Tetra Tech	Ensures quality aspects of the CLEAN program are implemented, documented, and maintained.
Kelly Carper	Project Chemist / Conducts data validation and reporting	Tetra Tech	Participates in project scoping, prepares laboratory scope of work (SOW), and coordinates laboratory-related functions with laboratory. Oversees data quality reviews and quality assurance of data validation deliverables.
Peter Seward	FOL / Manages field operations SSO / Oversees Site activities to ensure safety requirements are met	Tetra Tech	Supervises, coordinates, and performs field sampling activities. Responsible for on-Site project specific health and safety training and monitoring Site conditions. Details of these responsibilities are presented in the HASP.
Joseph Samchuck	DVM / Oversees data validation activities	Tetra Tech	Manages data validation activities within Tetra Tech, including: <ul style="list-style-type: none"> • Ensure quality assurance of data validation deliverables. • Provide technical advice on data usability. • Coordinate and maintain data validation review schedule.
Lee Leck	Data Manager / Manages analytical and applicable field data	Tetra Tech	Manages Tetra Tech databases and ensures correct input of data.
Matt Soltis	HSM / Oversees H&S activities	Tetra Tech	Oversees Tetra Tech's Navy CLEAN Program H&S
Edward Lawler	Laboratory PM / Manages project	Spectrum Analytical	Coordinates analyses with laboratory chemists, lower tier subcontract laboratories, ensures laboratory SOW is followed, provides QA of data packages, and communicates with Tetra Tech project staff.
tbd	Utility Subcontractor / Performs utility mark-out	tbd	Performs third-party utility clearance and mark-out (in addition to Miss Utility) at and near intrusive work according to SOW.
tbd	Drilling Subcontractor / Performs drilling activities	tbd	Performs drilling techniques to advance soil borings and installs monitoring wells according to SOW.
tbd	IDW Subcontractor / Handles IDW	tbd	Responsible for transport and disposal of IDW according to SOW.
tbd	Survey Subcontractor / Surveys locations	tbd	Determines location coordinates and elevation data for monitoring wells according to SOW.

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**TABLE 3-1
MONITORING WELL CONSTRUCTION DETAILS SUMMARY
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVAL STATION NEWPORT, RHODE ISLAND**

LOCATION	WELL TYPE		DIAMETER (inches)	SCREENED INTERVAL (feet bgs)	NORTHING	EASTING	TOP CASE ELEVATION (feet MSL)	TOP RISER ELEVATION (feet MSL)	GROUND ELEVATION (feet MSL)
DSY-MW219	Stickup	Overburden	2	10 - 20	161155.86	379641.84	16.98	16.77	14.1
DSY-MW08	Flush Mount	Overburden	2	6.05 - 11.05	160822.44	379991.86	11.6	11.13	11.1
DSY-MW2A	Stickup	Overburden	2	16 - 26	161948.08	379410.23	12.97	12.87	10.1
DSY-MW223	Flush Mount	Bedrock	2	41 - 51	162730.29	379643.75	48.82	48.3	48.3
DSY-MW204	Flush Mount	Overburden	2	8 - 18	161829.14	379641.02	12.38	12.03	12
DSY-MW218	Stickup	Overburden	2	10 - 20	161532.84	379577.95	16.95	16.67	13.8
DSY-MW220	Flush Mount	Overburden	2	5 - 20	162294.72	379304.57	9.97	9.62	9.6
DSY-MW221	Flush Mount	Overburden	2	3 - 15	162438.96	379372.49	10.54	10.14	10.1
DSY-MW12	Flush Mount	Overburden	2	15 - 25	162318.64	379382.82	10.69	10.28	10.3
DSY-MW03	Flush Mount	Overburden	2	5.79 - 15.79	162472.23	379433.81	11.82	11.3	11.3
DSY-MW11A	Open Hole	Temporary Well	2	5 - 10	162882.04	379225.08	--	--	10.2
DSY-MW222	Flush Mount	Overburden	2	4 - 14	162645.56	379356.34	10.92	10.53	10.5
DSY-MW104	Stickup	Overburden	4	5 - 25	--	--	--	--	--

bgs : below ground surface

MSL : mean sea level

Vertical control datum : NGVD 1929 MSL

Horizontal control datum: NAD 1983 (1986)

-- : Data unavailable

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**TABLE 3-2
SAMPLE LOCATION AND METHODS
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 1 OF 2**

Sampling Location / ID Number	Depth Interval (feet bgs)	Analytical Group	No. Samples (identify field duplicates) ⁽¹⁾	SOP Reference ⁽²⁾
SOIL SAMPLES ⁽³⁾				
SB301 (TP08)/ DSY-SB301-0001	0 - 1	SPLP Lead	1	GH-1.5, SA-1.3, SA-2.5
SB302 (TP10)/ DSY-SB302-0001	0 - 1	SPLP Lead	1	GH-1.5, SA-1.3, SA-2.5
SB303 (TP11)/ DSY-SB303-1213	12 - 13	SPLP Lead	1	GH-1.5, SA-1.3, SA-2.5
SB304 (TP16)/ DSY-SB304-0001	0 - 1	SPLP Lead and Naphthalene	1 (plus 1 duplicate)	GH-1.5, SA-1.3, SA-2.5
SB305 (TP26)/ DSY-SB305-0305	3 - 5	Naphthalene	1	GH-1.5, SA-1.3, SA-2.5
SB306 (TP28)/ DSY-SB306-0001	0 - 1	SPLP Lead	1	GH-1.5, SA-1.3, SA-2.5
SB307 (MW08)/ DSY-SB307-0.51.5	0.5 - 1.5	SPLP Lead	1	GH-1.5, SA-1.3, SA-2.5
SOIL QUALITY ASSURANCE/QUALITY CONTROL SAMPLES ⁽³⁾				
DSY-SB-DUP01-MMDDYY	TBD	SPLP Lead and Naphthalene	1	GH-1.5, SA-1.3, SA-2.5
DSY-SB-RB01-MMDDYY	N/A	SPLP Lead and Naphthalene	1	GH-1.5, SA-1.3, SA-2.5
MONITORING WELLS AND GROUNDWATER SAMPLE IDS ⁽³⁾				
DSY-MW02A/ DSY-MW02A-MMDD	16 - 26	TCL VOCs and MNA	1	SA-1.1
DSY-MW03/ DSY-MW03-MMDD	6 - 16	TCL VOCs and MNA	1	SA-1.1
DSY-MW08/ DSY-MW08-MMDD	6 - 11	TCL VOCs, PAHs, TAL Metals (dissolved and total), and MNA	1	SA-1.1
DSY-MW11B/ ⁽⁴⁾ DSY-MW11B-MMDD	5 - 10	TCL VOCs and MNA	1 (plus 1 duplicate)	SA-1.1, SA-2.5
DSY-MW12/ DSY-MW12-MMDD	15 - 25	TCL VOCs and MNA	1	SA-1.1
DSY-MW104/ DSY-MW104-MMDD	5 - 25	TCL VOCs, PAHs, TAL Metals (dissolved and total), and MNA	1	SA-1.1
DSY-MW204/ DSY-MW204-MMDD	8 - 18	TCL VOCs, PAHs, TAL Metals (dissolved and total), and MNA	1	SA-1.1
DSY-MW218/ DSY-MW218-MMDD	10 - 20	TCL VOCs, PAHs, TAL Metals (dissolved and total), and MNA	1	SA-1.1
DSY-MW219/ DSY-MW219-MMDD	10 - 20	TCL VOCs, PAHs, TAL Metals (dissolved and total), and MNA	1 (plus 1 duplicate)	SA-1.1
DSY-MW220/ DSY-MW220-MMDD	5 - 20	TCL VOCs and MNA	1	SA-1.1
DSY-MW221/ DSY-MW221-MMDD	3 - 15	TCL VOCs and MNA	1	SA-1.1
DSY-MW222/ DSY-MW222-MMDD	4 - 14	TCL VOCs and MNA	1	SA-1.1
DSY-MW223/ DSY-MW223-MMDD	41 - 51	TCL VOCs and MNA	1	SA-1.1
GROUNDWATER QUALITY ASSURANCE/QUALITY CONTROL SAMPLES ⁽³⁾				
DSY-MW-DUP01-MMDDYY	TBD	TCL VOCs, PAHs, TAL Metals (dissolved and total), and MNA	1	SA-1.1
DSY-MW-DUP02-MMDDYY	TBD	TCL VOCs and MNA	1	SA-1.1
DSY-MW-RB01-MMDDYY	N/A	TCL VOCs, PAHs, TAL Metals (dissolved and total)	1	SA-1.1
DSY-TB01-MMDDYY	N/A	TCL VOCs	3	SA-1.1

1 - Field duplicate locations may change in the field based sampling order and samples per day.

2 - Standard Operating Procedures (SOPs) for collecting these samples/analyses are provided in Appendix B.

3 - Soil: The two-digit top depth and two-digit bottom depth from which the soil sample is collected. Groundwater: The two-digit month and two-digit year during which the groundwater sample was collected. QA/QC Samples: The two-digit month, date, and year on which the samples were collected.

**TABLE 3-2
SAMPLE LOCATION AND METHODS
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 2 OF 2**

Sampling Location / ID Number	Depth Interval (feet bgs)	Analytical Group	No. Samples (identify field duplicates) ⁽¹⁾	SOP Reference ⁽²⁾
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4 - Temporary well DSY-MW11A from the 2011 Data Gaps Investigation no longer is present. It will be replaced with a new 1-inch pre-packed temp well (to be numbered MW11B) with the same screen depth interval (5-10 feet). Similarly, other existing wells that are unusable for groundwater sampling will be replaced with temp wells at the same respective screen depth intervals.

TBD : to be determined

SPLP : Synthetic Precipitation Leaching Procedure (East of the Mississippi conditions)

N/A : not applicable

TCL VOCs : Target Compound List Volatile Organic Corr PAHs : Polycyclic aromatic hydrocarbons

MNA : Monitored Natural Attenuation includes dissolved oxygen and iron²⁺ field test kits, anions (nitrate, nitrite, sulfate, chloride), sulfide, alkalinity, total organic carbon, and methane, ethane, and ethene.

**TABLE 3-3
SAMPLING DESIGN AND RATIONALE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

Location	Matrix	Depth of Samples	Analysis	Method	Number of Samples	Rationale	Sampling Strategy
On Shore Derecktor Shipyard	Soil	Surface Soil (0-1 and 0.5-1.5 feet bgs)	SPLP Lead	See Tables 4-1 and 4-2	5	Confirm analytical results that exceeded the GA Leachability Criteria from the 1997 SASE investigation	See Sections 3 and 4
			Naphthalene		1		
		Subsurface Soil (3-5 and 12-13 feet bgs)	SPLP Lead		1		
			Naphthalene		1		
	Temporary well groundwater	5-10 feet bgs and TBD	TCL VOC and MNA ¹		TBD ²	Confirm the analytical results from groundwater samples collected during the 2011 Additional Pre-ROD Sampling in addition to characterization an additional upgradient monitoring well.	
			PAHs and TAL Metals ³		TBD ²		
	Monitoring well groundwater	Surficial Water (anywhere from 5-26 feet bgs)	TCL VOC and MNA ¹		TBD ²		
			PAHs and TAL Metals ³		TBD ²		
		Deeper Water (41-51 feet bgs)	TCL VOC and MNA ¹		TBD ²		

1 – MNA Parameters include the following:

- Dissolved O₂ and Iron²⁺ by field test kits
- pH, oxidation-reduction potential (ORP), and salinity by field water quality meter
- Anions (Nitrate, Nitrite, Sulfate, Chloride)
- Sulfide
- Alkalinity
- Total Organic Carbon (TOC)
- Methane, Ethane, Ethene

2 – There are 13 total groundwater samples to be collected; samples will be collected from an existing monitoring well or temporary well as determined in the field (see Section 3.3.2.4).

3 – TAL metals will be analyzed for total and dissolved fractions.

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**TABLE 3-4
FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	Facility SOP Reference	Comments
PID	Visual Inspection, Calibration	Daily, before use	Manufacturer's Guidance	Replace	Tetra Tech FOL or designee	ME-12, Manufacturer's Guidance	None.
DPT/Drill Rig	Inspection	Daily	Equipment inspection sheet criteria	Replace	Tetra Tech FOL or designee	GH-1.5, SA-1.3, SA-2.5	None.
Hand Auger	Inspection and Decontamination	Daily, after each use	Manufacturer's Guidance	Replace	Tetra Tech FOL or designee	SA-1.3, SA-7.1	None.
Water Level Meter	Visual Inspection	Daily	Manufacturer's Guidance	Replace	Tetra Tech FOL or designee	GH-1.2 Manufacturer's Guidance	None.
Multi-Parameter Water Quality Meter (pH, Temp., Sp. Cond., D.O., ORP)	Visual Inspection, Calibration	Daily, before use	Manufacturer's Guidance	Replace	Tetra Tech FOL or designee	SA-1.1, Manufacturer's Guidance	None.
Turbidity Meter	Visual Inspection, Calibration	Daily, before use	Manufacturer's Guidance; Calibrations must bracket expected values.	Replace	Tetra Tech FOL or designee	SA-1.1, Manufacturer's Guidance	None.
			Initial Calibration Verification (ICV) must be + or -10 Nephelometric Turbidity Units (NTUs) of target value.				
Groundwater sampling pumps and tubing	Inspect pumps, tubing and air/sample line quick-connects	Regularly	Maintained in good working order per manufacturer's recommendations	Replace	Tetra Tech FOL or designee	SA-1.1, Manufacturer's Guidance	None.

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**TABLE 3-5
PROJECT SAMPLING SOP REFERENCES TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

SOP Reference Number	Title, Revision Date and / or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work?	Comments
				(Y/N)	
Geology					
GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement, 02/04, Rev. 0	Tetra Tech	Water level indicator	N	None.
GH-1.5	Borehole and Sample Logging, 02/04, Rev. 0	Tetra Tech	NA	N	None.
Water/Soil Sampling					
SA-1.1	Groundwater Sample Acquisition and OnSite Water Quality Testing, 03/08, Rev. 1	Tetra Tech	Pump, tubing, water quality meter, and accessories	N	None.
SA-1.3	Soil Sampling, 03/08, Rev. 1	Tetra Tech	EnCore sampler, trowel, shovel, hand auger, and/or split-barrel sampler	N	None.
SA-2.5	Direct Push Technology (Geoprobe/Hydropunch), 02/04, Rev. 0	Tetra Tech	Drilling equipment and accessories	N	None.
Decontamination					
SA-7.1	Decontamination of Field Equipment, 03/08, Rev. 1	Tetra Tech	Decontamination equipment, phosphate-free detergent, deionized water	N	None.
Health and Safety					
ME-12	Photovac 2020 Photoionization Air Monitoring, Rev. 1	Tetra Tech	Photo Ionization Detector	N	None.

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**TABLE 3-6
FIELD AND QUALITY CONTROL SAMPLE SUMMARY
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

SAMPLE TYPE	ANALYSIS	FIELD SAMPLES	RINSATE (EQUIPMENT) BLANKS ¹	FIELD DUPLICATES ²	TRIP BLANKS ³	TOTAL	LAB QA/QC ⁴
Soil	SPLP Lead	6	--	--	--	6	1
	Naphthalene	2	--	--	--	2	1
Groundwater	TCL VOCs	13	1	2	3	19	1
	PAHs	4	1	1	--	6	1
	TAL Metals (total)	5	1	1	--	7	1
	TAL Metals (dissolved)	5	1	1	--	7	1
	MNA Parameters	13	--	2	--	15	1

SPLP : Synthetic Precipitation Leaching Procedure

TCL VOCs : Target Compound List Volatile Organic Compounds

MNA : Monitored Natural Attenuation includes dissolved oxygen and iron²⁺ field test kits, anions (nitrate, nitrite, sulfate, chloride), sulfide, alkalinity, total organic carbon, and methane, ethane, and ethene.

PAHs : Polycyclic aromatic hydrocarbons

QA/QC : Quality Assurance/ Quality Control

1 - Collect 1 rinsate blank per 20 field samples, per type of equipment.

2 - Collect 1 duplicate per 10 field samples, minimum.

3 - Collect minimum of 1 trip blank per storage/shipment container of VOCs and GRO.

4 - Assign 1 Lab QC per 20 samples: Organics - Matrix Spike/Matrix Spike Duplicate (MS/MSD); Inorganics - Matrix Spike and Laboratory Duplicate. The Lab QC volume is not included in the total sample count

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**TABLE 3-7
FIELD SAMPLING REQUIREMENTS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 1 OF 2**

Matrix	Analytical Group	Analytical and Preparation Method/ SOP Reference⁽¹⁾	Containers (number, size, and type)	Sample volume⁽²⁾ (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time⁽³⁾ (preparation/analysis)
Aqueous	TCL VOCs	SW-846 8260C/Lab SOP 90.0012	2 x 40-milliliter (ml) volatile vials	40 ml	Hydrochloric acid to pH <2, cool to <6°C	14 days to analysis
	PAHs	SW-846 3510C/8270D, 8270D/SIM/Lab SOPs 50.0051, 70.0033	Two 1-Liter (L) amber glass bottles	1000 mL	Cool to ≤ 6 °C	7 days to extraction;
						40 days to analysis
	TAL Metals(total and dissolved)	SW-846 3005/3010/6010C/7470A/ Lab SOPs 100.0003, 100.0011, 100.0012	250-ml plastic	250 ml	Nitric acid to pH <2, cool to <6°C	180 days to analysis for ICP metals;
						28 days to analysis for mercury
	Anions (Nitrate, Nitrite, Chloride, and Sulfate)	SW-846 9056/ Lab SOP 100.0400	One 250-mL plastic bottle	5 mL for each analyte	Cool to ≤ 6 °C	Nitrate/Nitrite-48 hours to analysis
						Chloride and Sulfate - 28 days to analysis
	Dissolved gases (Methane, Ethane, Ethene)	RSK 175/ Lab SOP 90.006	Two 40-mL volatile vials	40 mL	Hydrochloric acid to pH <2, cool to <6°C	14 days to analysis
Sulfide	SM4500-S/Lab SOP 100.0018	One 250-mL plastic bottle	200 mL	4 drops of 2 N zinc acetate per 100 ml of sample; sodium hydroxide (NaOH) to pH >9; cool to ≤ 6 °C	7 days to analysis	
Alkalinity	SM2320B/Lab SOP 100.0002	250-mL polyethylene bottle	50 mL	Cool to ≤ 6 °C	14 days to analysis	
TOC	SW-846 9060A/ Lab SOP100.0025	Two 40-mL VOA vials	40 mL	Hydrochloric acid to pH < 2, cool to ≤ 6 °C	14 days to analysis	
Soil	Naphthalene	SW-846 3550B/8270D, 8270D/SIM/Lab SOPs 50.0052, 70.0011	8-oz wide mouth jar	30 g	Cool to <6°C	14 days to extraction; 40 days to analysis
	SPLP Lead	SW-846 1312/3005/3010/6010C Lab SOPs 100.0003, 100.0111	4-oz wide mouth jar	100 g	Cool to <6°C	180 days to analysis for ICP metals;
28 days to analysis for mercury						

**TABLE 3-7
FIELD SAMPLING REQUIREMENTS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 2 OF 2**

Matrix	Analytical Group	Analytical and Preparation Method/ SOP Reference ⁽¹⁾	Containers (number, size, and type)	Sample volume ⁽²⁾ (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time ⁽³⁾ (preparation/analysis)
Aqueous and Solid IDW ⁴	Toxicity Characteristic Leaching Procedure (TCLP) Regulatory List Organics	SW-846 1311,	One 4-oz glass jar	25 g VOCs/ 100 g SVOC	Cool to 0 to 6 °C	14 days to TCLP extraction; 14 days to analysis for VOC and 7 days until extraction; 40 days to analysis for all SVOCs
		SW-846 5030/8260B,				
		SW-846 8151A,				
		SW-846 3510C 8081A, SW-846 3510C/8270D				
	TCLP Regulatory List Inorganics	SW-846 1311,	One 4-oz glass jar	100 g	Cool to 0 to 6 °C	180 days to TCLP extraction, except mercury, which is 28 days. Then 180 days to analysis, except mercury, which is 28 days to analysis
		SW-846 3010A/6010C, SW- 846 7470A				
Reactivity	SW-846 9012 and 9030	One 500-mL polyethylene bottle/One 4- oz glass wide-mouth jar	500 mL/4 oz	Cool to above freezing and ≤ 6 °C	14 days to analysis	
Ignitability	SW-846 1010	One 500-mL polyethylene bottle/One 4- oz glass wide-mouth jar	500 mL/4 oz	Cool to above freezing and ≤ 6 °C	14 days to analysis	
pH	SW-846 9045D (soil)/ 9040C (aqueous)	One 500-mL polyethylene bottle/One 4- oz glass wide-mouth jar	500 mL/4 oz	Cool to above freezing and ≤ 6 °C	14 days to analysis	

Laboratory point of contact, e-mail address, and phone number: Ed Lawler, elawler@spectrum-analytical.com, 401-732-3400

Laboratory Name and Address:

Spectrum Analytical
646 Camp Avenue
North Kingstown, RI 02852

Data Package Turnaround time: 21 days

Tentative Sampling Dates: TB

1 - All methods are USEPA SW-846. Refer to the Analytical SOP References table (Worksheet #10) for Laboratory SOPs.

2 - Minimum sample volume or mass requirement.

3 - Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

4 - Aqueous and Soil IDW sample analyses are presented on this worksheet for the utilization of field personnel. QC information is not presented in any of the remaining worksheets as these samples are for waste disposal, not decision making purposes. IDW samples will not be validated.

PAHs : Polycyclic aromatic hydrocarbon.

SIM : Selected Ion Monitoring.

ICP : Inductively coupled plasma.

**TABLE 4-1
SOIL REFERENCE LIMITS AND EVALUATIONS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

Matrix: Soil

Chemical	Method	Project Action Limit (PAL) ⁽¹⁾	PAL Reference ⁽²⁾	Project Quantitation Limit (PQL) ⁽³⁾	Analytical Limits		
					LOQ	LOD	DL
Polycyclic Aromatic Hydrocarbons (PAHs)							
Naphthalene	SW846 8270D	0.8 mg/kg	RIDEM GA Leachability Criteria	0.27 mg/kg	0.33 mg/kg	0.133 mg/kg	0.041 mg/kg
Metals							
Lead	SW-846 1312/6010C	0.04 mg/L <i>(leachate test result)</i>	RIDEM GA Leachability Criteria <i>(via TCLP/SPLP)</i>	0.013 mg/L	0.010 mg/L	0.005 mg/L	0.0042 mg/L

mg/kg : milligram(s) per kilogram mg/L : milligram(s) per liter

LOQ : Limit of Quantitation LOD : Limit of Detections DL : Detection Limit

1 - The PAL is the lowest required quantification for each analyte, so that the data collected can be used at any phase of the CERCLA process.

2 - The determination of the PALs (lowest criteria) is provided in Section 4.1.1. PAL Reference: 'RIDEM (Rhode Island Department of Environmental Management) "GA" [Aquifer] Leachability Criteria, DEM-DSR-01-93, November 2011. RIDEM Leachability Criteria for metals in soil are leachate test result criteria from either TCLP or SPLP testing.

3 - The PQL is selected to meet the project data quality objectives. The PQL is set at a concentration of one-third or less than the PAL, if achievable by available analytical methods and laboratories.

Method References: SW846 - Test Methods for Evaluating Solid Wastes. EPA Office of Solid Waste. Third Edition, including all promulgated revisions.

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TABLE 4-2
GROUNDWATER REFERENCE LIMITS AND EVALUATIONS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 1 OF 3

Matrix: Groundwater

Chemical	Method	MCL ⁽¹⁾ (µg/L)	RIDEM GA Aquifer ^(2, 7) (µg/L)	Project Action Level ⁽³⁾ (µg/L)	PQL ⁽⁴⁾ (µg/L)	Analytical Limits		
						LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Volatile Organic Compounds								
1,1,1-Trichloroethane	SW-846 8260C	200	200	200	66.7	1	0.5	0.5
1,1,2,2-Tetrachloroethane	SW-846 8260C	--	--	--	1	1	0.5	0.42
1,1,2-Trichloroethane	SW-846 8260C	5	5	5	1.7	1	1	0.38
1,1-Dichloroethane	SW-846 8260C	--	--	--	1	1	0.5	0.25
1,1-Dichloroethene	SW-846 8260C	7	7	7	2.3	1	0.5	0.39
1,2,4-Trichlorobenzene	SW-846 8260C	70	70	70	23.3	1	0.5	0.26
1,2-Dibromoethane (EDB)	SW-846 8260C	0.05	0.05	0.05	0.02	1	0.5	0.5
1,2-Dibromo-3-Chloropropane (DBCP)	SW-846 8260C	0.2	0.2	0.2	0.1	1	1	0.75
1,2-Dichlorobenzene	SW-846 8260C	600	600	600	200	1	0.5	0.33
1,2-Dichloroethane	SW-846 8260C	5	5	5	1.7	1	0.5	0.41
1,2-Dichloropropane	SW-846 8260C	5	5	5	1.7	1	1	0.61
1,3-Dichlorobenzene	SW-846 8260C	--	--	--	1	1	0.5	0.29
1,4-Dichlorobenzene	SW-846 8260C	75	75	75	25	1	0.5	0.4
2-Butanone	SW-846 8260C	--	--	--	10	5	2.5	2.1
2-Hexanone	SW-846 8260C	--	--	--	5	5	2.5	1.7
4-Methyl-2-pentanone	SW-846 8260C	--	--	--	5	5	1	0.82
Acetone	SW-846 8260C	--	--	--	10	5	2.5	2.2
Benzene	SW-846 8260C	5	5	5	1.7	1	0.5	0.33
Bromomethane	SW-846 8260C	--	--	--	2	1	1	0.8
Carbon disulfide	SW-846 8260C	--	--	--	1	1	0.5	0.34
Carbon tetrachloride	SW-846 8260C	5	5	5	1.7	1	1	0.54
Chlorobenzene	SW-846 8260C	100	100	100	33.3	1	0.5	0.26
Chloroethane	SW-846 8260C	--	--	--	2	1	0.5	0.48
Chloromethane	SW-846 8260C	--	--	--	2	1	0.5	0.26
cis-1,2-Dichloroethene	SW-846 8260C	70	70	70	23.3	1	0.5	0.48
cis-1,3-Dichloropropene	SW-846 8260C	--	--	--	1	1	0.5	0.45
Cyclohexane	SW-846 8260C	--	--	--	1	1	1	0.71
Dichlorodifluoromethane	SW-846 8260C	--	--	--	2	1	1	0.66
Ethylbenzene	SW-846 8260C	700	700	700	233.3	1	0.5	0.35
Isopropylbenzene	SW-846 8260C	--	--	--	1	1	0.5	0.38
Methyl acetate	SW-846 8260C	--	--	--	2	1	1	0.29
Methylcyclohexane	SW-846 8260C	--	--	--	1	1	1	0.76
Methylene chloride	SW-846 8260C	5	5	5	1.7	1	0.5	0.41
Methyl-tert-butyl ether	SW-846 8260C	--	40	40	13.3	1	0.5	0.24
Styrene	SW-846 8260C	100	100	100	33.3	1	0.5	0.5

TABLE 4-2
GROUNDWATER REFERENCE LIMITS AND EVALUATIONS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 2 OF 3

Chemical	Method	MCL ⁽¹⁾ (µg/L)	RIDEM GA Aquifer ^(2, 7) (µg/L)	Project Action Level ⁽³⁾ (µg/L)	PQL ⁽⁴⁾ (µg/L)	Analytical Limits		
						LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Volatile Organic Compounds (cont.)								
Tetrachloroethene	SW-846 8260C	5	5	5	1.7	1	1	0.65
Toluene	SW-846 8260C	1000	1000	1000	333.3	1	0.5	0.32
trans-1,2-Dichloroethene	SW-846 8260C	100	100	100	33.3	1	1	0.65
trans-1,3-Dichloropropene	SW-846 8260C	--	--	--	1	1	0.5	0.48
Trichloroethene	SW-846 8260C	5	5	5	1.7	1	0.5	0.36
Trichlorofluoromethane	SW-846 8260C	--	--	--	2	1	1	0.54
Vinyl chloride	SW-846 8260C	2	2	2	0.7	1	0.5	0.5
Xylenes (total)	SW-846 8260C	10000	10000	10000	3333	1	1	0.36
Polynuclear Aromatic Hydrocarbons								
2-Methylnaphthalene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.018
Acenaphthene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.019
Acenaphthylene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.017
Anthracene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.017
Benzo(a)anthracene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.042
Benzo(a)pyrene	SW846 8270D-SIM	0.2	0.2	0.2	0.1	0.1	0.1	0.017
Benzo(b)fluoranthene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.056
Benzo(g,h,i)perylene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.021
Benzo(k)fluoranthene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.02
Chrysene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.073
Dibenzo(a,h)anthracene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.018
Fluoranthene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.019
Fluorene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.017
Indeno (1,2,3-cd)pyrene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.019
Naphthalene	SW846 8270D-SIM	--	100	--	33.3	0.1	0.1	0.05
Phenanthrene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.019
Pyrene	SW846 8270D-SIM	--	--	--	5	0.1	0.1	0.016
Metals (Total and Dissolved)⁽⁵⁾								
Aluminum	SW846 6010C	--	--	--	50	20	6.75	2.9
Antimony	SW846 6010C	6	6	6	2	2	0.2	0.2
Arsenic	SW846 6010C	10	10	10	3.3	2	0.375	0.19
Barium	SW846 6010C	2000	2000	2000	666.7	10	2	1.3
Beryllium	SW846 6010C	4	4	4	1.3	1	0.15	0.072
Cadmium	SW846 6010C	5	5	5	1.7	1	0.15	0.084
Calcium	SW846 6010C	--	--	--	1250	500	37.5	24
Chromium	SW846 6010C	100	100	100	33.3	2	0.25	0.16
Cobalt	SW846 6010C	--	--	--	13	1	0.05	0.024

**TABLE 4-2
GROUNDWATER REFERENCE LIMITS AND EVALUATIONS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 3 OF 3**

Chemical	Method	MCL ⁽¹⁾ (µg/L)	RIDEM GA Aquifer ^(2, 7) (µg/L)	Project Action Level ⁽³⁾ (µg/L)	PQL ⁽⁴⁾ (µg/L)	Analytical Limits		
						LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Metals (Total and Dissolved)⁽⁵⁾ (cont.)								
Copper	SW846 6010C	13008	1300	1300	433.3	2	0.375	0.23
Iron	SW846 6010C	--	--	--	25	200	20	14
Lead	SW846 6010C	158	15	15	5	1	0.15	0.068
Magnesium	SW846 6010C	--	--	--	1250	500	12	7.8
Manganese	SW846 6010C	--	--	--	3.8	2	1	0.83
Mercury	SW846 7470A	2	2	2	0.7	0.2	0.05	0.028
Nickel	SW846 6010C	--	100	100	33.3	1	0.25	0.17
Potassium	SW846 6010C	--	--	--	1250	500	20	14
Selenium	SW846 6010C	50	50	50	16.7	5	0.25	0.15
Silver	SW846 6010C	--	--	--	2.5	1	0.1	0.022
Sodium	SW846 6010C	--	--	--	1250	500	50	33
Thallium	SW846 6010C	2	2	2	0.7	1	0.075	0.048
Vanadium	SW846 6010C	--	--	--	13	5	1	0.61
Zinc	SW846 6010C	--	--	--	5	2	1	0.73
MNA Parameters								
Chloride	SW846 9056A	--	--	1000	333	0.002	0.0002	0.000078
Nitrate	SW846 9056A	--	--	10	3.3	0.00013	0.0000417	0.000023
Nitrite	SW846 9056A	--	--	5	1.7	0.00013	0.000125	0.0000018
Sulfate	SW846 9056A	--	--	5000	1667	0.005	0.001667	0.00061
Methane	RSKSOP 175	--	--	1	0.33	0.58	0.58	0.35
Ethane	RSKSOP 175	--	--	1	0.33	1.2	1.2	0.5
Ethene	RSKSOP 175	--	--	1	0.33	1.5	1.2	0.69
Carbon Dioxide	EPA 3C/RSK 175	--	--	10000	3333	22	22	22
Sulfide	SM4500-S	--	--	10	3.3	30	30	30
Alkalinity	SM2320B	--	--	50000	16667	20000	20000	20000
Dissolved Organic Carbon	SW846 9060A	--	--	100	33.3	10000	5000	2000

ug/L : micrograms per liter

LOQ : Limit of Quantitation

LOD : Limit of Detections

DL : Detection Limit

MCL :U.S. EPA Maximum Contaminant Levels for drinking water

RIDEM : Rhode Island Department of Environmental Management

Shading indicates that LOD exceeds project action level.

Method References:

SW846 - Test Methods for Evaluating Solid Wastes.

EPA Office of Solid Waste.

1 - Source: U.S. EPA (2012)

2 - RIDEM Groundwater Quality Standards for GA aquifers. Source: RIDEM (March, 2005)

3 - The project action level represents the lower of the MCL or the RIDEM Groundwater Quality Standards for GA aquifers.

4 - The project quantitation limit (PQL) is selected to meet the project data quality objectives. The PQL is set at a concentration at least three times lower than the project action level, if achievable by available analytical methods and laboratories.

5 - Samples for dissolved metals analysis will be filtered in the field.

6 - PALs will be based on federal criteria and use of RIDEM criteria is for comparison purposes only.

7 - RIDEM Remediation Regulations. Source: RIDEM (February, 2004)

8 - The EPA Action level is used for copper and lead as the PAL

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**TABLE 4-3
MEASUREMENT PERFORMANCE CRITERIA TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPCs)	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Trip Blanks	All VOCs	One per cooler.	Bias/Contamination	No analytes $\geq \frac{1}{2}$ LOQ, except common laboratory contaminants, which must be $<$ LOQ.	S & A
Equipment Rinsate Blanks	All analytical groups	1 per 20 field samples per type of non-dedicated sampling equipment, if	Accuracy/ Bias/ Contamination	No target analytes $\geq \frac{1}{2}$ LOQ (or $>$ LOQ for common laboratory contaminants).	S
Duplicate Samples	All analytical groups	One per 20 field samples collected per matrix.	Precision	Values $>$ 5X LOQ: Relative Percent Difference (RPD) must be $\leq 30\%$ ⁽¹⁾⁽²⁾ (aqueous), $\leq 50\%$ ^{1,2} (soils).	S & A
Cooler Temperature Indicator	All analytical groups	One per cooler.	Representativeness	Temperature must be between 0 and 6 degrees Celsius ($^{\circ}$ C).	S

1 - If duplicate values for non-metals are less than five times the LOQ, the absolute difference should be less than two times the LOQ.

2 - If duplicate values for metals are less than five times the LOQ, the absolute difference should be less than four times the LOQ.

3 - Equipment rinsate blanks will be collected if non-dedicated submersible pumps or other equipment are used.

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**TABLE 4-4
SAMPLE HANDLING SYSTEM
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVAL STATION NEWPORT, RHODE ISLAND**

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FOL or designee/Tetra Tech
Sample Packaging (Personnel/Organization): FOL or designee/Tetra Tech
Coordination of Shipment (Personnel/Organization): FOL or designee/Tetra Tech
Type of Shipment/Carrier: Federal Express
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodians/Spectrum
Sample Custody and Storage (Personnel/Organization): Sample Custodians/Spectrum
Sample Preparation (Personnel/Organization): Extraction Laboratory, Metals Preparation Laboratory, Dioxins Preparation Laboratory /Spectrum
Sample Determinative Analysis (Personnel/Organization): GC Laboratory, GC/MS Laboratory, Metals Laboratory/Spectrum
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): 60 days from receipt
Sample Extract/Digestate Storage (number of days from extraction/digestion): 3 months from sample digestion/extraction
Biological Sample Storage (Number of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: Sample Custodians/Spectrum

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**TABLE 4-5
ANALYTICAL SOP REFERENCES TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?	Variance from DOD Quality Systems Manual (QSM)?
						(Y/N)	(Y/N)
110.0031	Synthetic Precipitation Leaching Procedure by SW-846 Method 1312	Definitive	Metals	NA	Spectrum	N	N
70.0033	Semivolatiles by Method 8270D SIM, Rev 7, 8/11	Definitive	Aqueous/PAHs (SIM)	GC/MS	Spectrum	N	N
70.0011	Semivolatiles by Method 8270D, Rev 11, 7/11	Definitive	Soil /Naphthalene	GC/MS	Spectrum	N	N
100.0111	Metals by Method 6010C, Rev 13, 12/10	Definitive	Aqueous/Soil/ICP Metals	ICP-AES	Spectrum	N	N
100.0012	Mercury by Method 7470A/7471B, Rev 10, 6/10	Definitive	Aqueous/ Mercury	CVAA	Spectrum	N	N
90.0012	Volatile Organic Compounds by Method 8260C, Rev 13, 9/12	Definitive	Aqueous/VOCs	GC/MS	Spectrum	N	N
50.0052	Organic Preparation of Soil Samples by Sonication, Method 3550B, Rev 4, 8/13	Definitive	Soil/ PAHs	NA	Spectrum	N	N
50.0053	Organic Preparation of Soil Samples by Soxhlet, Method 3540C, Rev 3, 2/10	Definitive	Soil/PAHs	NA	Spectrum	N	N
50.005	Organic Preparation of Aqueous Samples by continuous liquid-liquid extraction, Method 3520C, Rev 6, 4/11	Definitive	Aqueous/PAHs	NA	Spectrum	N	N
50.0051	Organic Preparation of Aqueous Samples by separatory funnel extraction, Method 3510C, Rev 2, 2/10	Definitive	Aqueous/PAHs	NA	Spectrum	N	N
100.0104	Sample Preparation of Soils by Acid Digestion for ICP, Method 3050B, Rev 8, 3/10	Definitive	Soil/ICP Metals	NA	Spectrum	N	N
100.0003	Sample Preparation of Waters by Acid Digestion for ICP, ICP/MS Method 3005/3010, Rev 8, 2/10	Definitive	Aqueous /ICP, ICP-MS Metals	NA	Spectrum	N	N
100.04	Anions by IC EPA 300.0 and 9056A Rev. 4	Screening	Aqueous/ Anions	Ion Chromatography System	Spectrum	N	N
100.0018	Sulfides in Aqueous Samples (Methylene blue method) Rev. 9	Screening	Aqueous/ Sulfide	Glassware	Spectrum	N	N
90.006	Methane, Ethane, and Ethene by GC/FID Method RSKSOP-175, Rev.7	Screening	Aqueous/ Dissolved Gases (methane, ethane, ethene)	GC/FID	Spectrum	N	N
100.0002	Alkalinity (by Standard Method 2320B) Rev. 8	Screening	Aqueous/Alkalinity	Autotitrator	Spectrum	N	N
100.0025	Total Organic Carbon by Methods SW-846 9060A and SM5310B Rev. 8	Screening	Aqueous/ Total Organic Carbon	Carbonaceous Analyzer	Spectrum	N	N
100.0012	Mercury by Method 7470A/7471B, Rev 10, 6/10	Definitive	Aqueous/Soil/ Mercury	CVAA	Spectrum	N	N

A copy of Spectrum DOD ELAP accreditation is included in Appendix D.

CVAA - Cold vapor atomic absorption

GC/FID - Gas chromatography/flame ionization detector

GC/MS - Gas chromatography/mass spectrometry

ICP-AES - Inductively Coupled Plasma/ Atomic emission spectroscopy

NA - Not applicable

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**TABLE 4-6
LABORATORY QC SAMPLES TABLE - TCL VOC
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Matrix	Aqueous					
Analytical Group	TCL VOCs					
Analytical Method/SOP Reference	SW-846 8260C/Lab SOP 90.0012					
Method Blank	One per preparation batch of 20 or fewer samples of similar matrix.	No target analytes >one half of LOQ except for common lab contaminants not > LOQ.	Investigate source of contamination. Rerun method blank. No samples may be run until an acceptable method blank has been run.	Analyst, Supervisor	Accuracy/Bias/Contamination	Same as Method/SOP QC Acceptance Limits.
MS	One per batch of 20 or fewer samples of similar matrix.	%Recovery within DoD Quality Systems Manual (QSM) limits.	If recoveries are outside limits and surrogate and LCS criteria are met, note in narrative. If both the LCS and MS/MSD are unacceptable reprepare the samples and QC. Check standard prepare. Flag outliers with * on Form 3.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
MSD	One per batch of 20 or fewer samples of similar matrix.	%Recovery within DoD QSM limits; RPD must be > 40%.	Same as MS.	Analyst, Supervisor	Accuracy/Bias/Precision	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)/LCS Duplicate (LCSD)	One per batch of 20 or fewer samples of similar matrix. Include LCSD if preparation batch does not include MS/MSD.	%Recovery within DoD QSM limits; RPD must be > 40%.	Reanalyze once. If the LCS recoveries are high but the sample results are <LOQ narrate. Flag with * on Form 3.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Internal Standard (IS)	Each field and QC sample.	IS area -50% to +100% compared to IS from continuing calibration verification (CCV); IS Retention Time (RT) window \pm 0.5 minute compared to CCV RT.	Reanalyze affected samples. If similar results, report both runs. Flag outliers with an * on Form 8.	Analyst, Supervisor	Accuracy	Same as Method/SOP QC Acceptance Limits.
Surrogates	Four per sample.	Percent recoveries (%Rs) must be within: 1,2-Dichloroethane-d4 88-110% Soil 70-120% Water Bromofluorobenzene 85-170% Soil 75-120% Water Dibromofluoromethane 76-128%Soil 85-115% Water Toluene-d8 85-115%Soil 85-120% Water 1 out allowed.	If sample volume is available, reanalyze. Report both if second successful analysis is outside holding time or both fail QC criteria. Flag with * on Form 2.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Temperature Blank	One per cooler.	<6° C.	Laboratory will notify Tetra Tech Project Chemist of temperatures outside criteria. Tetra Tech Project Chemist will respond as to whether to proceed with analysis.	Analyst, Supervisor	Accuracy/Bias/Representativeness	Same as Method/SOP QC Acceptance Limits.
Results between DL and LOQ	NA	Apply "J" qualifier to results between DL and LOQ.	NA	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

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**TABLE 4-7
LABORATORY QC SAMPLES TABLE - PAH
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Method Blank	One per preparation batch of 20 or fewer samples of similar matrix.	No target analytes >one half of LOQ except for common lab contaminants not > LOQ.	Investigate source of contamination. Rerun method blank. No samples may be run until an acceptable method blank has been run.	Analyst, Supervisor	Accuracy/Bias/Contamination	Same as Method/SOP QC Acceptance Limits.
MS	One per batch of 20 or fewer samples of similar matrix.	%Recovery within DoD QSM limits.	If recoveries are outside limits and surrogate and LCS criteria are met, note in narrative. If both the LCS and MS/MSD are unacceptable reprepare the samples and QC. Check standard preparation. Flag outliers with * on Form 3.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
MSD	One per batch of 20 or fewer samples of similar matrix.	%Recovery within DoD QSM limits; RPD must be <40%.	Same as MS.	Analyst, Supervisor	Accuracy/Bias/Precision	Same as Method/SOP QC Acceptance Limits.
LCS/LCSD	One per batch of 20 or fewer samples of similar matrix. Include LCSD if preparation batch does not include MS/MSD.	%Recovery within DoD QSM limits; RPD must be <40%.	Reanalyze once. If the LCS recoveries are high but the sample results are <LOQ narrate. Flag with * on Form 3.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
IS	Each field and QC sample.	IS area -50% to +100% compared to IS from CCV; IS RT window \pm 0.5 minutes compared to CCV RT.	Reanalyze affected samples. If similar results, report both runs. Flag outliers with an * on Form 8.	Analyst, Supervisor	Accuracy	Same as Method/SOP QC Acceptance Limits.
Surrogates	Six per sample (full scan), one per sample (SIM).	Full scan: %Rs must be within: 2,4,6-Tribromophenol 35-125% Soil, 40-125% Water 2-Fluorobiphenyl 45-105% Soil, 50-110% Water 2-Fluorophenol 35-105% Soil, 20-110% Water Nitrobenzene-d5 35-100% Soil, 40-110% Water Phenol-d5 40-100% Soil, 10-115% Water Terphenyl-d14 30-125% Soil, 50-135% Water SIM: Benzo(e)pyrene-d12, 45% - 135% Soil, 80-120% Water.	If sample volume available, re-extract. Report both if second successful analysis is outside holding time or both fail QC criteria. Flag with * on Form 2.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Temperature Blank	One per cooler.	<6° C.	Laboratory will notify Tetra Tech Project Chemist of temperatures outside criteria. Tetra Tech Project Chemist will respond as to whether to proceed with analysis.	Analyst, Supervisor	Accuracy/Bias/Representativeness	Same as Method/SOP QC Acceptance Limits.
Results between DL and LOQ	NA	Apply "J" qualifier to results between DL and LOQ.	NA	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

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**TABLE 4-8
LABORATORY QC SAMPLES TABLE - METALS
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Matrix	Aqueous/Soil					
Analytical Group	Metals (ICP-AES)					
Analytical Method/SOP Reference	SW846 6010C/Lab SOPs 100.0003, 100.0011, 100.0012					
Preparation Blank	One per preparation batch of 20 or fewer samples of similar matrix.	No target analytes > ½ LOQ.	Redigest and reanalyze, if sample concentration is >10X blank concentration narrate.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
Interference Check Solutions (ICS-A and ICS-B)	At beginning and end of instrument run and after every 20 samples.	ICS-A: Unspiked analytes < LOD (unless they are a verified trace impurity from one of the spike analytes). ICS-AB: %Recovery must be within 80% - 120%.	Reanalyze samples analyzed after last acceptable ICS-A/ICS-B.	Analyst, Supervisor	Accuracy/Precision	Same as QC Acceptance Limits.
Serial Dilution	One per preparation batch of 20 or fewer samples of similar matrix.	%Difference must be between 90% - 110%.	Check instrument performance, qualify data.	Analyst, Supervisor	Accuracy/Bias/Precision	Same as QC Acceptance Limits.
LCS	One per preparation batch of 20 or fewer samples of similar matrix.	%Recovery must be between 80% - 120%.	Redigest and reanalyze, if recovery is high and sample is <LOQ narrate.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
Laboratory Duplicate	One per preparation batch of 20 or fewer samples of similar matrix.	RPD must be ≤20%	Check instrument performance, qualify data.	Analyst, Supervisor	Precision	Same as QC Acceptance Limits.
MS	One per preparation batch of 20 or fewer samples of similar matrix.	%Recovery must be between 80% - 120%.	Perform post-digestion spike analysis, qualify data.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
Post-Digestion Spike	For elements outside of QC limits in MS.	%Recovery 75% - 125%	Check instrument performance, qualify data.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
Temperature Blank	One per cooler.	<6° C	Laboratory will notify Tetra Tech Project Chemist of temperatures outside criteria. Tetra Tech Project Chemist will respond as to whether to proceed with analysis.	Analyst, Supervisor	Accuracy/Bias/Representativeness	Same as Method/SOP QC Acceptance Limits.

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**TABLE 4-9
LABORATORY QC SAMPLES TABLE - ANIONS
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

Matrix:	Aqueous					
Analytical Group:	Anions (Nitrate, Nitrite, Chloride, and Sulfate)					
Analytical Method/ SOP Reference:	SW-846 9056/Lab SOP 100.0400					
QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per batch of up to 20 samples	Analyte concentration must be $< \frac{1}{2}$ LOQ.	Correct problem, reprepare and reanalyze along with associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Contamination /Bias	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples	%R must be within 90-110%.	Correct problem, reprepare, and reanalyze along with associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD	One set is performed for each batch of up to 10 samples of the same matrix.	%R must be between 80-120%, MS/MSD %RPD must be $< 20\%$.	Failure to meet the control limits shall be discussed in the case narrative. If both the LCS and MS are unacceptable, all associated samples must be re-analyzed.	Analyst, Supervisor, Data Validator	Precision / Accuracy	Same as Method/SOP QC Acceptance Limits.

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TABLE 4-10
LABORATORY QC SAMPLES TABLE - DISSOLVED GASES
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND

Matrix:	Aqueous					
Analytical Group:	Dissolved Gases (Methane, Ethane, Ethene)					
Analytical Method/ SOP Reference:	RSK SOP 175/Lab SOP 100.0400					
QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per batch of up to 20 samples	Analyte concentration must be $< \frac{1}{2}$ LOQ.	Correct problem, re-prepare and reanalyze along with associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Contamination/Bias	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples	%R must be within 80-120% of the expected value.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD	One per batch of up to 20 samples	%R should be within 75-125% of the expected value. RPD \leq 20%	Contact client for guidance.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias/ Precision	Same as QC Acceptance Limits.

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TABLE 4-11
LABORATORY QC SAMPLES TABLE - SULFIDE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND

Matrix:	Aqueous					
Analytical Group:	Sulfide					
Analytical Method/ SOP Reference:	Standard Methods 4500 S/Lab SOP 100.0018					
QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	Corrective Active	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparation batch	No target analytes \geq LOD.	Correct problem. If required, re-prepare and reanalyze method blank and all samples processed with the contaminated blank.	Analyst, Laboratory Department Manager, and Data Validator	Contamination/ Bias	Same as QC Acceptance Limits.
LCS	One per sample preparation batch	%R must be between 80-120%.	Correct problem, then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD	One MS/MSD per analytical/preparation batch	%R must be between 75-125%. RPD \leq 20%	Identify problem; if not related to matrix interference, re-extract and reanalyze MS/MSD and all associated batch samples in accordance with DoD QSM requirements.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias/ Precision	Same as QC Acceptance Limits.

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TABLE 4-12
LABORATORY QC SAMPLES TABLE - ALKALINITY
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND

Matrix:	Aqueous					
Analytical Group:	Alkalinity					
Analytical Method/ SOP Reference:	SM2320B/SOP 100.0002					
QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per batch of up to 20 samples	Analyte concentration must be $< \frac{1}{2}$ LOQ.	Correct problem, reprepare and reanalyze along with associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Contamination/Bias	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples	%R must be within 90-110% of the expected value.	Correct problem, reprepare, and reanalyze along with associated samples.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD	One per batch of up to 20 samples	%R should be within 75-125% of the expected value. RPD \leq 20%	Contact client for guidance.	Analyst, Laboratory Department Manager, and Data Validator	Accuracy/Bias/Precision	Same as QC Acceptance Limits.

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**TABLE 4-13
 LABORATORY QC SAMPLES TABLE - TOC
 ON SHORE DERECKTOR SHIPYARD, SITE 19
 NAVSTA NEWPORT, RHODE ISLAND**

Matrix:	Aqueous					
Analytical Group:	TOC					
Analytical Method/ SOP Reference:	SW846 Method 9060A/Lab SOP100.0025					
QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch of 20 or fewer samples	The target analyte must be $\leq \frac{1}{2}$ LOQ.	Correct problem, re-prepare and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Bias/Contamination	Same as QC Acceptance Limits
LCS	One per preparatory batch of 20 or fewer samples	%R must be within 80-120% of true value.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Accuracy/Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix	%R should be within 80-120% of true value. RPD should be $\leq 20\%$.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Accuracy/Bias/Precision	Same as QC Acceptance Limits

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**TABLE 4-14
DATA VERIFICATION (STEP 1) PROCESS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 1 OF 2**

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/External
Chain-of-Custody Forms	The Tetra Tech FOL or designee will review and sign the chain-of-custody form to verify that all samples listed are included in the shipment to the laboratory and that the sample information is accurate. The forms will be signed by the sampler, and a copy will be retained for the project file, Tetra Tech PM, and Tetra Tech Data Validators. The Tetra Tech FOL or designee will review the chain-of-custody form to verify that all samples listed in the SAP have been collected. All deviations will be documented in the report.	Sampler and FOL, Tetra Tech	Internal
Chain-of-Custody Forms	1 - The Laboratory Sample Custodian will review the sample shipment for completeness and integrity and will sign accepting the shipment. 2- The Tetra Tech Data Validators will check that the chain-of-custody form was signed and dated by the Tetra Tech FOL or designee relinquishing the samples and also by the Laboratory Sample Custodian receiving the samples for analyses.	1 - Laboratory Sample Custodian, Spectrum 2 - Data Validators, Tetra Tech	External
Chain-of-Custody Forms and SAP	Ensure that the custody and integrity of the samples were maintained from collection to analysis and that the custody records are complete and any deviations are recorded. Review that the samples were shipped and stored at the required temperature and preservation conditions for chemically preserved samples. Ensure that the analyses were performed within the holding times listed in the SAP.	Data Validators, Tetra Tech	External
Sample Log Sheets, Chain-of-Custody Forms, SAP, and Laboratory Sample Login Documentation	Verify that information recorded on the log sheets is accurate and complete. Verify that samples were correctly identified, that sampling location coordinates are accurate, and that documentation establishes an unbroken trail of documented chain of custody from sample collection to report generation. Verify that the correct sampling and analytical methods/SOPs were applied. Verify that the sampling plan was implemented and carried out as written and that any deviations are documented. Document any discrepancies in the final report.	PM, FOL, or designee, Tetra Tech	Internal
SAP, Analytical SOPs, and Analytical Data Packages	Ensure that all laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied. Establish that all method QC samples were analyzed and in control as listed in the analytical SOPs. If method QA is not in control, the Laboratory QAM will contact the Tetra Tech PM verbally or via e-mail for guidance prior to report preparation.	Laboratory QAM, Spectrum	Internal
SAP/Chain-of-Custody Forms	Check that all field QC samples determined necessary were collected as required.	FOL or designee, Tetra Tech	Internal
Analytical Data Package	Verify all analytical data packages for completeness. The Laboratory QAM will sign the case narrative for each data package.	Laboratory QAM, Spectrum	Internal
Electronic Data Deliverables (EDDs)/ Analytical Data Packages	Check each EDD against the chain-of-custody form and hard-copy data package for accuracy and completeness. Compare laboratory analytical results to the electronic analytical results to verify accuracy. Evaluate sample results for laboratory contamination, and qualify false detections using the laboratory method/preparation blank summaries. Qualify analyte concentrations between the DL and LOQ as estimated. Remove extraneous laboratory qualifiers from the validation qualifier.	Data Validators, Tetra Tech	External

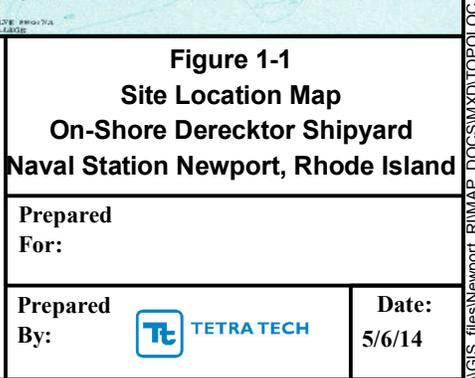
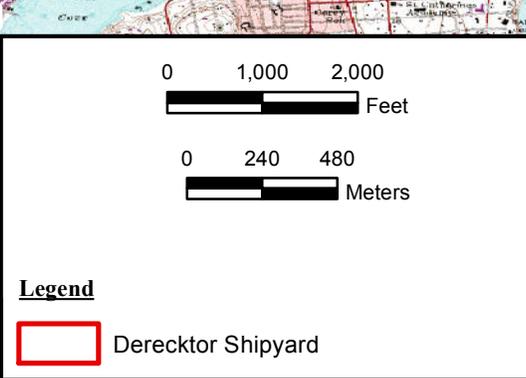
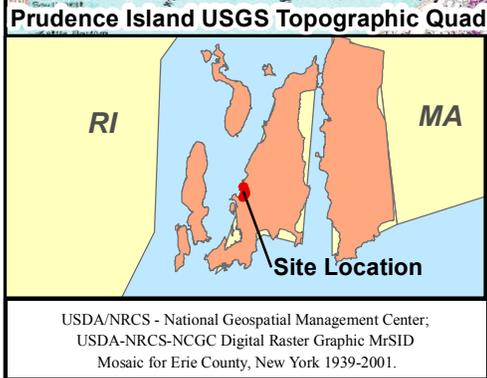
**TABLE 4-14
DATA VERIFICATION (STEP 1) PROCESS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND
PAGE 2 OF 2**

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/External
Analytical Data Package	Verify each data package for completeness. Request missing information from the Laboratory PM.	Data Validators, Tetra Tech	External
SAP/Laboratory Data Packages/EDDs	Ensure that the laboratory QC samples were analyzed and that the MPCs listed in were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed and that the analytical QC criteria set up for this project were met.	Data Validators, Tetra Tech	External
SAP/Laboratory Data Packages/EDDs	Check field sampling precision by calculating RPDs for field duplicate samples. Check laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses, MS/MSDs, and LCS/LCSD, if available. Ensure compliance with the methods and project MPCs accuracy goals listed in the SAP.	Data Validators, Tetra Tech	External
SAP/Laboratory Data Packages/EDDs	Check that the laboratory recorded the temperature at sample receipt and the pH of samples preserved with acid or base to ensure sample integrity from sample collection to analysis.	Data Validators, Tetra Tech	External
SAP/ Laboratory Data Packages/EDDs	Review the chain-of-custody forms generated in the field to ensure that the required analytical samples have been collected, appropriate sample identifications have been used, and correct analytical methods have been applied. The Tetra Tech Data Validator will verify that elements of the data package required for validation are present, and if not, the laboratory will be contacted and the missing information will be requested. Check that all data have been transferred correctly and completely to the Tetra Tech Structured Query Language (SQL) database.	Data Validators, Tetra Tech	External
SAP/ Laboratory Data Packages/ EDDs	Ensure that the project LOQs listed in SAP were achieved.	Data Validators, Tetra Tech	External
SAP/Laboratory Data Packages/EDDs	Discuss the impact on DLs that are elevated because of matrix interferences. Be especially cognizant of and evaluate the impact of sample dilutions on low-concentration analytes when the dilution was performed because of the high concentration of one or more other contaminants. Document this usability issue and inform the Tetra Tech PM. Review and add PSLs to the laboratory EDDs. Flag samples and notify the Tetra Tech PM of samples with concentrations exceeding the PSLs listed in SAP.	Data Validators, Tetra Tech	External
SAP/Laboratory Data Packages/EDDs	Ensure that all QC samples specified in the SAP were collected and analyzed and that the associated results were within prescribed SAP acceptance limits. Ensure that QC samples and standards prescribed in analytical SOPs were analyzed and within the prescribed control limits. If any significant QC deviations occur, the Laboratory QAM shall have contacted the Tetra Tech PM.	Data Validators, Tetra Tech	External
SAP/Laboratory Data Packages/EDDs	Summarize deviations from methods, procedures, or contracts in the Data Validation Report. Determine the impact of any deviation from sampling or analytical methods and SOPs requirements and matrix interferences effect on the analytical results. Qualify data results based on method or QC deviation and explain all the data qualifications. Print a copy of qualified data stored in the project database to depict data qualifiers and data qualifier codes that summarize the reasons for data qualifications. Determine if the data met the MPCs and determine the impact of any deviations on the technical usability of the data.	Data Validators, Tetra Tech	External

**TABLE 4-15
DATA VALIDATION (STEPS IIA AND 11B) PROCESS TABLE
ON SHORE DERECKTOR SHIPYARD, SITE 19
NAVSTA NEWPORT, RHODE ISLAND**

Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
Soil and Aqueous VOCs, PAHs, Metals, and MNA parameters	Validation of sample data will follow USEPA Region I guidelines for Tier II data review as outlined in the USEPA New England document titled "Environmental Data Review Supplement for Regional Data Review Elements and Superfund Specific Guidance/Procedures, April 2013" (USEPA, 2013c). Tier II data validation will be performed for VOCs, SVOCs, pesticides, PCBs, metals, and TPH-DRO (C9-C40) by the analytical methods and criteria listed in this SAP and the current DoD QSM. A Tier II validation combines all elements included in a Tier I review, such as data completeness, data verification, and an evaluation of all method quality control parameters, plus a review of instrument raw data (chromatograms, quantitation results, mass spectra). One result per analytical fraction will be checked for calculation accuracy. USEPA National Functional Guidelines for Organic Data Validation (USEPA, 2008) and USEPA National Functional Guidelines for Inorganic Data Review (USEPA, 2010) will be used to apply qualifiers to data to the extent possible.	Data Validation Specialist, Tetra Tech

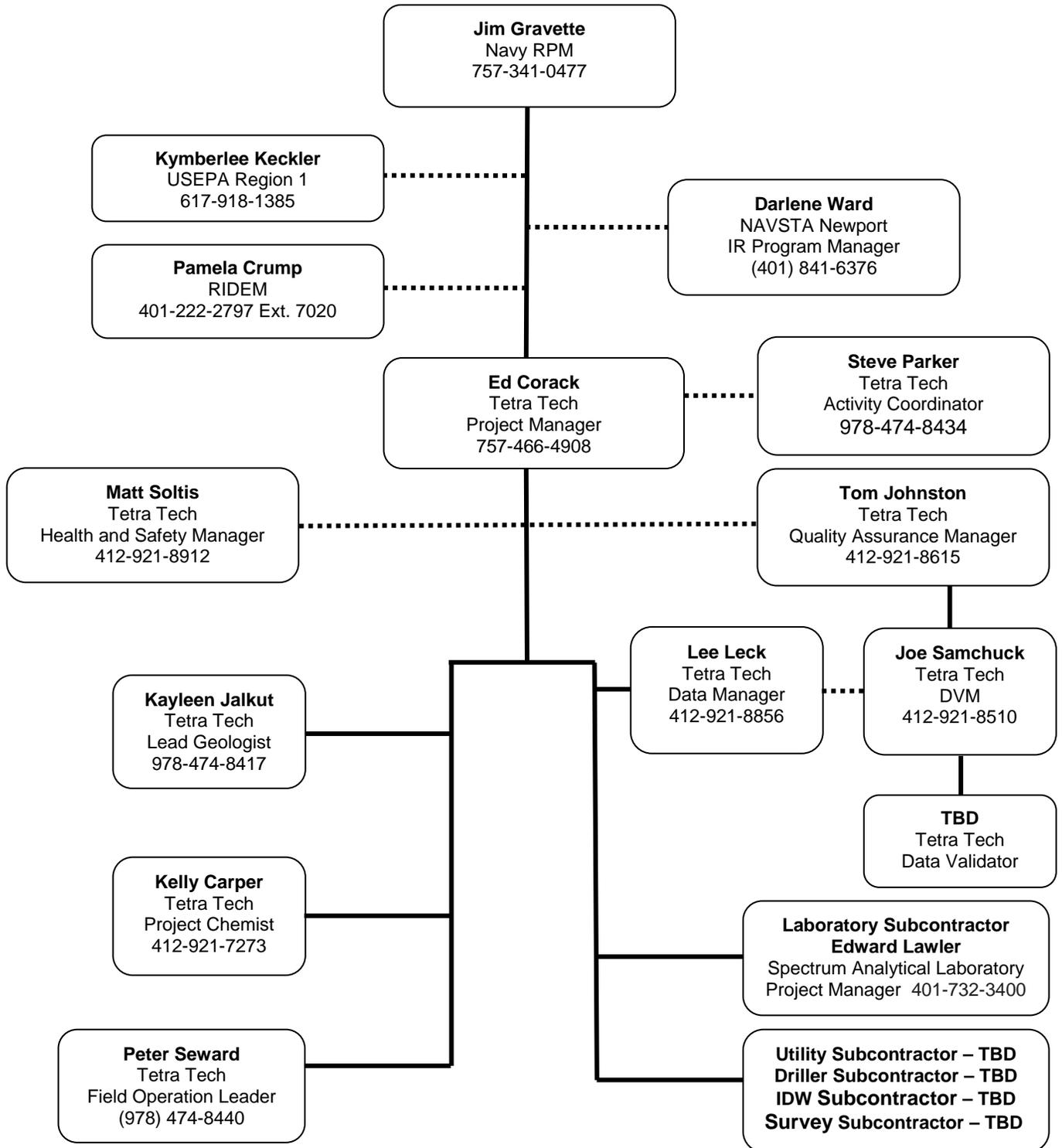
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FIGURE 1-2
PROJECT ORGANIZATIONAL CHART
ON SHORE DERECKTOR
NAVSTA NEWPORT, RHODE ISLAND

Lines of Authority ————— Lines of Communication



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-  Existing Monitoring Well
-  Former or Unusable Monitoring Well
-  100-Year Floodplain
-  CERCLA Action Required for soils
-  No further CERCLA action for Soils

Source: ESRI, i-cubed, USDA FSA, USGS AEX, GeoEye, Getmapping, Aerogrid, IGP

RIDEM- Rhode Island Department of Environmental Management Remediation Regulations, November 2011

Bing Maps aerial:
Aerial photograph from ESRI Bing Maps map service
(© 2010 Microsoft Corporation and its data suppliers).

 **TETRA TECH**

Map by: MC 3/11/14

Approved: EC 3/11/14

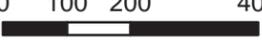
Project #: 112G04095



N



0 100 200 400



Scale in Feet

FIGURE 2-1
SITE PLAN
ON-SHORE DERECKTOR SHIPYARD
NAVAL STATION NEWPORT, RHODE ISLAND

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LEGEND

- Surface/ Subsurface
- Groundwater contaminants
- | Groundwater Monitoring Well

RECEPTORS

Current/Future Trespasser—Dermal contact with and incidental ingestion of surface soil/air.

Future Resident—Dermal contact with and incidental ingestion of surface soil/subsurface soil; dermal contact with and ingestion of tap water (groundwater); inhalation of air.

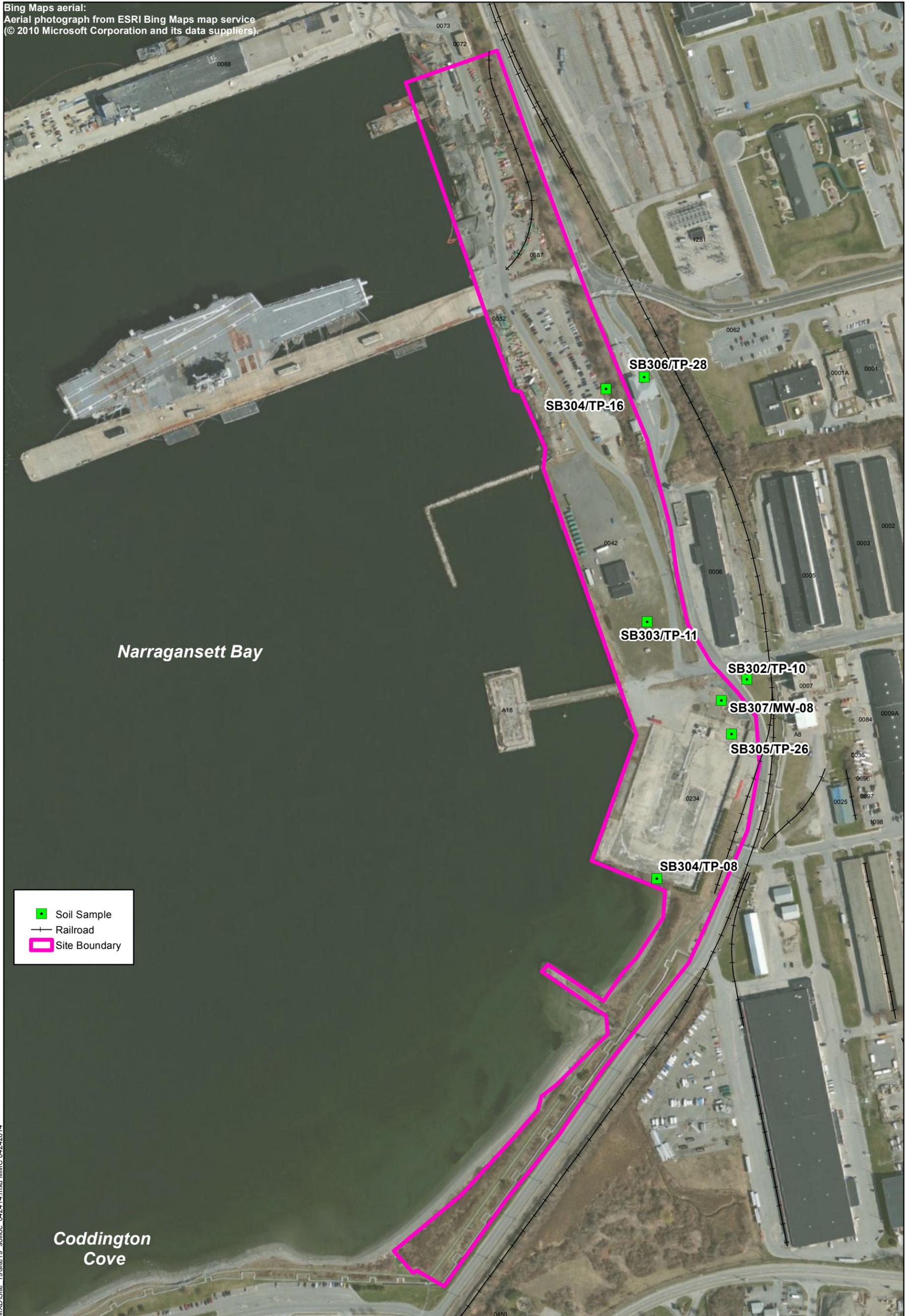
Current/Future Industrial Worker—Dermal contact with and incidental ingestion of surface soil/subsurface soil, air and groundwater.

Current/Future Construction Worker—Dermal contact with and incidental ingestion of soil/shallow groundwater; inhalation of dust and trench air.

	
NAVAL STATION NEWPORT NEWPORT, RHODE ISLAND CONCEPTUAL SITE MODEL SITE 19 - ON-SHORE DERECKTOR SHIPYARD OU12 - SOIL AND GROUNDWATER RECORD OF DECISION	
File	No Scale (perspective)
Figure Number 2-2	Date: 05/30/14

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Bing Maps aerial:
Aerial photograph from ESRI Bing Maps map service
(© 2010 Microsoft Corporation and its data suppliers).



	Soil Sample
	Railroad
	Site Boundary

\\GIS_files\Newport_RI\MAP_DOCS\MXD\Site_19\site19_solidloc_042414.mxd MMC-04242014


Map by: MC 5/6/14
Approved: RS 5/6/14
Project #: 112G04095

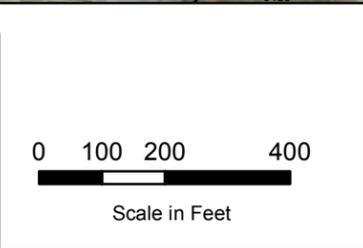


Figure 3-1
Soil Sample Location Map
On-Shore Derektor Shipyard
Naval Station Newport, Rhode Island

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Bing Maps aerial:
Aerial photograph from ESRI Bing Maps map service
(© 2010 Microsoft Corporation and its data suppliers).

Note: New temporary well MW11B
will be installed at same screen
depth (5 to 10 feet) as the previous
(2011) temporary well MW11A .



-  Monitoring Well to be sampled in June 2014
-  Former or Unusable Monitoring Well
-  Railroad
-  Approximate IR Site Boundary

I:\GIS_files\Newport_RI\MAP_DOCS\MXD\Site_19\Site19_mwloc042414.mxd MMC 04242014



Map Location



Figure 3-2
Monitoring Well Location Map
On-Shore Derektor Shipyard
Naval Station Newport, Rhode Island

Map by: MC 5/6/14
Approved: RS 5/6/14
Project #: 112G04095

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APPENDICES

Appendices are provided electronically on the enclosed CD.

- A 2011 SAP ADDENDUM (WORK PLAN ADDENDUM NO. 1)
- B SELECTED FIELD STANDARD OPERATING PROCEDURES
- C FIELD DOCUMENTATION FORMS
- D LABORATORY DOD ELAP ACCREDITATION

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APPENDIX A
2011 SAP ADDENDUM

N62661.AR.002384
NS NEWPORT
5090.3a

WORK PLAN ADDENDUM 1 FOR STUDY AREA SCREENING EVALUATION ON SHORE
DEREKTOR SHIPYARD SITE 19 NS NEWPORT RI
02/01/2011
TETRA TECH NUS

Work Plan Addendum 1

for

Study Area Screening Evaluation

**On-Shore Derecktor Shipyard, Site 19
Naval Station Newport
Newport, Rhode Island**



**Naval Facilities Engineering Command
Mid-Atlantic**

**Contract Number N62470-08-D-1001
Contract Task Order WE20**

February 2011

WORK PLAN ADDENDUM 1
ON-SHORE DERECKTOR SHIPYARD, SITE 19
NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND
COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

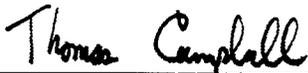
Submitted to:
Naval Facilities Engineering Command Mid-Atlantic
9742 Maryland Avenue
Norfolk, Virginia 23511-3095

Submitted by:
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406

CONTRACT NUMBER N62470-08-D-1001
CONTRACT TASK ORDER WE20

February 2011

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QUALITY ASSURANCE MANAGER
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REFERENCES

APPENDICES (Submitted on CD)

- A Selected Field Standard Operating Procedures
- B Field Documentation Forms
- C Analytical Services Technical Specification
- D Selected Analytical Laboratory Standard Operating Procedures

ACRONYMS

bgs	Below Ground Surface
B&RE	Brown and Root Environmental
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chain of Custody
COPC	Chemical of Potential Concern
CTO	Contract Task Order
DEC	Direct Exposure Criteria
DO	Dissolved Oxygen
DPT	Direct Push Technologies
DQO	Data Quality Objective
DRO	Diesel Range Organics
FEP	Fluorinated ethylene propylene
FID	Flame Ionization Detector
FOL	Field Operations Leader
FTMR	Field Modification Request Form
GPS	Global Positioning System
GRO	Gasoline Range Organics
HASP	Health and Safety Plan
ID	Inside Diameter
IDQTF	Intergovernmental Data Quality Task Force
IDW	Investigation Derived Waste
LNAPL	Light Non-Aqueous Phase Liquid
LQAP	Laboratory Quality Assurance Plan
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
mg/L	Milligrams per Liter
mL	Milliliter
ml/min	Milliliter per Minute
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAD	North American Datum
NAVSTA	Naval Station Newport
NGVD	National Geodetic Vertical Datum
NTU	Nephelometric Turbidity Units
ORP	Oxygen Reduction Potential
PA	Preliminary Assessment
PAHs	Polynuclear Aromatic Hydrocarbons
PAL	Project Action Levels
PCBs	Polychlorinated Biphenyls
PE	Polyethylene
PID	Photo Ionization Detector
PM	Project Manager
PPE	Personal Protective Equipment
ppm	Parts Per Million
PQL	Project Quantitation Limit
PQOs	Project Quality Objectives
PRT	Post-Run Tubing
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QAM	QA Manager
QAPP	Quality Assurance Project Plan
QC	Quality Control
RI	Remedial Investigation
RIDEM	Rhode Island Department of Environmental Management

RSLs	Regional Screening Levels
RTC	Response to Comments
SASE	Study Area Screening Evaluation
SOP	Standard Operating Procedure
SSO	Site Safety Officer
TAL	Target Analyte List
TPH	Total Petroleum Hydrocarbons
TtEC	Tetra Tech EC, Inc.
TtNUS	Tetra Tech NUS, Inc.
UFP	Uniform Federal Policy
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VOCs	Volatile Organic Compounds

1.0 INTRODUCTION

This Work Plan Addendum was prepared by Tetra Tech NUS, Inc, (TtNUS) for the U.S. Department of Navy (Navy) to conduct onshore field work as part of additional sampling activities for a Study Area Screening Evaluation (SASE) for Site 19, On-Shore Derecktor Shipyard (the site) at Naval Station (NAVSTA) Newport, Rhode Island. This addendum is a supplement to the *Work Plan for On-Shore Site Assessment Screening Evaluation, Former Derecktor Shipyard, Naval Education & Training Center, Newport, Rhode Island* (B&RE, 1996) and will be used to guide TtNUS personnel in performing additional site characterization activities following a series of removal actions that were conducted between 1998 and 2007. The results of this characterization will be presented in an addendum to the existing SASE Report prepared by Brown & Root Environmental (B&RE) in June 1997. The sections in this work plan addendum correspond to sections in the above-named work plan, with section-specific text added for activities to be conducted as part of this additional fieldwork. This work is being conducted at the request of the Navy under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62470-08-D-1001, Contract Task Order (CTO) WE20.

The Derecktor Shipyard was a privately operated ship maintenance and construction facility from 1979 to 1992. The property was leased to Robert E. Derecktor but owned by the U.S. Navy, which had also used the site for shipbuilding activities from 1962 to 1978. The site location is shown on Figure 1-1. A Preliminary Assessment (PA) was conducted by Halliburton NUS Corporation and ENSR Consultants and Engineers in May 1993. The PA identified several areas of concern where additional investigations were recommended. These areas were identified by visual observations and by review of historical records for the shipyard. Following the PA, the SASE completed for the On-Shore Derecktor Shipyard identified and evaluated contaminants present onshore in the buildings, fill, soil, and groundwater, due to past operations at the site. The SASE targeted known areas of contaminant discharge for sample collection and analysis. The SASE Report summarized contaminants detected, probable contaminant discharge routes, and risks to receptors. Recommendations included excavation of "hot spots", filling of sumps and trenches, and addressing various outfalls and catch basins. Various removal actions were conducted from 1997 to 2007 to address the recommendations contained in the SASE Report.

1.1 PROJECT OBJECTIVES

The objectives of the onshore field work are to collect additional samples from areas where data gaps were identified by Navy and regulators, to obtain analytical data representative of current conditions after the aforementioned removal actions, to compare analytical results to screening criteria, to utilize the existing sample database and newly collected samples to revise the original SASE preliminary human health risk assessment as necessary, and to determine if additional action is required at the site.

The proposed field work will target seven areas of Site 19 that include the following:

- Southern Waterfront Area (northern portion)
- Building 234 (Sump 234-4)
- Building 6/Test Pit 14 Area
- Building 42 (“hotspot” excavation area and downgradient of sump S42-1)
- Huts 1 and 2
- Northern Waterfront Area

Data generated as part of this fieldwork and existing data from the SASE Report prepared in 1997 will be used to revise the preliminary human health risk assessment (included in the report). In addition, the vapor intrusion pathway will be evaluated, using sample results from the Northern Waterfront Area.

As noted above, this document amends the original work plan prepared for the initial onshore SASE, as described in the following sections.

1.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

Section 1.2 was amended by the addition of the following text.

TtNUS will be responsible for the overall management of the project, including the performance of field activities presented in this Work Plan.

Key project personnel, contact information, and communication pathways are listed in Table 1-1, and the project organizational chart is presented as Figure 1-2.

Navy personnel from NAVFAC Mid-Atlantic will be responsible for administrative and technical oversight of the program, as well as project management and coordination with the federal and state regulatory agencies. Navy personnel from NAVSTA Newport will be responsible for on-site coordination with TtNUS.

TtNUS project personnel responsible for implementing the On-Shore Derecktor field work program will include the following:

- The TtNUS Project Manager (PM) will have the primary responsibility for implementing and managing the program, and will be the primary TtNUS point of contact with the Navy and the

regulatory agencies. The PM will also be responsible for notifying the Navy of upcoming field activities or schedule modifications. The PM is responsible for evaluating and interpreting the field and analytical data, and reporting the investigation results.

- The Lead Geologist will assist in planning and implementing the field programs and will advise the PM regarding geologic conditions found and determining whether there are potential migration pathways that have not been adequately investigated.
- The Field Operations Leader (FOL) will be responsible for directing on-site field activities and will report directly to the PM. The FOL will coordinate efforts of the field sampling staff and will be responsible for identifying problem areas and bringing them to the attention of the PM for resolution.
- A Site Safety Officer (SSO) will be designated prior to field activities and will be responsible for ensuring adherence to the site-specific Health and Safety Plan. The SSO reports directly to the CLEAN Health and Safety Manager and the PM.
- The Project Chemist will advise the PM on technical requirements of the chemical data, review laboratory specifications for analysis of samples collected, coordinate with the subcontracted analytical laboratories, and review or oversee the validation of the analytical reports prepared.

In addition to the above personnel, TtNUS program personnel will provide overall support in subcontracting, cost tracking, progress reporting, and supervising the PM. The program personnel include:

- The CLEAN Program Manager is responsible for the overall implementation of program level functions to ensure that the scopes of work for all CTOs are planned and implemented in accordance with the CLEAN contract requirements, and in accordance with TtNUS technical, administrative, quality assurance, and health and safety requirements. The CLEAN Program Manager also ensures that CTOs are implemented in accordance with approved project schedules and budgets.
- The CLEAN Deputy Program Manager is responsible for the technical oversight of the CTOs and is the primary point of contact for the TtNUS project managers. The Deputy Program Manager provides guidance and direction in the overall implementation of the CTO scopes of work.

- The CLEAN Quality Assurance Manager is responsible for Quality Assurance/Quality Control (QA/QC) requirements for the TtNUS CLEAN program. The CLEAN Quality Assurance Manager reviews data and deliverable documents, and performs system audits to ensure that contract QA/QC goals are met.
- The CLEAN Health and Safety Manager is responsible for reviewing health and safety plans for all CLEAN operations, and performs site audits to ensure compliance with program and site health and safety requirements.

1.3 PROJECT DELIVERABLES

Section 1.3 was amended by the addition of the following text.

Project deliverables will include a SASE Addendum. The addendum will present the results of the fieldwork, update relevant sections from the original SASE Report, and will include new sections to discuss the risk assessment's vapor intrusion pathway analysis for the Northern Waterfront Area. The addendum will follow the same format as the SASE report, either appending new information to existing sections (summary of sampling results) or presenting new information in new sections (vapor intrusion modeling). The report contents are discussed further in Section 5.4 of this work plan addendum.

1.4 WORK PLAN ORGANIZATION

No changes were made to Section 1.4 in this Work Plan Addendum.

1.5 CHANGES TO THE WORK PLAN

Section 1.5 was amended by the addition of the following text.

This Work Plan Addendum meets the requirements of *QA/R-5, EPA Requirements for Quality Assurance Project Plans* (U.S. EPA, 2001) and contains the main elements required by the Intergovernmental Data Quality Task Force (IDQTF) Uniform Federal Policy (UFP) for Quality Assurance Program Plans manual (IDQTF, 2005). During project execution, it may become necessary to modify the sampling plan presented in Section 3.0 after it is finalized, because of new information, developments in the field, or evaluation of the data. Minor modifications to the plan, if needed, will be implemented by using a Field Task Modification Request (FTMR) form.

The FTMR will be used for modifications that do not significantly impact the Work Plan Addendum, such as changes in personnel, minor changes in sample collection or analytical methods, or relocating a station/sample location. The FTMR will document the circumstances, the reasons for the modification, and the recommended disposition related to any major impact on the quality of work, cost, or schedule. The FTMR will be prepared by the Project Manager (or designee) or the Navy, and will be submitted to the regulatory agencies (e.g., U.S. Environmental Protection Agency [EPA] and Rhode Island Department of Environmental Management [RIDEM]) for informational purposes. Changes in sample collection and analytical methods as those listed above will be discussed with the regulatory agencies prior to implementation.

If major modifications to the work planned in this document are required, they will be made through a revision to this Work Plan Addendum. Revisions will be developed, reviewed, and approved according to the same process required for this Work Plan Addendum.

1.6 SCHEDULE AND REGULATORY OVERSIGHT

Section 1.6 was amended by the addition of the following text.

A schedule for field activities will be provided to EPA and RIDEM upon completion of the review process for this Work Plan Addendum.

2.0 BACKGROUND

Section 2.0 was amended by the addition of the following text.

Information in this section has been augmented by adding the findings of the SASE Report and a summary of various removal actions conducted subsequent to the SASE.

2.1 ACTIVITY HISTORY

No changes were made to Section 2.1 in this Work Plan Addendum.

2.2 SURROUNDING LAND USE

No changes were made to Section 2.2 in this Work Plan Addendum.

2.3 GEOLOGY/HYDROGEOLOGY

No changes were made to Section 2.3 in this Work Plan Addendum.

2.4 FINDINGS OF THE PRELIMINARY SITE ASSESSMENT

No changes were made to Section 2.4 in this Work Plan Addendum.

2.5 RECENT ACTIVITY

No changes were made to Section 2.5 in this Work Plan Addendum.

2.6 RECOMMENDATIONS OF THE PRELIMINARY ASSESSMENT REPORT

No changes were made to Section 2.6 in this Work Plan Addendum.

2.7 FINDINGS OF THE SITE ASSESSMENT SCREENING EVALUATION REPORT

In July 1996, B&RE commenced the SASE investigation to determine the presence of contaminants in the soils and groundwater in the areas of concern previously identified by the Derecktor Shipyard PA (Halliburton NUS, 1993).

Investigations were conducted through sample collection, chemical analysis, and evaluation of contaminant transport mechanisms. Soil samples were collected by advancing test pits and borings. Twenty-eight test pits were excavated on the site and 25 soil borings were advanced, eight of which were completed as groundwater monitoring wells. Soils were evaluated using field-screening instruments and visual observations, and samples of suspect soils were delivered to an analytical laboratory for chemical analysis. Two borings were advanced and sampled in areas upgradient of the site to provide background/upgradient data to compare to onsite data collected.

Groundwater samples were collected from eight groundwater monitoring wells installed on the site, one well installed in an upgradient location, and one well installed on site during an earlier investigation. All groundwater samples were submitted for laboratory analysis.

Findings of the SASE Investigation

Soil sample analysis confirmed the conclusions of the PA that surficial discharge of various contaminants had occurred at several locations across the site. Much of the contamination in soils was localized and apparently related to surficial discharges. Low concentrations of contaminants were also detected in groundwater samples collected at the site. The SASE findings are summarized below:

- Elevated concentrations of phenolic compounds and polynuclear aromatic hydrocarbon (PAH) compounds were detected in soils in the area around Huts 1 and 2 (Test Pit [TP]16 and TP17). The evaluation of data determined that the contaminants were likely associated with the former vehicle maintenance operations that were performed in these huts.
- Elevated concentrations of polychlorinated biphenyls (PCBs), PAH compounds, and metals were found in soils from unpaved areas northeast of Building 6 (TP14), which received surface runoff from the Penn-Central Railway, the electrical transformer pad, and the paved areas east of Building 6 where transformers had reportedly been stored. In addition, the former "pipe shop" was located in the northeast corner of Building 6 and was suspected to have discharged to soils in this area.
- Slightly elevated concentrations of PAHs and metals were found in soils from the former location of a bilge water disposal area north of Building 42 (MW05).
- Slightly elevated concentrations of pesticides and leachable metals were detected in soils from the area south of Building 42 (MW07 and TP11), which was a former bulk material storage area.

- Elevated concentrations of phthalate compounds were detected in the soils south of Building 234 (TP07 and TP08), which was an area of suspected chemical discharge described in the PA report.
- High concentrations of semivolatile organic compounds and butyltin compounds were detected in the soils under Building 42, apparently due to past discharges from sumps within the building.
- Petroleum-related contaminants were found in soils from the former parking area, east (upgradient) of Huts 1 and 2; however, the contamination appeared to be the result of upgradient releases from former underground storage tanks (USTs) at Building 62. This area was investigated as part of a separate study.
- Low concentrations of petroleum fuel components were detected in the shallow soils north of Building 234. These were believed to be residual contaminants from former USTs in this area.

Findings of the Risk Evaluation Assessment

A human health risk evaluation was performed to identify risks to potential receptors. The current potential receptors evaluated were limited to persons working at the site on a full-time basis, as well as persons trespassing on the site. Future receptors evaluated included industrial workers, excavation workers, trespassers, and residents. The primary contributors to the risk evaluated in the analysis were arsenic (all areas) and PCBs (from surface soils north of Building 6).

Arsenic is a naturally occurring element in soil and groundwater in Rhode Island, related to the character/mineralogy of the geologic units in the area. A risk-based acceptable (target) level for arsenic in soils has been set by RIDEM, for industrial properties. Many samples of soil at and upgradient of this and other sites on Aquidneck Island have been found to exceed this target level.

PCBs were found at elevated concentrations in soils north of Building 6. Industrial workers in this area may be exposed to these surface soils, which could cause an increased risk of cancer above the EPA-recommended target level of one in one hundred thousand for incremental cancer risk.

2.8 RECOMMENDATIONS OF THE SITE ASSESSMENT SCREENING EVALUATION REPORT

Recommendations of the SASE included performing limited soil excavations at several areas found to have elevated concentrations of chemical contaminants. These areas were located to the northeast of Building 6, where the risk evaluation showed an increased risk from PCBs present in the soil and the soils under

Building 42 which were found to be contaminated with paint residues. Finally, some of the drainage systems under the Building 234 foundation and south of Building 42 were recommended for dismantling or repair, depending on the plans for future use of these areas.

2.9 REMOVAL ACTIVITIES

In August 1995, NAVSTA contracted with OHM Corporation to conduct a removal action to excavate and dispose of sandblast grit that was known to be present on the ground to the north and east of Building 42. OHM removed this material and covered the exposed ground with a sand and crushed stone mix. As part of this effort, the embankment to the east of Building 42 was excavated and repaired.

Various removal actions were conducted by Foster Wheeler Environmental Corporation (subsequently known as Tetra Tech EC, Inc.) from 1997 through 2008. These actions included the following:

- **Southern Waterfront Berm Removal.** A berm containing construction debris and soil located in the southern waterfront area was removed. Prior to removal, the berm was divided into six equal sections. Soils from each section were removed and stockpiled for composite sampling prior to disposal. Shoreline restoration activities were conducted after the removals.
- **Building 42 S42-1 Sump Pit Removal.** Sump 1, located beneath former Building 42, was removed. Soils beneath the sump were also removed to a depth of 1 foot below ground surface (bgs). Confirmatory samples were collected and, upon review of the data, removal activities were concluded.
- **Test Pit 14 PCB Contaminated Soil Removal.** A series of excavations and confirmatory sampling was conducted to delineate and remove PCB-contaminated soils. Approximately 430 tons of PCB-contaminated soil was removed from the Test Pit 14 area.
- **Building 42 S42-5 Sump Investigation and Removal.** A concrete sump and associated valve chamber were removed. Approximately 42 tons of concrete debris were disposed. Confirmation samples were collected and piping and associated soil were also removed.
- **Exploratory Trenching, Former Disposal Pits.** Three exploratory trenches were excavated north of former Building 42 (*i.e.* bilge water disposal area). Based on sample analysis of the soil excavated from the trenches, a hotspot removal was conducted at one location. Approximately 25 cubic yards of soil were removed.
- **Sandblast Grit Removal.** A series of removal actions were conducted north of Building 6 in the vicinity of a new watchtower to remove subsurface sand blast grit.

3.0 FIELD INVESTIGATION AND SAMPLING PLAN

Section 3.0 was amended by the addition of the following text.

This section describes additional tasks proposed as part of the field work program to be implemented under this work plan addendum. These additional field tasks will provide data to evaluate the potential presence of contamination at concentrations above comparison criteria.

3.1 OBJECTIVES

Section 3.1 was amended by the addition of the following text.

The following lists the field tasks to be conducted under this Work Plan Addendum:

- Mobilize and demobilize for field investigation
- Inspect historic sump (former Building 234) for concrete bottom
- Conduct drilling and soil sampling
- Conduct soil-gas sampling
- Install and develop overburden groundwater monitoring wells
- Measure groundwater levels
- Conduct groundwater sampling at new and existing monitoring wells
- Perform land surveying
- Manage investigation-derived waste (IDW)

3.2 VISUAL AND INSTRUMENT INSPECTIONS

Section 3.2 was amended by the addition of the following text.

TtNUS field activities will include an inspection of one historic sump located in the former Building 234.

3.2.1 Task 1: Mechanical Pits and Trenches Inspection

Section 3.2.1 was amended by the addition of the following text.

An inspection will be conducted of sump 234-4 which is located in the foundation of former Building 234. The sump will be examined to determine its present condition and ascertain if a sample can be collected at the former bottom of the sump.

3.2.2 Task 2: Underground Drainage Systems Tracking and Clearing

No changes were made to Section 3.2.2 in this Work Plan Addendum.

3.2.2.1 Storm Drains/Catch Basins

No changes were made to Section 3.2.2.1 in this Work Plan Addendum.

3.2.2.2 Floor Drains

No changes were made to Section 3.2.2.2 in this Work Plan Addendum.

3.3 INTRUSIVE INVESTIGATIONS

Section 3.3 was amended by the addition of the following text.

Intrusive field activities described in this work plan addendum include additional soil borings for the collection of soil samples and soil-gas samples, and for the installation of overburden groundwater monitoring wells. Groundwater samples will be collected from newly installed and existing overburden groundwater monitoring wells. The proposed sample locations are summarized in Table 3-1 and are depicted on Figure 3-2a. All proposed sample locations will be field verified with EPA and RIDEM personnel prior to sampling activities.

3.3.1 Task 3: Test Pit Excavation and Sample Collection

No changes were made to Section 3.3.1 in this Work Plan Addendum.

3.3.1.1 Test Pit Excavation

No changes were made to Section 3.3.1.1 in this Work Plan Addendum.

3.3.1.2 Sample Collection

No changes were made to Section 3.3.1.2 in this Work Plan Addendum.

3.3.2 Task 4: Geologic/Hydrogeologic Investigation

Section 3.3.2 was amended by the addition of the following text.

For the purpose of collecting soil samples, fourteen soil borings will be advanced using conventional drilling techniques and one of these borings will also be used for the installation of an overburden groundwater monitoring well. Six additional soil borings will be advanced for the purpose of installing shallow overburden groundwater monitoring wells for collection of groundwater samples. Three additional soil boring locations will be advanced using a hand auger, also for the purpose of collecting soil samples. For the purpose of collecting soil-gas samples, four borings will be advanced using direct-push technology (DPT) drilling techniques. The seven new monitoring wells and five existing groundwater monitoring wells will be sampled.

3.3.2.1 Investigation of Target Areas

Section 3.3.2.1 was amended by the addition of the following text.

The investigation covered by this work plan includes the following borings and wells to be installed and/or sampled. The locations are listed according to approximate physical location at Derecktor Shipyard, generally from south to north, as shown on Figure 3-2a:

In the Southern Waterfront Area, immediately south of former Building 234: two borings will be advanced and soil samples collected from below the topsoil layer in order to investigate if any potential PAH or metals contamination exists in Section 6 of the Southern Waterfront area.

At former Building 234, former Sump 234-4: one boring will be advanced to determine if a concrete bottom is present within the sump and to investigate for any potential historic TPH contamination associated with the operations in former Building 234.

North of former Building 234: existing overburden monitoring well MW-8 will be sampled to investigate any potential impact from test pit TP-26 (former location of USTs and a machine shop) to the shallow overburden aquifer.

In the Central Shipyard Area, west of former Building 42 and downgradient of former sump S42-1: one overburden monitoring well will be installed and sampled to investigate any potential contamination in the shallow overburden groundwater from sump discharges from a paint room in former Building 42.

North of former Building 42, in the vicinity of test pit TP-25: one overburden monitoring well will be installed and sampled to investigate any potential contamination in the overburden groundwater downgradient of a suspected disposal pit area.

North and east of Building 6: seven borings will be advanced to confirm that previous soil excavations removed polychlorinated biphenyl (PCB)-contaminated soils. The borings will serve to confirm the depth to bedrock (predicted to be shallow, based on available information) and soil samples will be collected to document residual soil conditions.

North of Building 6, at the former transformer bank: three hand-auger soil samples will be collected to investigate any potential PCB contamination in shallow soil.

North of former Huts 1 and 2, in the vicinity of test pit TP-16: three borings will be advanced and one additional boring will be completed as an overburden monitoring well to be sampled to investigate any potential contamination to overburden groundwater in the vicinity of two former vehicle maintenance buildings.

In the Northern Waterfront Area: four overburden monitoring wells will be installed and sampled, including one in an upgradient location, east of the site. Four existing overburden monitoring wells will be sampled. Four DPT borings will be co-located with the existing monitoring wells for the purpose of collecting soil-gas samples. Samples will be collected to investigate historic detections of VOCs in groundwater.

3.3.2.2 Advancement of Overburden Borings

Section 3.3.2.2 was amended by the addition of the following text.

Conventional drilling will be performed by a subcontractor to Tetra Tech (applicable Standard Operating Procedures [SOPs], including GH-1.3, are included in Appendix A). TtNUS will develop a scope of work, procure the subcontractor, and oversee all drilling activities. All down-hole drilling equipment will be steam-cleaned before use at each boring (Section 3.6 provides detailed decontamination procedures).

Based on observations recorded during the previous SASE investigation, the bedrock depth at the site ranges from approximately 18 feet (Northern Waterfront Area) to 46 feet (Building 234 area), and most of the overburden is a dense till. Overburden borings in all target areas identified in Section 3.3.2.1 to be advanced and sampled using conventional drilling techniques will be advanced to refusal (depth of most borings estimated to be approximately 20 feet) using hollow-stem auger or drive-and-wash drilling techniques with driven casing, to allow for 2-inch inside-diameter (ID) wells to be installed in selected

borings as described in Section 3.3.2.1. Continuous split-barrel samples will be retrieved at 2-foot intervals throughout the length of the boring using a 2-inch ID, stainless steel, split-barrel sampler, and all required information will be recorded on the boring log sheet (Appendix B) according to SOP GH-1.5. The 13 soil borings not to be completed as monitoring wells will be backfilled with bentonite to within 1 foot below ground surface (bgs), and capped with natural materials surrounding the boring.

A direct-push technology (DPT) drill machine will be used to install temporary soil-gas collection points. The soil-gas sample locations are depicted on Figure 3-2. The rationale for sample locations is summarized in Table 3-1. Table 3-2 lists the sample locations and Table 3-4 lists applicable QC samples. Table 3-5 lists the analytical methods that will be followed for analyses. Soil-gas samples will be collected at designated locations using Geoprobe's® Post-Run Tubing (PRT) system (GeoProbe, 1996). Approximately 1.25-inch diameter steel rods equipped with a PRT point holder and an expendable steel drive point will be driven through the vadose zone to a target depth of approximately 6 to 8 feet below ground surface (bgs).(Figure 3-7). Soil vapor will be purged from an interval estimated to be a minimum of 1 to 2 feet above the water table. Water level information will be collected from nearby overburden monitoring wells each day of soil vapor monitoring. If refusal is reached before the target depth of interest, up to two additional attempts will be made at each location. Soil-gas samples will not be collected within 1 day of any significant rainfall, when there is standing water on the ground surface at the sample location, or during any time when rain is falling.

3.3.2.3 Soil Samples Collected From Borings

Section 3.3.2.3 was amended by the addition of the following text.

Soil samples will be analyzed for VOCs, polycyclic aromatic hydrocarbons (PAHs), PCBs, target analyte list (TAL) metals, and total petroleum hydrocarbons (TPH) [gasoline range organics (GRO)/diesel range organics (DRO)] at selected locations. The analytical methods for these analyses are presented in Table 3-5. Sample numbers including quality control (QC) samples are summarized in Table 3-4. Soil project action levels (PALs) and project quantitation limits (PQLs) are summarized in Table 4-2.

As the split-barrel samplers are retrieved from the borehole, soil samples will be collected in accordance with SOP SA-1.3 (Appendix A). The split-barrel sampler will be opened, visually inspected, and scanned for VOCs using a PID according to SOP ME-12, or a FID according to SOP ME-15 (Appendix A). Grab samples will be collected from the most heavily contaminated portion of the split-barrel sampler, based on the initial screening results and/or visual observations. One sample aliquot will be used for jar headspace screening analysis (see procedures below), and a second aliquot will be collected according to the sampling procedures below for volatile organics samples and stored temporarily for possible laboratory

analysis of VOCs. The specific depth of the grab VOC samples within the 2-foot split-barrel sample will be recorded. The remainder of the soil interval will be kept for possible laboratory analyses for the remaining analytical parameters.

After reaching the total depth of the boring, sample intervals for laboratory analysis will be selected based on the jar headspace screening results and visual observations. The remaining contents of each selected interval will be uniformly mixed to provide a composite sample that will be split into aliquots for the remaining analyses.

The procedures for collection of the VOC grab samples, the jar headspace screening samples, the VOC percent moisture sample, and for the remaining sample analyses are presented below.

Sampling Procedure for VOC Soil Samples for Laboratory Analysis (Grab)

Each soil sample for VOC laboratory analysis will be collected using a cut syringe or equivalent device. Two reagent-grade water-preserved vials with septa caps and one methanol-preserved vial with a septa cap will be collected for VOCs. The water-preserved samples will be maintained at 4°C for up to 48 hours and either analyzed or frozen to below -7°C for up to 14 days. The methanol-preserved vials will be maintained at 4°C for up to 14 days. The following procedures should be followed for the soil VOC sample collection:

1. Label the following sample containers with the sample location number and a bottle letter such as A, B, etc.: two pre-tare weighed, 40-milliliter (mL) amber vials containing 5 mL of reagent-grade water and one 40-mL amber vial containing 5 mL of methanol for the VOC aliquots.
2. Collect approximately 5 grams of sample by coring or stabbing the soil with a 10-mL pre-cut syringe. If non-aqueous phase liquid (NAPL) is noted within the soils, then a reduced volume of approximately 1 to 2 grams will be collected as a separate "medium concentration" (NAPL) sample. Extrude the sample into one of the 40-mL VOC vials containing 5 mL of reagent-grade water or methanol. The soil must be immersed in the water or methanol; recollect the sample using a smaller volume, if necessary. Avoid touching the threads on the vial's neck, and loss of water or methanol by evaporation. Cap the vial and tap the vial against your hand several times to mix the sample.
3. Weigh each sample vial to the nearest 0.01 gram and record the weight on the field log sheet. Repeat the sample collection procedure for the remaining vials. Pack and ship samples to the

laboratory, including the field log sheet containing the sample weight information with the samples.

Field duplicate samples will also be collected: after filling the first set of VOC vials for a designated duplicate sample, a second set of vials will be filled from the same sampling interval to complete the second sample for the field duplicate pair.

For laboratory QC analyses, collect six reagent-grade, water-preserved vials for VOC analyses and three methanol-preserved vials of soil samples for VOC (medium level concentration) analyses.

Sampling Procedure for Percent Moisture Samples (for each VOC soil sample)

Fill one 2-oz. container with soil representing the same locations where the 40-mL VOC sample vials were collected. Every effort should be made to obtain the percent moisture soil aliquot as close as possible to the location where the VOC samples were collected.

Jar Headspace Screening Procedure (for VOCs)

For all soil sample intervals within each boring, an aliquot of soil will be collected for jar headspace screening to be conducted using a PID or FID. The procedure for jar headspace screening is provided below:

1. Collect sufficient soil representative of the sample interval to half-fill one clean 8-oz. glass jar. Quickly cover the jar with clean aluminum foil and apply the screw cap ring (without lid) to tightly seal the jar.
2. Vigorously shake the jar for 15 seconds. Allow headspace development for at least 10 minutes. Headspace development shall be performed within a vehicle or building that is temperature-controlled between 65°F and 80°F. Ambient temperatures during the screening tests will be recorded in the field notes.
3. After headspace development, quickly puncture the foil seal with the instrument probe and advance the probe tip to about one-half of the headspace depth. Exercise care to avoid the uptake of water droplets or soil particles.
4. Record the highest instrument reading as the jar headspace VOC concentration. The maximum response should occur between 2 to 5 seconds. Erratic meter response may occur with high

organic vapor concentrations or high moisture content. If erratic responses are obtained, stop the headspace screening and record as such.

Operation, maintenance, and calibration of the monitoring instrument will be performed in accordance with SOP ME-12 (Photovac 2020 PID) and ME-15 (Photovac Micro FID), as applicable. The SOPs are included in Appendix A.

Soil Sampling Procedure for Non-VOC Analytical Parameters

1. Record all required data on the boring log, which will also serve as the soil sample log sheet (Appendix B). Include the sampling equipment, sampling personnel, date, time, sample depth interval, and sample analyses. Record soil descriptions, depth of strata changes, observations of soil moisture, etc on the boring log. Field scientist or engineers shall record soil descriptions using the Unified Soil Classification System (ASTM D-2488-98).
2. Label appropriate sample jars with the sample location identifier, sampler's name, date, and applicable analysis.
3. Transfer the soil from the split-barrel sampler to a decontaminated, stainless steel bowl, using only decontaminated, stainless steel trowels, and homogenize the sample.
4. Remove any large particles such as gravel or artificial fill too large to be sent for analysis. Note the removal of material on the boring log.

If there is insufficient sample volume to fill all the required containers for the non-VOC analyses, an equal amount of materials from the intervals immediately above and below the selected sample interval may be used to supplement the composite sample, to ensure sufficient soil volume for all required analyses.

1. Fill the appropriate sample containers.
2. For field duplicate samples, after homogenization, fill one set of sample containers for the original sample and fill another set for the field duplicate sample.
3. Ensure that the samples are properly labeled, maintained in coolers with ice, and that the chain-of-custody (COC) procedures described in Section 4.3.2 are followed. Package and ship the sample coolers to the appropriate laboratory for overnight delivery.

4. Decontaminate the sampling equipment before reuse (see Section 3.6).

Care should be taken in handling all soil samples to ensure that the exterior of the sample containers are clean and free of soil before shipping to the laboratory.

Drill cuttings and excess soil samples will be contained in drums and stored onsite for characterization and disposal, as described in Section 3.4.

3.3.2.4 Groundwater Monitoring Well Installation

Section 3.3.2.4 was amended by the addition of the following text.

The drilling subcontractor will install overburden monitoring wells at seven boring locations (Figure 3-2a). The wells will be constructed according to SOP GH-2.8 (Appendix A), using 2-inch ID, Schedule 40 polyvinyl chloride (PVC) casing with threaded joints and 10-slot (0.010-inch) screened PVC threaded riser. In general, wells will be screened across intervals of interest identified by the field geologist, and are anticipated to be constructed with 10-foot screens. Wells to be screened to intersect the water table (shallow overburden) will have 10-foot screens installed with the bottom of the screen approximately 5 feet below the water table. This screen position is selected to allow for detection of potential light non-aqueous phase liquids (LNAPL), if present, and will allow for periodic water table fluctuations. In deeper overburden wells, a screen shorter than 10-feet may be used under certain conditions (e.g. to screen a potentially contaminated zone bracketed by less-transmissive zones).

The appropriate size filter pack and well screen slot size will be determined by the field geologist after review of the geologic materials in the screened zone of each well. At least two different filter pack materials will be available at the site during well installation activities.

Upon completion of the boring, the well screen and riser will be assembled with a silt-trap on the bottom and placed in the borehole. The selected filter pack will be installed in the annular space from the bottom of the hole to a depth of 2 to 4 feet above the top of the screen. To ensure proper placement of the filter pack within the screen interval (i.e., minimize voids and the potential for pack consolidation and grout contamination), the well may be surged using a surge block after the sand is delivered to the screen interval. The intent of this procedure is to minimize the collapse of soil that prevents the uniform distribution of sand. A bentonite seal, one to two feet in thickness, will then be placed immediately above the filter pack, and the remaining annular space will be backfilled with grout (a cement-bentonite mixture). If the top of the filter pack sand layer is less than 10 feet below ground surface, the driller may elect to backfill the borehole with hydrated bentonite instead of grout. Monitoring wells will be completed with

flush mounted casings in traffic areas and elevated (stick-up) protective casings other areas. A cement apron will be installed to hold the protective casing in place. The well installation will be documented on a monitoring well construction log sheet (Appendix B).

3.3.2.5 Well Development

Section 3.3.2.5 was amended by the addition of the following text.

After installation of the new groundwater monitoring wells and prior to groundwater sampling, the seven newly installed monitoring wells and five existing monitoring wells (Figure 3-2a) will be developed by surging and pumping. For newly installed wells, development will be conducted no sooner than 3 days after installation to allow seals to set. Proper well development is necessary to remove silt and other fine material from the well and filter pack and to establish a good hydraulic connection with the screened formation.

Development will be conducted according to the procedures in SOP GH-2-8 (Appendix A). This will include alternately surging the well with a surge block and removing water from the well using submersible pumps operating at various flow rates or by bailing. Measurements of pH, specific conductance, temperature, dissolved oxygen, and turbidity will be periodically collected during development and recorded on well development data sheets (Appendix B). The pH, specific conductance, and temperature will be measured with one water quality instrument. Turbidity will be measured separately with a nephelometer. The instruments will be calibrated according to the manufacturer's specifications as described in Section 3.1.10. Well development will proceed until the extracted water is clear, up to a maximum of 4 hours. If purged water is not visually clear after 4 hours, this will be noted on the well development data sheet. All well development results will be evaluated to determine if any of the wells have high turbidity and/or low-flow problems. If applicable, the lead hydrogeologist will be consulted to address potential issues.

Purged groundwater will be captured in drums and stored onsite for characterization and disposal as described in Section 3.4.

Groundwater level measurement and sampling activities will not be conducted before a minimum of 48 hours after development to allow water levels in the wells to stabilize.

3.3.2.6 Groundwater Elevation Survey

No changes were made to Section 3.3.2.6 in this Work Plan Addendum.

3.3.2.7 Hydraulic Conductivity Testing

No changes were made to Section 3.3.2.7 in this Work Plan Addendum.

3.3.2.8 Groundwater Sample Collection

Section 3.3.2.8 was amended by the addition of the following text.

Groundwater samples for laboratory analysis will be collected from seven newly-installed and developed monitoring wells and from five existing monitoring wells (Figure 3-2a). Groundwater samples collected from all monitoring wells will be analyzed for VOCs, and selected samples (MW08, MW204, MW218, and MW219, as indicated in Table 3-2) will be analyzed for PAHs and for total and dissolved Target Analyte List (TAL) metals (i.e. both unfiltered and filtered metals samples will be collected, the filtered metals samples using a 0.45 micron in-line filter). The analytical methods as well as required sample containers, preservatives, and holding times for each analytical group are presented in Tables 3-5 and 3-3, respectively. In addition, QC samples including field duplicates, rinsate blanks, field blanks, and laboratory QC will be collected for analysis as part of the groundwater investigation. One rinsate blank for metals analysis will be collected from the filtration system. QC samples are summarized in Table 3-4 and are described further in Section 4.1.3. Table 4-1 lists target analytes with associated PALs and PQLs that must be met by the laboratory.

Prior to initiating the purging process, monitoring wells will be checked for the presence of NAPL using an oil-water interface probe. If NAPL is detected, a sample of the NAPL will be collected. All monitoring wells will be sampled using low stress (low-flow) purging and sampling procedures according to the GW-001 EPA Region I low-flow SOP (Appendix A). This method emphasizes the need to minimize water-level drawdown and groundwater pumping rates in order to collect samples with minimal alterations to groundwater chemistry.

Dedicated tubing will be used for each monitoring well to minimize cross-contamination between monitoring well during well purging, water level drawdown and flow rate will be recorded on low-flow groundwater sample log sheets (Appendix B). Groundwater will be pumped through a flow-through cell which will allow measurements of pH, specific conductance, temperature, dissolved oxygen, (DO) oxidation-reduction potential (ORP), and salinity, which will be recorded. Turbidity will be measured separately with a nephelometer. The instruments will be calibrated according to the manufacturer's specifications. Purging is considered complete and sampling may begin when all parameters have

stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at 3- to 5-minute intervals, are within the following limits:

- Turbidity (less than 5 Nephelometric Turbidity Units (NTU); or if turbidity greater than 5 NTU, readings within + or – 10%);
- DO (+ or – 10% for values greater than 2 mg/L; within 0.5 mg/L for values less than 2 mg/L);
- Specific conductance (+ or – 3%);
- Temperature (+ or – 3%);
- pH (+ or – 0.1 units);
- ORP (\pm 10 millivolts); and
- Drawdown (no more than 0.3 feet).

All pertinent sampling information will be recorded on the low-flow groundwater sample log sheet, with a general summary and any special circumstances recorded in the field logbook. Salinity results for each sample will also be noted on the chain-of-custody form (Appendix B) in order to aid the analytical laboratory in establishing dilution requirements for metals analysis, where salinity could present an interference concern.

Purged groundwater will be captured in drums and stored onsite for characterization and disposal as described in Section 3.4.

3.3.2.9 Soil-Gas Sample Collection

Soil-gas samples for VOCs analysis will be collected from four locations (co-located with monitoring wells), to be advanced by hand or using DPT drilling techniques. Table 3-2 lists the sample locations and Table 3-4 lists applicable QC samples. Table 3-5 lists the analytical method to be followed for the VOC analysis.

After installation, the vapor probe will be sealed to prevent short circuiting from the atmosphere to the probe. A leak test will be conducted using helium gas to verify the integrity of the seal of the soil vapor probe. The probe volume (volume of the vapor probe and tubing) will be calculated and three probe volumes will eventually be purged using a vacuum pump. The pump will be calibrated to a rate matching that at which the sample will later be collected, i.e., approximately 200 ml/min, to ensure collection of representative samples. The purged volume will be collected in PE gas bags. A PID will be used to screen the soil vapor in the gas for total VOCs. A helium detector will be used to evaluate the seal. Passive, grab samples will be collected using 100 percent laboratory-certified clean 6-liter Summa™ canisters.

After the target depth has been reached, the following steps will be taken to set-up for soil-gas sampling (see also Figure 3-8).

1. Cut enough plastic sheeting to cover an area approximately 2 feet from the rod in all directions. Weigh down the edges of the plastic sheeting. Seal the plastic sheeting around the rod with modeling clay.
2. Fasten a PRT adapter to the end of a length of FEP tubing. Insert the adapter end of the tubing through the hollow rod until it hits bottom, which is the top of the expendable point holder. Keep at least 4 feet of tubing extending out of the rod above ground. Grasp the tubing and apply some downward pressure while rotating it in a counter-clockwise direction to engage the adapter threads with the expendable point holder. Gently tug on the tubing to confirm engagement of the threads. Seal the top-side of the rod and the tubing with a small amount of modeling clay.
3. Using a jack, retract the probe rods approximately 6 to 12 inches to disengage the expendable steel point and allow soil gas to enter the system. In order to prevent the possible flow of atmospheric air down around the rod, re-seal the plastic sheeting to the rod with additional clay. Place a plate-style dumbbell weight (up to 5-pounds) over the rod and onto the plastic sheeting. Cover the weight with clay and add a second weight. Cover the second weight with more clay.
4. In preparation for a leak test, encapsulate the probe rods with a plastic bucket or equivalent device, making sure to pull the tubing through a hole on the topside of the bucket before securing the bucket to the polyethylene sheeting with double-stick tape.
5. Seal the interface between the FEP tubing and the top of the bucket with modeling clay. Place additional weights on top of the bucket and cover with more clay, as needed. Attach a three-way switching valve (tee, preferably stainless steel) to the top of the FEP tubing on the outside of the bucket with a ferrule. Connect tubing to each side of the switching valve with more ferrules. One leg of the tubing will be attached to a calibrated vacuum pump (used for purging the probe of standing dead air), and the other leg will be attached to a 6-liter SUMMA™ canister outfitted with an in-line particulate filter and a vacuum gauge. Make certain all valves are closed. If numbered, record the gauge number with the appropriate SUMMA™ canister number on a log sheet. In addition, record weather conditions, barometric pressure, and any pertinent observations, such as odors on field log sheets.

6. Using an airline connected to a length of plastic tubing fitted with a ball valve, slowly open the helium valve and then the ball valve. Slowly fill the bucket with helium and monitor breakthrough around the base of the bucket using a helium detector. Readings should be greater than 10 percent (100,000 parts per million). Helium on the outside of the bucket signifies that all of the air inside the bucket has been displaced. Once done, close both the helium and ball valves.
7. Open the switching valve to the vacuum pump, turn-on the pump, and purge three probe volumes into a 3-liter gas bag at a flow rate of approximately 200 ml/min. Measure organic vapor levels inside the bag with a PID. Attach a helium detector to the bag to evaluate seal issues. If more than 1 percent (10,000 ppm) helium is detected in the gas bag, the seal needs to be re-adjusted. Repeat process until levels are acceptable.
8. After purging is complete and testing establishes that all connections are sealed, turn the switching valve to the off position, evacuate the leg of the tubing connected to the vacuum pump, then shut-down the vacuum pump. Wait 1 hour for equilibration. After 1-hour, turn the switching valve toward the 6-liter SUMMA™ canister. Next open the valve on the 6-liter SUMMA™ canister. Record the initial canister pressure, the time sampling begins, the time sampling ends, and record the final pressure. Samples will be collected as grab samples so actual sampling time may only be minutes depending on the soil material. Stop collecting the sample by closing the SUMMA™ canister valve. The canister should have a small amount of vacuum (approximately 5 psi mercury) remaining. This will provide a way to assess if the canister leaks while in transit to the laboratory. Field duplicate samples will be collected using a T-fitting to properly split the sample between SUMMA™ canisters.
9. After the SUMMA™ canister is closed, disconnect the tubing from the canister or gauge. Remove in-line particulate filter and vacuum gauge from the canister. Cover valve with one of the brass caps supplied by the laboratory. Complete sample labels and chain-of-custody. Confirm that the information on each sample label exactly matches the sample designation on the chain-of-custody. Attach sample labels to each canister and complete required information on any other attached tag, as needed. Package the canister, gauge and any other returnable parts in the shipping container supplied by the laboratory for return shipment. Include all appropriate forms in shipping containers. The SUMMA™ canister does not require preservation with ice during shipment. Once all samples have been collected, secure each container and ship via overnight courier to the laboratory. Verify laboratory receipt as soon as possible.
10. After sample collection, the bucket set-up will be broken down. Tubing will be released from the adapter at the bottom of the rod and disposed of as refuse. The probe rods will then be retrieved

from the ground and the expendable point holder with the PRT adapter recovered. Prior to the next use, the probe rods and equipment will be scrubbed with a detergent (Liquinox) solution, rinsed with potable water, and then rinsed with distilled water. The temporary monitoring stations will be backfilled with bentonite and covered with cold-patch to match the surrounding asphalt surface. All sample locations will be recorded with a GPS unit.

3.3.3 Tasks 5 and 6: Underground Drainage Systems Sampling

No changes were made to Section 3.3.3 in this Work Plan Addendum.

3.3.3.1 Task 5: Catch Basin and Sump Sampling

Section 3.3.3.1 was amended by the addition of the following text.

Sump 234-4, which has been filled with sand, will be investigated for the presence of a concrete bottom. A drill rig will advance a boring into the sump. The boring split spoon will then be inspected for the presence of concrete. If concrete is not detected, a second split spoon will be advanced to a sample interval below the historic bottom depth of the sump. One soil sample will be collected from this interval directly beneath the sump bottom.

3.3.3.2 Task 6: Floor Drain Discharge Area Sampling

No changes were made to Section 3.3.3.2 in this Work Plan Addendum.

3.4 INVESTIGATION-DERIVED WASTE (IDW)

Section 3.4 was amended by the addition of the following text.

It is anticipated that the following waste materials will be generated during the field investigation:

- Decontamination fluids;
- Used personal protective equipment (PPE);
- Used disposable sampling equipment;
- Drill cuttings and excess soil samples; and
- Well purge water

IDW will be managed as described below, in accordance with RIDEM regulations.

TtNUS will be responsible for arranging the removal and proper disposal of all accumulated waste materials following completion of the field investigation. Manifests and shipping papers will be signed by a representative of the NAVSTA waste management office. Disposal will be arranged with licensed waste haulers and approved receiving facilities. Characterization analyses will be conducted by the waste disposal subcontractor.

3.4.1 Solid Wastes

Section 3.4.1 was amended by the addition of the following text.

Used PPE, such as sampling gloves, Tyvek coveralls, paper towels, or other materials will be bagged and sealed prior to disposal as general refuse. Used disposable sampling equipment, which generally has minor contamination, will be disposed of with the PPE as general refuse. If PPE or disposable equipment is grossly contaminated, it will be segregated, labeled, and containerized in 55 gallon drums, staged as "contaminated material" in a secure area designated by the Navy and Tetra Tech. If off-site transport is required, TtNUS will arrange with a licensed waste hauler for additional sampling of the PPE (if required), transportation, and disposal at a licensed receiving facility.

3.4.2 Soil Wastes

Section 3.4.2 was amended by the addition of the following text.

Drill cuttings and excess soil samples will be contained in 55-gallon drums or bulk containers and staged at a secure area. Any drums used for storage will be clearly marked with a grease pencil or other water-resistant marker to indicate the borehole from which the cuttings were removed. The word "soil" will be used to differentiate between drummed cuttings and from drummed well purge water or well development water. The drums or bulk containers will be staged in an orderly fashion, with proper spacing, in an area designated by the Navy. After the analytical data from the soil sampling program have been received and evaluated, a determination will be made as to the proper disposal method for the contained soils. If off-site transport is required, TtNUS will arrange with a licensed waste hauler for additional sampling of the soil (if required), transportation, and disposal at a licensed receiving facility.

3.4.3 Sandblast Material

No changes were made to Section 3.4.3 in this Work Plan Addendum.

3.4.4 Aqueous Wastes

Section 3.4.4 was amended by the addition of the following text.

Decontamination fluids consisting of phosphate-free detergent wash water and rinse water will be containerized in 55 gallon drums or bulk containers.

Water generated during well development and well purging and sampling will be collected and transferred for staging in 55-gallon drums or bulk containers. The water will be staged with the other IDW, pending receipt of analytical results. The drums and bulk containers will be clearly marked with a grease pencil or other water-resistant marker to indicate "water" and the associated well(s). After the analytical data from the groundwater sampling program have been received and evaluated, a determination will be made as to the proper disposal method for the contained water. If off-site transport is required, TtNUS will arrange with a licensed waste hauler for additional sampling of the water (if required), transportation, and disposal at a licensed receiving facility.

3.5 TASK 7: SURVEY

Section 3.5 was amended by the addition of the following text.

After completion of sample collection activities, the coordinates of all soil borings, monitoring wells, and other pertinent features will be determined by a Rhode Island registered land surveyor. The coordinates of the features will be incorporated into the NAVSTA Newport GIS database and used for site mapping.

Surveying activities will establish the horizontal coordinates of borings and monitoring wells and will establish ground surface elevations at all investigation locations. At monitoring wells, additional elevation measurements will also be taken at the top of the inner PVC casing and the top of the protective steel casing. All vertical measurements will be surveyed in United States Geological Survey (USGS) National Geodetic Vertical Datum of 1929 (NGVD 1929) coordinates, in feet. All horizontal measurements will be in Rhode Island State Plane coordinates, using 1983 North American Datum (NAD 1983), in feet.

Horizontal locations will be measured to the nearest 0.1 foot NAD 1983. Vertical positions of well risers will be measured to the nearest 0.01 foot NVGD 1929. Vertical and horizontal control will be brought to the site using local benchmark information and temporary benchmarks will be established as needed.

The subcontractor deliverable will include a base map of the site, showing existing permanent features as well as sample stations (borings, wells, and other stations of interest).

3.6 DECONTAMINATION PROCEDURES

Section 3.6 was amended by the addition of the following text.

All non-disposable equipment that comes in contact with the sample medium will be decontaminated to prevent cross-contamination between sampling points. This includes equipment such as stainless steel bowls, scoops, as well as heavy equipment. Personnel decontamination is discussed in the health and safety plan (HASp).

Water level indicators will be sprayed with a liquid detergent solution, wiped with clean paper towels, and rinsed with deionized water in between every well.

Standard Operating Procedures for decontamination are addressed in the TtNUS SOP SA-7.1 (Appendix A). The following sequence will be used to decontaminate equipment and tools to be used to collect soil samples:

- Remove gross contamination by scrubbing with potable water,
- Scrub with potable water/liquinox,
- Rinse with potable water,
- Rinse with deionized water,
- Rinse with 2-propanol,
- Rinse with deionized water,
- Air dry (to extent possible), and
- Wrap with aluminum foil, dull side toward equipment.

All heavy equipment, including the drilling rig, rods and augers, and other downhole equipment used during site investigation activities will be decontaminated prior to beginning work and between all boreholes, using a high-pressure steam wash. The water to be used during steam-cleaning will be from a potable source. For the drive-and-wash drilling method, the wash tub will also be decontaminated between boreholes.

3.7 TASK 8: EVALUATION OF CULTURAL AND ECOLOGICAL SETTINGS

No changes were made to Section 3.7 in this Work Plan Addendum.

3.7.1 Cultural Setting

No changes were made to Section 3.7.1 in this Work Plan Addendum.

3.7.2 Off-Shore Ecological Setting

No changes were made to Section 3.7.2 in this Work Plan Addendum.

3.7.3 On-Shore Ecological Setting

No changes were made to Section 3.7.3 in this Work Plan Addendum.

3.7.3.1 Characterization of Habitats

No changes were made to Section 3.7.3.1 in this Work Plan Addendum.

3.7.3.2 Literature Review

No changes were made to Section 3.7.3.2 in this Work Plan Addendum.

3.7.3.3 Review of Threatened And Endangered Species

No changes were made to Section 3.7.3.3 in this Work Plan Addendum.

3.7.3.4 Field Assessments

No changes were made to Section 3.7.3.4 in this Work Plan Addendum.

3.7.3.5 Data Products

No changes were made to Section 3.7.3.5 in this Work Plan Addendum.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Section 4.0 was amended by the addition of the following text.

The correct implementation of the planned QA/QC procedures described in this work plan addendum will be assessed to ensure that the activities were performed as required. Scheduled assessments will be performed for the field and laboratory activities as described in the following sections.

Pertinent SOPs are included in this Work Plan Addendum as Appendix A. These SOPs include, but are not limited to:

<u>TtNUS SOP</u>	<u>DESCRIPTION</u>
CT-04	Sample Nomenclature
GH-1.1	Site Reconnaissance
GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement
GH-1.3	Soil and Rock Drilling Methods
GH-1.5	Borehole and Sample Logging
GH-2.5	Groundwater Contour Maps and Flow Determinations
GH-2.8	Groundwater Monitoring Well Installation
HS-1.0	Utility Locating and Excavation Clearance
SA-1.3	Soil Sampling
SA-6.1	Non-Radiological Sample Handling
SA-6.3	Field Documentation
SA-7.1	Decontamination of Field Equipment and Waste Handling

<u>EPA SOP</u>	<u>DESCRIPTION</u>
EPA GW-0001	USEPA Region I – Low Stress Purging and Sampling Procedure

4.1 QUALITY ASSURANCE OBJECTIVES

Section 4.1 was amended by the addition of the following text.

The objectives of the sampling are to provide data that are sufficient in quantity and quality to confirm that removal activities successfully addressed contaminants present at the on-shore portion of Derecktor Shipyard, and to allow appropriate revision/update of the original SASE human health risk assessment. To accomplish these objectives, the following samples will be collected:

- Laboratory-analyzed samples for VOC, PAH, PCB, metals, and TPH (GRO/DRO) parameters (soil, soil-gas, and groundwater). Analyses will be specific to selected locations and media as described in Table 3-2.

4.1.1 Data Quality Objectives

Section 4.1.1 has been amended by the addition of the following text.

Project Quality Objectives (PQOs) define the type, quantity, and quality of data that are needed to answer specific environmental questions and support proper environmental decisions. To develop the PQOs for this investigation, the data quality objectives (DQOs) planning process described in the EPA *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (U.S. EPA, 2006a) is used. The EPA QA/G-4 document suggests seven steps to be followed to develop project DQOs (performance and acceptance criteria) that clarify the investigation objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions that mitigate risks or address threats to the environment.

The intended use of the data resulting from the investigation is the primary determining factor in defining the DQOs for that data. To be certain that the data are consistent with the goals of the investigation, the seven steps of defining DQOs are presented in this section.

Define Problem

The SASE for the On-Shore Derecktor Shipyard site identified several areas where contaminants exceeded regulatory criteria; therefore, several removal actions were conducted in these areas to remove elevated levels of contaminants. The Project Team, including Navy, EPA, and RIDEM, has identified several areas where it is suspected that contaminants are still present at concentrations above regulatory criteria. Additional sampling is required to confirm if any remaining contamination exists at levels exceeding comparison criteria before a “no further action” status can be granted for the site. In addition, a focused human health risk assessment will be conducted using applicable existing data and newly collected data.

Inputs to the Decision

Inputs to the decision are chemical data and project action limits. Project Action Limits are the lowest of the applicable comparison criteria (risk-based and/or regulatory criteria) and are used to determine the analytical sensitivity required for the use of the data throughout the CERCLA process. Chemical-specific PALs for groundwater, soil, and soil-gas samples are presented in Tables 4-1, 4-2, and 4-3, respectively.

The following groundwater data are needed to resolve the problem identified above:

- VOC concentrations in groundwater from monitoring wells located in the Northern Waterfront area; and
- VOC, PAH, and TAL metal (total and dissolved) concentrations in groundwater from monitoring wells located in the Building 234 area, the Building 42 area, and the Huts 1 & 2 area.

These analytical groups were selected based on the analytical results from the SASE and analytical results from the various removal actions. Comparison criteria to be used for groundwater analytical results will be the lower of: (1) the EPA Maximum Contaminant Levels (MCLs) for drinking water (U.S. EPA, 2010) or (2) the RIDEM Groundwater Quality Standards for GA aquifers (RIDEM, 2005).

The following soil data are needed to resolve the problem identified above:

- VOC, PAH, TAL metals, and TPH (GRO/DRO) concentrations in soil from sample stations located in the Building 234 area and the Huts 1 & 2 area;
- PAH and metals concentrations in soil from sample stations located in the Southern Waterfront Area;
- PAH, PCB, TAL metals, and TPH (GRO/DRO) concentrations in soil from samples located in the Building 6/Test Pit 14 area; and
- PCB concentrations in soil from samples located in the former transformer bank near Building 6.

These analytical groups were selected based on the analytical results from the SASE and analytical results from the various removal actions. Comparison criteria to be used for soil analytical results will be the lower of: (1) U.S. Environmental Protection Agency (EPA) Regional Screening Level (RSLs) for Residential Soil (EPA, 2010), and (2) the RIDEM Residential Direct Exposure Criteria (DEC) (RIDEM, 2004) as appropriate for each step in the CERCLA process..

The following soil-gas data are needed to resolve the problem identified above:

- VOC concentrations in soil-gas from sample stations located in the Northern Waterfront Area. These locations will be co-located with existing monitoring wells MW02, MW03, MW11, and MW12, where VOCs were previously detected in groundwater samples collected as part of the SASE.

Comparison criteria to be used for soil-gas analytical results will be the U.S. EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway for Groundwater and Soils (EPA, 2002) Target Deep Soil Gas Concentrations.

Boundaries of the Study

The media to be investigated, as identified in the problem definition (groundwater, soil, and soil-gas), are those media that were or could have been contaminated by a chemical release, or to which released chemicals may have migrated.

The groundwater population of interest is the overburden aquifer underlying several areas in the On-Shore Derecktor site, including the areas of Building 234, Building 42, Huts 1 and 2, Test Pit 25, and the Northern Waterfront Area. In the Building 234 area, an existing monitoring well (MW-08, screened from 6.5 feet to 11.5 feet bgs) will be used to sample the shallow overburden aquifer. In the Building 42 area, Huts 1 and 2 area, and Test Pit 25 area, new monitoring wells will be installed with screens placed in the shallow overburden, to intersect the water table, where lighter-than-water organic chemicals (floaters) may accumulate. In the Northern Waterfront Area where the SASE reported VOC detections, well screens will be installed deeper in the overburden, above the bedrock interface, where denser, heavier-than-water organic chemicals (sinkers) would be expected within the groundwater column. Groundwater at the eastern perimeter of the Northern Waterfront Area will also be investigated to determine if potential upgradient sources may be impacting the site. Total and dissolved metals will be analyzed to evaluate possible high turbidity groundwater impacts on analytical results.

The soil population of interest is within several areas of the On-Shore Derecktor site area, which include Building 234, Building 6/Test Pit 14, Huts 1 and 2, Test Pit 16, and the Southern Waterfront Area. In the Building 234 area, the soil of interest includes the soil present beneath the bottom of Sump 234-4. The Building 6/Test Pit 14 area soil of interest includes soil located directly above bedrock, to confirm successful removal of PCB-contaminated soil in a previous removal action. The soil of interest in the Huts 1 and 2 and Test Pit 16 areas include surficial and subsurface soils. The Southern Waterfront Area soil of interest includes soil located beneath the topsoil layer.

The soil-gas area of interest is the Northern Waterfront Area, where VOCs were detected in groundwater during the SASE. The analytical results from soil-gas samples will help evaluate potential risks that could arise if buildings were to be constructed over areas of subsurface contamination. If buildings are constructed in the Northern Waterfront Area, then the project team will assess the need for indoor air sampling. Soil-gas samples will be collected immediately above the groundwater table to obtain samples that will reflect the potential vadose zone concentrations beneath a future building foundation. Groundwater in the Northern Waterfront Area is estimated to range from 6 to 10 feet bgs. (In the event of a significant rain event, soil-gas sampling would be postponed to allow equilibration of the groundwater table, in order to avoid potentially low-biased results.) For other media, there are no physical constraints on the timing for data collection; however, the Project Team proposes implementing the data collection activities at the earliest reasonable time.

Analytical Approach

The chemical data will be used to make project decisions using the following decision rule:

1. In the targeted sampling areas at the site, if target analyte concentrations in any groundwater, soil-gas, or soil samples exceed the applicable comparison criteria, the Project Team will determine whether a removal action or a Remedial Investigation (RI) and a baseline risk assessment are required. The tendency will be to conduct a removal action if localized areas of relatively high (compared to other site data) concentrations of contaminants are identified that can be relatively easily removed, or if an acute risk is anticipated from one or more areas at the site. If any target analyte concentration exceeds its comparison criteria in any sample, but a removal action is not warranted, the Project Team may recommend a baseline risk assessment (RI). If all target analyte concentrations in all samples are less than their comparison criteria, a recommendation of "no further action" will be made by the Project Team.

Performance Criteria

Measured concentrations of target analytes representing locations biased toward potential contamination will be compared to criteria. The Project Team will use the results of this investigation to determine whether the amount, type, and quality of data collected are sufficient to support the attainment of project objectives. This will involve an evaluation of contaminant concentrations, spatial contamination patterns, and an evaluation of uncertainty for contaminants that have criteria which are less than the MDLs, to ensure that contaminants are likely to have been detected, if present.

Results of data validation (i.e., data qualifications) will be considered in these evaluations, with a tendency to recommend additional investigation increasing with decreasing data quality. Data validation

criteria are presented in Section 4.10.2. The data usability assessment process is described in more detail in Section 4.1.2.

Sampling Design

The DQO process presented in the EPA QA/G-4 document describes the use of various approaches for developing a data set. These approaches are based on contaminant distributions and outputs of the previous steps. The sampling design for the efforts covered in this work plan addendum was based on previous sample data and the historical uses at locations of the site, as described in Section 2.6.1.

Specifics of the data collection design, rationale, and procedures are presented in Section 3.0.

4.1.2 PARCC Parameters

Section 4.1.2 has been amended by the addition of the following text.

The parameters that indicate the quality of the data needed in order to support the environmental decisions for this project are referred to as data quality indicators. Data quality indicators to be met during this project, include precision, accuracy/bias, representativeness, comparability, sensitivity (quantitation limits), and completeness (PARCC parameters). These indicator parameters will be assessed based on pre-established measurement performance criteria to determine if the project objectives were met. The measurement performance criteria and associated data quality indicators for the field sampling and laboratory QC samples are presented by analysis in Tables 4-4 through 4-10. Acceptance criteria for laboratory analytical instrument calibration and for laboratory instrument maintenance, testing, and inspection are presented in Tables 4-11 and 4-12. Field equipment calibration is discussed in Section 4.4.

The overall quality assurance objective is to develop and implement procedures for field sampling, chain of custody, laboratory analysis, and reporting, that will provide results that meet the data quality objectives. Specific procedures for sampling, chain-of-custody, instrument calibration, laboratory analysis, reporting of data, internal quality control audits, preventative maintenance of field equipment, and corrective action will be followed.

4.1.3 Quality Control Samples

No changes were made to Section 4.1.3 in this Work Plan Addendum.

4.1.3.1 Field Duplicates

Section 4.1.3.1 has been amended by the addition of the following text. Field QC samples are summarized in table 3-4.

Field duplicates are used to assess the combined field and laboratory precision. The results are anticipated to exhibit more variability than laboratory duplicates, which measure only laboratory precision. Field duplicates for solid matrices will be collected by splitting a well-homogenized sample into two representative field samples. Field duplicate samples for soil-gas will be collected by using a T-fitting to properly split the sample between SUMMA™ canisters. Field samples for water matrices will be collected by alternately filling sample bottles from the source being sampled. Field duplicate samples will be collected at a frequency of 10 percent per sample matrix for each chemical parameter. Field duplicate samples provide precision information regarding sample homogeneity, handling, shipping, storing, preparation, and analysis. Field duplicate samples will be shipped as “blind” samples to the laboratories.

4.1.3.2 Rinsate Blanks

Section 4.1.3.2 has been amended by the addition of the following text.

Equipment rinsate blanks are obtained under representative field conditions by running analyte-free deionized/distilled water (provided by the laboratory) through sample collection equipment after decontamination and prior to use, and placing it in the appropriate pre-preserved sample containers for analysis. These samples are used to assess the effectiveness of decontamination procedures. Rinsate blanks will be collected at a frequency of 1 for every 20 or fewer investigative samples, for each piece of decontaminated equipment. Equipment rinsate blanks should contain no target analytes above the PQL.

4.1.3.3 Field Blanks

Section 4.1.3.3 has been amended by the addition of the following text.

Field blanks are used to determine the quality of the source water used for decontamination. These samples will consist of the contaminant-free deionized water used in the last step of decontamination. At a minimum, field blanks will be prepared at the rate of one per sampling event or one per source.

4.1.3.4 Trip Blanks

Section 4.1.3.4 has been amended by the addition of the following text.

Trip blanks are used to assess the potential for cross-contamination during shipment and storage. Trip blanks are used for VOCs and GRO. For groundwater samples, aqueous trip blanks will be prepared by filling a 40-ml VOC vial with VOC-free water, and preserving with hydrochloric acid to a pH below 2. Trip blanks associated with soil samples for VOC analysis will consist of two VOC vials containing 5-ml of VOC-free reagent water and one vial containing 5 ml of methanol. GRO trip blank will consist of one VOC vial containing 5 ml of methanol. Trip blanks will be prepared at the rate of one per shipment of VOC samples. No trip blanks will be sent with the SUMMA canisters.

4.1.3.5 Matrix Spike/Matrix Spike Duplicates (MS/MSD)

Section 4.1.3.5 has been amended by the addition of the following text.

Laboratory matrix spikes for organic analyses are performed in duplicate and are hereinafter referred to as MS/MSD samples. A single matrix spike (MS) analysis will be performed for inorganic parameters. Laboratory duplicates are used to assess laboratory precision for inorganic parameters. Matrix spike and laboratory duplicate analyses will be performed at a frequency of one for every 20 or fewer investigative samples, per sample matrix, as indicated in Table 3-4 (Lab QC column). No extra volume of sample is required for soil samples. For groundwater samples, triple volume of groundwater should be collected for laboratory MS/MSD analysis.

4.2 SAMPLING PROCEDURES

Section 4.2 has been amended by the addition of the following text.

Field sampling will be conducted in accordance with Section 3.0 of this document and the Tetra Tech SOPs presented in Appendix A. Allowable holding times and preservation requirements are listed in Table 3-3.

4.3 SAMPLE DESIGNATION AND CUSTODY

No changes were made to Section 4.3 in this Work Plan Addendum.

4.3.1 Sample Numbering

Section 4.3.1 has been amended by the addition of the following text.

Each sample to be collected will be assigned a unique sample-tracking number to be used to catalog the associated results. The sample-tracking number will consist of alpha-numeric characters identifying the

site, sample medium, location, and depth or date. Any other pertinent information regarding sample identification will be recorded on the sample log sheets or in the field logbooks.

The alpha-numeric (A-N) coding to be used in the sample-tracking system is detailed below and in the subsequent definitions.

AAA	-	AANNN (or AANN for some existing wells)	-	NNNN
(Site ID)	-	(Medium & Location)	-	(Depth or Date)

Site identifier: "DSY" for Derecktor Shipyard

Medium identifier: "MW" for groundwater samples,
"SB" for soil samples, and
"SG" for soil-gas samples

Sample location identifier: The sample location identifier will be numeric characters within the portion of the sample-tracking number that represent the assigned location number, either the monitoring well number, soil boring number, or soil vapor location number. The locations to be advanced during the work conducted under this work plan addendum are assigned a "200-series" location number, beginning with "201". (Existing wells to be sampled have different location identifiers).

Depth/Date: For soil sample locations, this portion of the sample-tracking number will represent the depth in feet below ground surface from which the sample was collected; e.g., for soil samples collected from 2 to 4 feet bgs, this portion of the sample tracking number will be "0204".

For groundwater samples collected from monitoring wells, this portion of the sample-tracking number will represent the month and year (MMYY) the sample was collected.

For soil-vapor samples, this portion of the sample-tracking number will represent the month and year (MMYY) the sample was collected.

For example, a soil sample from soil boring SB201 from the 10 to 12 feet interval will be labeled DSY-SB201- 1012. A groundwater sample from this location collected in October 2010 will be labeled DSY-MW201-1010.

Quality Control Samples QC samples collected during the field work program will use the same coding system as the environmental samples. Field QC sample types are presented in Section 3.4. Field QC designations will conform to the following formats:

- **Field Duplicates:** Blind field duplicate samples will be designated such that the location designation will be replaced with a sequential "-DUP" label, followed by the date (MMDDYY). The sample log sheet will note which sample location the duplicate was collected from. For example the first groundwater field duplicate sample collected on October 17, 2010 will be labeled DSY-MW-DUP01-101710 and the second field duplicate will be DSY-MW-DUP02-101710. The first soil field duplicate collected will be labeled DSY-SB-DUP01-101710.
- **Field Blanks:** Field blank sample identifiers will consist of the medium, a sequential "FB" label, and the date (MMDDYY). Example: DSY-SB-FB01-101710.
- **Rinsate Blanks:** Rinsate blank sample identifiers will consist of the medium, a sequential "RB" label, and the date (MMDDYY). Example: DSY-SB-RB01-101710.

Laboratory QC samples (matrix spike and laboratory duplicate samples) have no separate sample identifier codes, but are noted on the chain-of-custody record and sample log sheet.

4.3.2 Sample Chain-of-Custody

Section 4.3.2 has been amended by the addition of the following text.

Custody of samples must be maintained and documented at all times. To ensure the integrity of a sample from collection through analysis, an accurate written record is necessary to trace the possession and handling of the sample. This documentation is referred to as the "chain-of-custody" form. Chain-of-custody begins when samples are collected in the field, and is maintained by storing the samples in secure areas until custody can be passed on. All samples will be accompanied by a chain-of-custody form that will describe the sample identifiers, the analytical parameters, and the persons who are responsible for the sample integrity.

Following collection, samples will be placed on ice in a secure cooler and attended by TtNUS personnel or placed in locked vehicles or designated storage areas until analysis or shipment to an off-site laboratory. Chain-of-custody procedures are described in further detail in the following TtNUS SOPs (presented in Appendix A):

- SA-6.3 Field Documentation
- SA-6.1 Non-Radiological Sample Handling

The samples will be shipped to the laboratories in coolers packed with ice and bubble wrap, or equivalent packing material, to cushion the samples to prevent breakage and to maintain the required temperature for the samples. A container filled with water and labeled "temperature blank" will be included in each cooler. The temperature of this blank will be measured by the laboratory upon sample receipt to verify acceptable sample preservation temperature. The coolers will be taped and sealed with a signed custody seal to ensure the chain-of-custody is maintained. The chain-of-custody forms are shipped to the laboratory with the samples.

Samples will be shipped to the laboratories by an overnight courier to ensure that maximum sample holding times are not exceeded. The maximum allowable sample holding times before sample extraction, digestion, or analysis are presented in Table 3-3 . Saturday deliveries will be coordinated with the laboratory. This table also lists the sample containers, chemical preservatives, and temperature condition requirements to maintain the integrity of the sample.

Each sample collected will be assigned a unique sampling-tracking number, as described in Section 4.3.1. The sample number, sample collection date and time, person collecting the sample, and a list of the sample analyses to be performed will be recorded on each container, and also on the chain-of-custody form. The chain-of-custody form is a two-part form: the original accompanies the samples to the analytical laboratory, and the copy is retained by the sampling staff until it is submitted to the project manager and data validators.

One copy of the chain-of-custody form will be kept by archiving in the project files. Information to be recorded on the chain-of-custody form should include:

- Project name and number
- Sample matrix
- Sample collector's name
- Dates/times of sample collection
- Sample identification numbers
- Number and type of containers for each sample aliquot
- Type of preservation
- Quality control (QC) sample designation
- Analysis method
- Special handling instructions
- Destination of samples

- Name, date, time, and signature of each individual releasing the shipping container

The field crew will attempt to identify any potentially high-concentration samples on the chain-of-custody form. Groundwater sample salinity will be noted on the form to aid the analytical laboratory in establishing dilution requirements for metals analyses, where salinity could present an interference concern.

4.4 CALIBRATION PROCEDURES

No changes were made to Section 4.4 in this Work Plan Addendum.

4.5 ANALYTICAL PROCEDURES

No changes were made to Section 4.5 in this Work Plan Addendum.

4.5.1 Laboratory Analysis

Section 4.5.1 has been amended by the addition of the following text.

Chemical analysis for all analytical groups will be performed by a subcontracted fixed-base laboratory. The laboratory will be accredited under the DoD Environmental Laboratory Accreditation Program (ELAP). Analyses will be performed in accordance with the analytical methods identified in Table 3-5 and the requirements of the technical specifications for laboratory services developed by TtNUS for this work (Appendix D). The laboratory will meet the PQLs specified in Tables 4-1, 4-2, and 4-3.

The soil, soil-gas, and groundwater samples will be analyzed for VOCs, PAHs, PCBs, TAL metals, and TPH (GRO/DRO), (as indicated in Table 3-2) according to the EPA SW-846 methods listed in Table 3-5. The groundwater samples for dissolved metals will be filtered at the site. The types of sample containers, preservatives, and holding times for each analytical group are presented in Table 3-3.

The laboratory technical specifications detail the analytical requirements, number of samples, matrix, methods to be performed, sample containers, preservatives, holding times, the quantitation limits required for the project, and data deliverables. The laboratory will perform the chemical analyses following laboratory-specific SOPs (presented in Appendix E) developed based on the methods listed in Table 3-5. The laboratory QC sample method/SOP acceptance limits to be met for each analysis are listed in Tables 4-4 through 4-10. Instrument calibration will be as per the EPA Method requirements. The procedures and acceptance criteria for laboratory analytical instrument calibration are presented in Table 4-11 and for laboratory instrument maintenance, testing, and inspection are presented in Table 4-12.

TtNUS will evaluate and track the technical performance of the laboratory.

4.5.2 Field Screening

No changes were made to Section 4.5.2 in this Work Plan Addendum.

4.6 DATA REDUCTION, REVIEW, AND REPORTING

Section 4.6 has been amended by the addition of the following text.

The data generated under this project will be examined and evaluated by various personnel at various levels of detail. This process includes data verification, data validation and data usability assessment. Data verification is a process of evaluating the data completeness before the review process continues in order to determine whether the required information is available for further review. Data validation is an analyte- and sample-specific process to determine the quality of a specific data set. Data that do not meet the project performance criteria (Tables 4-4 through 4-10) are evaluated and qualified. Data usability assessment examines the data in the context of the project objectives to determine whether the data are suitable for supporting the attainment of these objectives.

The internal data verification requirements for this project include the maintenance and periodic review of field documentation (site logbooks, instrument calibration logs, chain-of-custody forms, field summary reports, and field modification records) and laboratory analytical data packages.

Data validation is a systematic review of the analytical data package with respect to sample receipt and handling, compliance with required analytical methods, quality control requirements, data reporting and deliverables, and document control. TtNUS qualified chemists will review the analytical data packages using U.S. EPA procedures and project-specific validation acceptance limits.

Usability assessment will be performed by project level personnel who understand the intended use of the data. These personnel include, but are not necessarily limited to the Project Manager, project chemists, geologists, and risk assessors. The usability assessment will be shared with all members of the Project Team for concurrence before final decisions are made and before the team agrees whether project objectives are attainable.

4.7 INTERNAL QUALITY CONTROL

No changes were made to Section 4.7 in this Work Plan Addendum.

4.8 PERFORMANCE AND SYSTEM AUDITS

No changes were made to Section 4.8 in this Work Plan Addendum.

4.9 PREVENTATIVE MAINTENANCE

No changes were made to Section 4.9 in this Work Plan Addendum.

4.10 DATA ASSESSMENT PROCEDURES

Section 4.10 has been amended by the addition of the following text.

System audits will be performed as appropriate to ensure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner.

- The TtNUS FOL will supervise the field operations. The FOL will perform a daily check to ensure that the field instruments are calibrated, equipment is properly decontaminated, samples are collected and handled properly, and the fieldwork is accurately and neatly documented. Corrective actions will be implemented immediately if any non-compliance is observed.
- System audits for the laboratory will be performed regularly and in accordance with NFESC guidance and Department of Defense Quality Systems Manual for Environmental Laboratories (DoD QSM) (DoD, 2006), as provided in the Laboratory Quality Assurance Plan (LQAP).
- The data will be reviewed to ensure that the analytical results were obtained through the approved methodology, and that the appropriate levels of QC were followed. The data review effort will be supervised by the TtNUS Project Chemist.

The Project Manager will oversee the FOL and data reviewer, and check that management of the acquired data proceeds in an organized and expeditious manner.

4.10.1 Representativeness, Accuracy, and Precision

Section 4.10.1 has been amended by the addition of the following text.

An independent performance audit of field activities may be conducted at the discretion of, and under the direction of the CLEAN QA Manager (QAM). During formal field audits, the QAM will check that sample collection, handling, and shipping protocols, as well as equipment decontamination and field

documentation procedures, are being performed in accordance with the approved project planning documents and SOPs. Field audit checklists will be developed by the QAM or designee based on the specific field activity to be audited. These audits and laboratory systems audits will identify the following:

- The assessed entity (e.g., field crew, office personnel, etc. and the associated project, field event, office, etc.)
- Whether the audit is internal or external
- Location and date(s) of assessment
- Assessment team members
- Type of assessment
- Scope of assessment
- Documents to be reviewed
- Notification dates
- Proposed assessment schedule
- Assessment number
- Contract number

Performance audits of laboratories are coordinated through NFESC and are conducted every 18 months by NFESC's independent quality assurance contractor.

4.10.2 Data Validation

Section 4.10.2 has been amended by the addition of the following text.

Step I Data Verification - During this process, the data generated will be reviewed for completeness to verify that all the data required by the project are available. This includes field data, to verify that all samples were collected, as well as analytical laboratory data. Verification inputs are summarized in Table 5-1.

Field data will be periodically reviewed by technical lead personnel and/or the TtNUS Project Manager to assess whether the sample collection procedures described in the work plan addendum were followed. This check ensures that the data collected are well documented, clearly described, and appropriate for the investigation and its ultimate use.

Upon receipt of analytical laboratory results, TtNUS personnel will evaluate electronic and hardcopy deliverables for conformance to data format specifications and for completeness. TtNUS validation chemists also perform completeness verification to determine that information is complete, all samples were collected, preserved, analyzed, and reported for the parameters specified in the QAPP.

Step II Data Validation - Data validation assesses both the field and analytical data for compliance with the requirements of the Work Plan Addendum and the requirements of the analytical procedures. Validation of field data will be limited to real-time checks in the field as data are generated, whereas laboratory analytical data will be validated in accordance with current applicable U.S. EPA guidance.

The analytical data will be reviewed by qualified TtNUS technical staff. The review of field and analytical data includes the following general tasks:

- Check data for accuracy of sample identification, sample location, collection date, and units.
- Organize data summary tables by sample matrix and sample location, and calculate and report the average of field duplicate results. Consolidate results of two sample dilutions into one set of results.
- Perform analytical data validation to check that the QC criteria required in the analytical methods were met. Data that exceed QC criteria are qualified as estimated. Results deemed to be not useable to meet the quality objectives are rejected.
- Verify that the validation reports are complete, that all data have been transferred correctly and completely to the final project database, including the data validation qualifiers.

Step II Analytical Data Review - The analytical data will be reviewed by TtNUS technical staff to assess compliance of the project measurement performance criteria (Table 4-4 to 4-10) following EPA New England data validation guidelines. The Region I EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part II, December 1996 (U.S. EPA, 1996) will be applied using the method criteria for VOCs, PAHs, GRO, and DRO. The Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part III, February 2004 (U.S. EPA, 2004) will be applied using the laboratory method criteria for PCBs. The metals Region I, EPA-NE Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, February 1989 (U.S. EPA, 1989) will be applied using the laboratory method criteria for metals.

A Tier II level of data validation will be performed. A data review memorandum summarizing the outcome of the measurement performance criteria data assessment will be prepared and submitted to the Project Manager. A Tier II level data validation includes checking for the following parameters for organic and inorganic analyses:

- Completeness assessment;
- Sample preservation and holding times;
- Instrument performance check;
- Initial and continuing calibration, blank analysis;
- Surrogate spike recoveries (organics only);
- Internal standard performance,
- Field duplicate precision;
- Matrix spike/matrix spike duplicates;
- ICP interferences check (metals);
- Laboratory Duplicates (metals);
- Laboratory control sample results;
- ICP Serial Dilution Results (metals).

The analytical data will be qualified, if necessary, as a result of the Tier II validation. The qualified summary table will be included as an appendix to the SASE Report Addendum.

The data validators will determine the impact of any deviations from sampling or analytical methods on the quality of data generated. The reviewer will verify that the required method performance criteria described in tables 4-4 to 4-10 were achieved. The reviewer will determine whether the sampling plan was executed as proposed, and whether the samples were collected following the requirements specified in Section 3.0 of this Work Plan Addendum.

4.10.3 Data Evaluation

No changes were made to Section 4.10.3 in this Work Plan Addendum.

4.11 CORRECTIVE ACTION

Section 4.11 has been amended by the addition of the following text.

Assessment findings that require corrective action initiate a sequence of events that include documentation of deficiencies, notification of findings, request for corrective action, implementation of corrective action, and follow-up assessment of the corrective action effectiveness. Table 4-13 summarizes the procedure for handling any work plan deviations and project deficiencies that are identified through the planned project assessments.

Potential problems may involve nonconformance with the SOPs and/or analytical procedures established for the project, or other unforeseen difficulties. Any person identifying a condition adverse to project

quality will notify the PM. The PM, with the assistance of the QA officer, will be responsible for developing and initiating appropriate corrective action. If the identified deficiencies involve field work, this will be done through the FOL; if the deficiencies involve the laboratory, this will be done through the laboratory project manager. The corrective actions will require follow-through to the point of verifying that the corrective action has been effective. Corrective actions may include re-sampling and/or re-analyzing samples, or amending or adjusting project procedures. If warranted by the severity of the problem (for example, if a change in the approved plan is required), the Navy will be notified in writing and the Navy's approval will be obtained before such a change is implemented. Minor changes will be documented for the project file by the TtNUS PM. Additional work that depends on an activity identified as nonconforming will not be performed until the problem has been eliminated. The overall corrective action responsibility for system audits will reside with the PM. The overall corrective action responsibility for field audits will reside with the QA officer.

For QA issues involving the analytical laboratory to be used for the project, the laboratory also maintains an internal closed-loop corrective action system that operates under the direction of the laboratory QA coordinator.

4.12 QUALITY ASSURANCE REPORTS/DOCUMENTS

Section 4.12 has been amended by the addition of the following text.

Table 4-14 presents the reports that will be generated for Quality Assurance management.

5.0 REPORTING

No changes were made to Section 5.0 in this Work Plan Addendum.

5.1 BACKGROUND AND FINDINGS OF THE INVESTIGATIONS

No changes were made to Section 5.1 in this Work Plan Addendum.

5.2 PRELIMINARY HUMAN HEALTH RISK ASSESSMENTS

No changes were made to Section 5.2 in this Work Plan Addendum.

5.3 ECOLOGICAL ASSESSMENT

No changes were made to Section 5.3 in this Work Plan Addendum.

5.4 SASE ADDENDUM - ADDITIONAL INVESTIGATIONS

TtNUS will prepare a Draft Addendum to the SASE Report to document the additional investigation activities described in this work plan addendum. The report will be distributed to RIDEM, EPA, NAVSTA Newport, and Navy. The report addendum will update relevant sections from the original SASE Report and include new sections to discuss the vapor intrusion pathway analysis for the Northern Waterfront Area. The report addendum will include a summary of the additional sampling activities conducted and a revised focused human health risk assessment that will evaluate previous and newly collected data to assess potential human health exposure and risk to groundwater, soil, and soil gas at the site.

The revised risk assessment will consist of five subsections: Data Evaluation and Chemicals of Potential Concern (COPC) Selection, Exposure Assessment, Toxicity Assessment, Risk Characterization, and Uncertainty Analysis. The risk assessment processes to be used will be in accordance with current EPA risk assessment guidance (EPA, 1989), and other applicable general EPA guidance (EPA, 2001b). The revised risk assessment will re-evaluate receptors identified in the original risk assessment (which included residential exposure to soil) and in addition will evaluate two additional receptor scenarios: residential ingestion of groundwater and vapor intrusion into indoor air. A screening vapor intrusion evaluation will be completed to evaluate potential risks that could arise if a building were to be constructed over areas of subsurface contamination. This evaluation will include a contaminant fate and transport model (i.e. Johnson and Ettinger Model, 1991).

After receipt of review comments from EPA and RIDEM, TtNUS will prepare one set of responses to comments (RTCs). A meeting with Navy and regulators may be held to resolve outstanding questions/issues on the regulatory comments prior to preparation of a Draft Final Addendum to the SASE Report, which will be distributed to RIDEM, EPA, NAVSTA, and Navy.

After receipt of EPA and RIDEM review comments on the Draft Final Addendum to the SASE Report, TtNUS will prepare one set of RTCs. Any outstanding questions/issues will be resolved via conference call prior to completion of the Final Addendum to the SASE Report, to be distributed as noted above.

TABLES

**TABLE 1-1
 COMMUNICATION PATHWAYS
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Communication Drivers	Responsible Entity	Name	Mailing Address	Email address	Phone Number	Procedure (Timing, Pathways, etc.)
QAPP amendments	Navy Remedial Project Manager (RPM)	Winoma Johnson	NAVFAC MIDLANT 9742 Maryland Ave Bldg N-26, Room 3208 Norfolk, VA 23511	winoma.johnson@navy.mil	757-444-3418	Send scope change to TtNUS Program office
Changes in schedule	TtNUS PM	Tom Campbell	55 Jonspin Road Wilmington, MA 01887	Thomas.campbell@tetrattech.com	978-474-8404	Inform Navy via schedule impact letter as soon as impact is realized
Issues in the field that result in changes in scope of field work	TtNUS FOL	Miki Alroy	55 Jonspin Road Wilmington, MA 01887	Michael.Alroy@tetrattech.com	978-474-8400	FOL inform PM; PM inform RPM; RPM issue scope change if warranted; Scope change to be implemented before work is executed Document changes on Field Task Modification Request (FTMR) form.
	TtNUS FOL TtNUS PM	Steve Parker	55 Jonspin Road Wilmington, MA 01887	Stephen.Parker@tetrattech.com	978-474-8434	
Recommendations to stop work and initiate work upon corrective action	TtNUS FOL	Miki Alroy	55 Jonspin Road Wilmington, MA 01887	Michael.Alroy@tetrattech.com	978-474-8442	Responsible Party immediately informs subcontractors, the Navy, and Project Team
	TtNUS PM	Tom Campbell	55 Jonspin Road Wilmington, MA 01887	Thomas.campbell@tetrattech.com	978-474-8404	
	TtNUS QA Officer	Tom Johnston	661 Anderson Drive Foster Plaza 7 Pittsburgh, PA 15220	Thomas.johnston@tetrattech.com	412-921-8615	
	TtNUS HSM	Matt Soltis	661 Anderson Drive Foster Plaza 7 Pittsburgh, PA 15220	Matt.Soltis@tetrattech.com	412-921-8912	
	Navy RPM	Winoma Johnson	NAVFAC MIDLANT	winoma.johnson@navy.mil	757-444-3418	
Analytical data quality issues	TDB	TBD	TBD	TBD	TBD	Immediately notify TtNUS Project Chemist Notify Data Validation Staff and TtNUS PM if necessary

**TABLE 3-1
 SUMMARY OF PROPOSED BORINGS, MONITORING WELLS, AND SOIL GAS LOCATIONS
 ON-SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND
 PAGE 1 OF 2**

SAMPLE LOCATION IDENTIFIER	GENERAL LOCATION DESCRIPTION	PURPOSE/OBJECTIVE
Borings		
SB201	Southern Waterfront Area	To investigate potential PAH or metals contamination in Section 6 of the Southern Waterfront area
SB202	Southern Waterfront Area	To investigate potential PAH or metals contamination in Section 6 of the Southern Waterfront area
SB203	Sump 234-4	To investigate potential contamination in the bottom of former sump 234-4
SB204	Huts 1 and 2	To investigate potential soil and groundwater contamination in the vicinity of TP-16 and TP-27.
SB205	Huts 1 and 2	To investigate potential soil contamination in the vicinity of TP-16
SB206	Huts 1 and 2	To investigate potential soil contamination in the vicinity of TP-16
SB207	Huts 1 and 2	To investigate potential soil contamination in the vicinity of TP-16
SB208	Building 6/TP-14 Area	To investigate potential soil contamination in the vicinity of the Building 6/TP-14 PCB removal area
SB209	Building 6/TP-14 Area	To investigate potential soil contamination in the vicinity of the Building 6/TP-14 PCB removal area
SB210	Building 6/TP-14 Area	To investigate potential soil contamination in the vicinity of the Building 6/TP-14 PCB removal area
SB211	Building 6/TP-14 Area	To investigate potential soil contamination in the vicinity of the Building 6/TP-14 PCB removal area
SB212	Building 6/TP-14 Area	To investigate potential soil contamination in the vicinity of the Building 6/TP-14 PCB removal area
SB213	Building 6/TP-14 Area	To investigate potential soil contamination in the vicinity of the Building 6/TP-14 PCB removal area
SB214	Building 6/TP-14 Area	To investigate potential soil contamination in the vicinity of the Building 6/TP-14 PCB removal area
SB215	Building 6/TP-14 Area (Transformer Bank)	To investigate potential PCB soil contamination beneath the gravel layer in the transformer bank area
SB216	Building 6/TP-14 Area (Transformer Bank)	To investigate potential PCB soil contamination beneath the gravel layer in the transformer bank area
SB217	Building 6/TP-14 Area (Transformer Bank)	To investigate potential PCB soil contamination beneath the gravel layer in the transformer bank area

**TABLE 3-1
 SUMMARY OF PROPOSED BORINGS, MONITORING WELLS, AND SOIL GAS LOCATIONS
 ON-SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND
 PAGE 2 OF 2**

SAMPLE LOCATION IDENTIFIER	GENERAL LOCATION DESCRIPTION	PURPOSE/OBJECTIVE
Monitoring Wells		
MW08 (existing well)	Northeast of former Building 234 in area of former USTs and former machine shop	To investigate potential impact from former USTs and machine shop to shallow overburden aquifer (area of TP-26)
MW218	Building 42	To investigate potential contamination in shallow overburden groundwater downgradient of TP- 25
MW219	Building 42	To investigate potential contamination in shallow overburden groundwater downgradient of sump S42-1
MW02 (existing well)	Northern Waterfront Area (West of former oil discharge area)	To investigate potential groundwater contamination in the vicinity of areas of former oil discharges to soil and groundwater
MW03 (existing well)	Northern Waterfront Area (former Hazardous Waste Storage Area)	Assess impacts of hazardous waste storage area on deep portions of soil and groundwater
MW11 (existing well)	Northern Waterfront Area (Between Pier 2 and the Former Hazardous Waste Storage Area)	Assess impacts of former storage areas and other disposal on deep portions of overburden aquifer
MW12 (existing well)	Northern Waterfront Area (Between Pier 1 and the Former Hazardous Waste Storage Area)	Assess impacts of former storage areas and other disposal on deep portions of overburden aquifer
MW204	Huts 1 and 2	To investigate potential groundwater contamination in the vicinity of TP-16 and TP-27.
MW220	Northern Waterfront Area	To investigate potential groundwater contamination downgradient of the former hazardous waste storage area
MW221	Northern Waterfront Area	To investigate potential groundwater contamination downgradient of the former hazardous waste storage area
MW222	Northern Waterfront Area	To investigate potential groundwater contamination in the central portion of the Northern Waterfront Area
MW223	Northern Waterfront Area (Upgradient location)	To provide an upgradient/background groundwater data point
Soil Gas		
SG224	Northern Waterfront Area	Co-located with existing groundwater monitoring well MW02, to assess potential presence of VOCs in soil gas
SG225	Northern Waterfront Area	Co-located with existing groundwater monitoring well MW12, to assess potential presence of VOCs in soil gas
SG226	Northern Waterfront Area	Co-located with existing groundwater monitoring well MW03, to assess potential presence of VOCs in soil gas
SG227	Northern Waterfront Area	Co-located with existing groundwater monitoring well MW11, to assess potential presence of VOCs in soil gas

**TABLE 3-2
 SUMMARY OF PROPOSED ANALYTICAL PARAMETERS FOR EACH PROPOSED SAMPLE LOCATIONS
 ON-SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND
 PAGE 1 OF 2**

SAMPLE LOCATION IDENTIFIER	VOCs	PAHs	PCBS	Metals	GRO/DRO
Borings					
SB201 (Southern Waterfront Area)		X		X	
SB202 (Southern Waterfront Area)		X		X	
SB203 (Building 234)	X	X		X	X
SB204 (Huts 1 and 2)	X	X		X	X
SB205 (Huts 1 and 2)	X	X		X	X
SB206 (Huts 1 and 2)	X	X		X	X
SB207 (Huts 1 and 2)	X	X		X	X
SB208 (Building 6/TP-14)		X	X	X	X
SB209 (Building 6/TP-14)		X	X	X	X
SB210 (Building 6/TP-14)		X	X	X	X
SB211 (Building 6/TP-14)		X	X	X	X
SB212 (Building 6/TP-14)		X	X	X	X
SB213 (Building 6/TP-14)		X	X	X	X
SB214 (Building 6/TP-14)		X	X	X	X
SB215 (Building 6/TP-14)			X		
SB216 (Building 6/TP-14)			X		
SB217 (Building 6/TP-14)			X		
Monitoring Wells					
MW08 (existing well) (Building 234)	X	X		X	
MW218 (Building 42)	X	X		X	
MW219 (Building 42)	X	X		X	
MW02 (existing well) (Northern Waterfront Area)	X				
MW03 (existing well) (Northern Waterfront Area)	X				
MW11 (existing well) (Northern Waterfront Area)	X				
MW12 (existing well) (Northern Waterfront Area)	X				
MW204 (Huts 1 and 2)	X	X		X	
MW220 (Northern Waterfront Area)	X				
MW221 (Northern Waterfront Area)	X				
MW222 (Northern Waterfront Area)	X				

TABLE 3-2
SUMMARY OF PROPOSED ANALYTICAL PARAMETERS FOR EACH PROPOSED SAMPLE LOCATIONS
ON-SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, RHODE ISLAND
PAGE 2 OF 2

SAMPLE LOCATION IDENTIFIER	VOCs	PAHs	PCBS	Metals	GRO/DRO
MW223 (Northern Waterfront Area)	X				
Soil Gas					
SG224 (Northern Waterfront Area)	X				
SG225 (Northern Waterfront Area)	X				
SG226 (Northern Waterfront Area)	X				
SG227 (Northern Waterfront Area)	X				

**TABLE 3-3
 SAMPLE ANALYSIS, CONTAINER, PRESERVATIVE, AND HOLDING TIME REQUIREMENTS
 ON-SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

SAMPLE MEDIUM	ANALYSIS	SAMPLE CONTAINER ⁽¹⁾	PRESERVATIVE	HOLDING TIME
Soil	VOCs	1-40mL VOC vial	5 mL methanol, Cool to 4°C	14 days to analysis
		2-40mL VOC vials	1 g NaHSO ₄ in 5 mL reagent water, Cool to 4°C	14 days to analysis
		1-2 oz jar, percent moisture	Cool to 4°C	14 days to analysis
	PAHs	1-8 oz wide mouth jar	Cool to 4°C	14 Days (Extraction) / 40 Days (Analysis) None for PCBs
	PCB			
	DRO			
	Metals	1-4 oz wide mouth jar	Cool to 4°C	6 Months (Analysis), 28 Days for mercury
GRO	1-40 mL VOC vial	5 mL methanol, Cool to 4°C	14 Days to Analysis	
Groundwater	VOCs	2-40mL VOC vials	HCl to pH <2, Cool to 4°C	14 Days to Analysis
	PAHs	1 liter amber class bottles	Cool to 4°C	7 Days (Extraction) / 40 Days (Analysis)
	Metals	1 500 mL polyethylene bottle	Nitric acid to pH <2, Cool to 4°C	6 Months (Analysis), 28 Days for mercury
Aqueous Field QC	VOCs	2-40mL VOC vials	HCl to pH <2, Cool to 4°C	14 Days to Analysis
	PAHs	2 liter amber class bottles	Cool to 4°C	7 Days (Extraction) / 40 Days (Analysis)
	PCB	2 liter amber class bottles	Cool to 4°C	None for PCBs
	Metals	1 500 mL polyethylene bottle	Nitric acid to pH <2, Cool to 4°C	6 Months (Analysis), 28 Days for mercury
Soil Gas	VOCs	1-Summa Canister	None	Analyze 30 days

Notes:

(1) Triple volume needed for laboratory MS/MSD (organic) or double volume for MS/laboratory duplicate (inorganic) analyses.

**TABLE 3-4
 FIELD AND QUALITY CONTROL SAMPLE SUMMARY
 ON-SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

SAMPLE TYPE	ANALYSIS	FIELD SAMPLES	RINSATE (EQUIPMENT) BLANKS ⁽¹⁾	FIELD DUPLICATES ⁽²⁾	FIELD BLANKS ⁽³⁾	TRIP BLANKS ⁽⁴⁾	TOTAL	LAB QC ⁽⁵⁾
Soil	VOCs	5	1	1	1	3	11	1
	PAHs	14	1	2	1	0	18	1
	PCBs	10	1	2	1	0	14	1
	Metals	14	1	2	1	0	18	1
	GRO	12	1	2	1	6	22	1
	DRO	12	1	2	1	0	16	1
Groundwater	VOCs	12	1	2	1	3	19	1
	PAHs	4	1	1	1	0	7	1
	Metals (total)	4	1	1	1	0	7	1
	Metals (dissolved)	4	1	1	1	0	7	1
Soil Gas	VOCs	4	0	1	1	0	6	0

Notes:

- (1) Collect 1 rinsate blank per 20 field samples, per type of equipment.
- (2) Collect 1 duplicate per 10 field samples, minimum.
- (3) Collect 1 field blank per water source (e.g. decontamination rinse water).
- (4) Collect minimum of 1 trip blank per storage/shipment container of VOCs and GRO.
- (5) Assign 1 Lab QC per 20 samples: Organics - Matrix Spike and a Matrix Spike Duplicate (MS/MSD); Inorganics - Matrix Spike and Laboratory Duplicate. The Lab QC volume is not included in the total sample count

**TABLE 3-5
 ANALYTICAL METHODS FOR SOIL, GROUNDWATER, AND SOIL GAS SAMPLES
 ON-SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

MATRIX	PARAMETER	ANALYSIS METHOD	REFERENCE
Soil	VOC	8260B	SW846
	GRO	8015B	SW846
	DRO	8015B	SW846
	PAH	8270C	SW846
	PCB	8082	SW846
	Metals	6010C/7471A	SW846
Groundwater and Aqueous Field QC	VOC	8260B	SW846
	PAH	8270C	SW846
	PCB	8082	SW846
	Metals	6010C/7470A	SW846
Soil Gas	VOC	TO-15	Air method Compendium

Notes:

Method References:

- SW846 – Test Methods for Evaluating Solid Wastes. U. S. EPA Office of Solid Waste. Third Edition, including all promulgated revisions.
- Compendium of methods for the determination of Toxic Organic Compounds in Ambient Air. EPA/625/R-96/010b. January 1999.

If needed, EPA Method 1640 will be used for groundwater sample preparation (prior to analysis) to overcome salinity interference in metals analysis.

**TABLE 4-1
 GROUNDWATER FIXED LABORATORY PARAMETERS
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA, NEWPORT, RHODE ISLAND
 PAGE 1 OF 3**

Chemical	Method	MCL ⁽¹⁾ (ug/L)	RIDEM GA Aquifer ^(2, 7) (ug/L)	Project Action Level ⁽³⁾ (ug/L)	PQL ⁽⁴⁾ (ug/L)
Volatile Organic Compounds					
1,1,1-Trichloroethane	SW-846 8260B	200	200	200	66.7
1,1,1,2,2-Tetrachloroethane	SW-846 8260B				1
1,1,2-Trichloroethane	SW-846 8260B	5	5	5	1.7
1,1-Dichloroethane	SW-846 8260B				1
1,1-Dichloroethene	SW-846 8260B	7	7	7	2.3
1,2,4-Trichlorobenzene	SW-846 8260B	70	70	70	23.3
1,2-Dibromoethane (EDB)	SW-846 8260B	0.05	0.05	0.05	0.02
1,2-Dibromo-3-Chloropropane (DBCP)	SW-846 8260B	0.2	0.2	0.2	0.1
1,2-Dichlorobenzene	SW-846 8260B	600	600	600	200
1,2-Dichloroethane	SW-846 8260B	5	5	5	1.7
1,2-Dichloropropane	SW-846 8260B	5	5	5	1.7
1,3-Dichlorobenzene	SW-846 8260B	--	--	--	1
1,4-Dichlorobenzene	SW-846 8260B	75	75	75	25
2-Butanone	SW-846 8260B				10
2-Hexanone	SW-846 8260B				5
4-Methyl-2-pentanone	SW-846 8260B				5
Acetone	SW-846 8260B				10
Benzene	SW-846 8260B	5	5	5	1.7
Bromomethane	SW-846 8260B				2
Carbon disulfide	SW-846 8260B				1
Carbon tetrachloride	SW-846 8260B	5	5	5	1.7
Chlorobenzene	SW-846 8260B	100	100	100	33.3
Chloroethane	SW-846 8260B				2
Chloromethane	SW-846 8260B				2
cis-1,2-Dichloroethene	SW-846 8260B	70	70	70	23.3
cis-1,3-Dichloropropene	SW-846 8260B				1
Cyclohexane	SW-846 8260B				1
Dichlorodifluoromethane	SW-846 8260B				2
Ethylbenzene	SW-846 8260B	700	700	700	233.3
Isopropylbenzene	SW-846 8260B				1
Methyl acetate	SW-846 8260B				2
Methylcyclohexane	SW-846 8260B				1
Methylene chloride	SW-846 8260B	5	5	5	1.7
Methyl-tert-butyl ether	SW-846 8260B		40	40	13.3
Styrene	SW-846 8260B	100	100	100	33.3

**TABLE 4-1
 GROUNDWATER FIXED LABORATORY PARAMETERS
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA, NEWPORT, RHODE ISLAND
 PAGE 2 OF 3**

Chemical	Method	MCL ⁽¹⁾ (ug/L)	RIDEM GA Aquifer ^(2, 7) (ug/L)	Project Action Level ⁽³⁾ (ug/L)	PQL ⁽⁴⁾ (ug/L)
Volatile Organic Compounds (cont.)					
Tetrachloroethene	SW-846 8260B	5	5	5	1.7
Toluene	SW-846 8260B	1000	1000	1000	333.3
trans-1,2-Dichloroethene	SW-846 8260B	100	100	100	33.3
trans-1,3-Dichloropropene	SW-846 8260B				1
Trichloroethene	SW-846 8260B	5	5	5	1.7
Trichlorofluoromethane	SW-846 8260B				2
Vinyl chloride	SW-846 8260B	2	2	2	0.7
Xylenes (total)	SW-846 8260B	10000	10000	10000	3333
Polyaromatic Hydrocarbons					
2-Methylnaphthalene	SW846 8270C				5
Acenaphthene	SW846 8270C				5
Acenaphthylene	SW846 8270C				5
Anthracene	SW846 8270C				5
Benzo(a)anthracene	SW846 8270C				5
Benzo(a)pyrene	SW846 8270C	0.2	0.2	0.2	0.1
Benzo(b)fluoranthene	SW846 8270C				5
Benzo(g,h,i)perylene	SW846 8270C				5
Benzo(k)fluoranthene	SW846 8270C				5
Chrysene	SW846 8270C				5
Dibenzo(a,h)anthracene	SW846 8270C				5
Fluoranthene	SW846 8270C				5
Fluorene	SW846 8270C				5
Indeno (1,2,3-cd)pyrene	SW846 8270C				5
Naphthalene	SW846 8270C		100		33.3
Phenanthrene	SW846 8270C				5
Pyrene	SW846 8270C				5
Metals (Total and Dissolved)⁽⁵⁾					
Aluminum	SW846 6010C				50
Antimony	SW846 6010C	6	6	6	2.0
Arsenic	SW846 6010C	10	10	10	3.3
Barium	SW846 6010C	2000	2000	2000	666.7
Beryllium	SW846 6010C	4	4	4	1.3
Cadmium	SW846 6010C	5	5	5	1.7
Calcium	SW846 6010C				1250
Chromium	SW846 6010C	100	100	100	33.3

**TABLE 4-1
 GROUNDWATER FIXED LABORATORY PARAMETERS
 ON SHORE DEREKTOR SHIPYARD
 NAVSTA, NEWPORT, RHODE ISLAND
 PAGE 3 OF 3**

Chemical	Method	MCL ⁽¹⁾ (ug/L)	RIDEM GA Aquifer ^(2, 7) (ug/L)	Project Action Level ⁽³⁾ (ug/L)	PQL ⁽⁴⁾ (ug/L)
Metals (Total and Dissolved)⁽⁵⁾ (cont.)					
Cobalt	SW846 6010C				13
Copper	SW846 6010C	1300 ⁸	1300	1300	433.3
Iron	SW846 6010C				25
Lead	SW846 6010C	15 ⁸	15	15	5.0
Magnesium	SW846 6010C				1250
Manganese	SW846 6010C				3.8
Mercury	SW846 7470A	2	2	2	0.7
Nickel	SW846 6010C		100	100	33.3
Potassium	SW846 6010C				1250
Selenium	SW846 6010C	50	50	50	16.7
Silver	SW846 6010C				2.5
Sodium	SW846 6010C				1250
Thallium	SW846 6010C	2	2	2	0.7
Vanadium	SW846 6010C				13
Zinc	SW846 6010C				5.0

Notes:

Shading indicates that PQL exceeds project action level.

1. Source: U.S. EPA (May, 2009)
2. RIDEM Groundwater Quality Standards for GA aquifers. Source: RIDEM (March, 2005)
3. The project action level represents the lower of the MCL or the RIDEM Groundwater Quality Standards for GA aquifers.
4. The project quantitation limit (PQL) is selected to meet the project data quality objectives. The PQL is set at a concentration at least three times lower than the project action level, if achievable by available analytical methods and laboratories.
5. Samples for dissolved metals analysis will be filtered in the field.
6. PALs will be based on federal criteria and use of RIDEM criteria is for comparison purposes only.
7. RIDEM Remediation Regulations. Source: RIDEM (February, 2004)
8. The EPA Action level is used for copper and lead as the PAL

ug/L - micrograms per liter
 MCL - U.S. EPA Maximum Contaminant Levels for drinking water
 RIDEM - Rhode Island Department of Environmental Management
 -- Not Available

Method References:

- SW846 -Test Methods for Evaluating Solid Wastes. EPA Office of Solid Waste. Third Edition, including all promulgated revisions for methods 8260B; 8270C; 8081A; 8082; 8015B; 6010C; 6020; and 7470A; and 9012A.

TABLE 4-2
SOIL FIXED LABORATORY PARAMETERS
ON SHORE DEREKTOR SHIPYARD
NAVSTA NEWPORT, RHODE ISLAND
PAGE 1 OF 4

Chemical	Method	Project Action Limit ⁽¹⁾ (mg/Kg)	Project Action Limit Reference ⁽²⁾	PQL ⁽³⁾ (mg/Kg)
Volatile Organic Compounds				
1,1,1-Trichloroethane	SW846 8260B	540	RIDEM DEC Res	180
1,1,2,2-Tetrachloroethane	SW846 8260B	0.56	RSL	0.2
1,1,2-Trichloroethane	SW846 8260B	1.1	RSL	0.37
1,1-Dichloroethane	SW846 8260B	3.3	RSL	1.1
1,1-Dichloroethene	SW846 8260B	0.2	RIDEM DEC Res	0.067
1,2,4-Trichlorobenzene ⁽⁴⁾	SW846 8260B	6.2 ⁽⁵⁾	RSL	2.1
1,2-Dibromo-3-chloropropane	SW846 8260B	0.0054	RSL	0.002
1,2-Dibromoethane (EDB)	SW846 8260B	0.034	RSL	0.01
1,2-Dichlorobenzene ⁽⁴⁾	SW846 8260B	190	RSL	0.01
1,2-Dichloroethane	SW846 8260B	0.43	RSL	0.14
1,2-Dichloropropane	SW846 8260B	0.89	RSL	0.3
1,3-Dichlorobenzene ⁽⁴⁾	SW846 8260B	430	RIDEM DEC Res	143
1,4-Dichlorobenzene ⁽⁴⁾	SW846 8260B	2.4	RSL	0.8
2-Butanone	SW846 8260B	2800	RSL	933.3
2-Hexanone	SW846 8260B	21	RSL	7
4-Methyl-2-pentanone (MIBK)	SW846 8260B	530	RSL	177
Acetone	SW846 8260B	6100	RSL	2033
Benzene	SW846 8260B	1.1	RSL	0.4
Bromodichloromethane	SW846 8260B	0.27	RSL	0.1
Bromoform	SW846 8260B	61	RSL	20.3
Bromomethane	SW846 8260B	0.73	RSL	0.2
Carbon disulfide	SW846 8260B	82	RSL	27.3
Carbon tetrachloride	SW846 8260B	0.61	RSL	0.2
Chlorobenzene	SW846 8260B	29	RSL	9.7
Chloroethane	SW846 8260B	1500	RSL	500
Chloroform	SW846 8260B	0.29	RSL	0.097
Chloromethane	SW846 8260B	12	RSL	4
cis-1,2-Dichloroethene	SW846 8260B	16	RSL	5.3
cis-1,3-Dichloropropene	SW846 8260B	1.7 ⁽⁶⁾	RSL	0.57
Cyclohexane	SW846 8260B	700	RSL	233.3
Dibromochloromethane	SW846 8260B	0.68	RSL	0.2
Dichlorodifluoromethane	SW846 8260B	18	RSL	6.0
Ethylbenzene	SW846 8260B	5.4	RSL	1.8

TABLE 4-2
SOIL FIXED LABORATORY PARAMETERS
ON SHORE DEREDKTOR SHIPYARD
NAVSTA NEWPORT, RHODE ISLAND
PAGE 2 OF 4

Chemical	Method	Project Action Limit ⁽¹⁾ (mg/Kg)	Project Action Limit Reference ⁽²⁾	PQL ⁽³⁾ (mg/Kg)
Isopropylbenzene	SW846 8260B	27	RIDEM DEC Res	9
Methyl acetate	SW846 8260B	7800	RSL	2600
Methylcyclohexane	SW846 8260B	--	--	--
Methylene chloride	SW846 8260B	11	RSL	3.67
Methyl-tert-butyl ether	SW846 8260B	43	RSL	14.3
Styrene	SW846 8260B	13	RIDEM DEC Res	4.33
Tetrachloroethene	SW846 8260B	0.55	RSL	0.2
Toluene	SW846 8260B	190	RIDEM DEC Res	63.3
trans-1,2-Dichloroethene	SW846 8260B	15	RSL	5
trans-1,3-Dichloropropene	SW846 8260B	1.7 ⁽⁶⁾	RSL	0.57
Trichloroethene	SW846 8260B	2.8	RSL	0.93
Trichlorofluoromethane	SW846 8260B	79	RSL	26.3
Vinyl chloride	SW846 8260B	0.02	RIDEM DEC Res	0.007
Xylenes (total)	SW846 8260B	63	RSL	21
Polycyclic Aromatic Hydrocarbons				
2-Methylnaphthalene	SW846 8270C	31	RSL	10.3
Acenaphthene	SW846 8270C	340	RSL	113.3
Acenaphthylene	SW846 8270C	23	RIDEM DEC Res	7.67
Anthracene	SW846 8270C	35	RIDEM DEC Res	11.7
Benzo(a)anthracene	SW846 8270C	0.15	RSL	0.05
Benzo(a)pyrene	SW846 8270C	0.015	RSL	0.01
Benzo(b)fluoranthene	SW846 8270C	0.15	RSL	0.1
Benzo(g,h,i)perylene	SW846 8270C	0.8	RIDEM DEC Res	0.27
Benzo(k)fluoranthene	SW846 8270C	0.9	RIDEM DEC Res	0.33
Chrysene	SW846 8270C	0.4	RIDEM DEC Res	0.067
Dibenzo(a,h)anthracene	SW846 8270C	0.015	RSL	0.005
Fluoranthene	SW846 8270C	20	RIDEM DEC Res	6.67
Fluorene	SW846 8270C	28	RIDEM DEC Res	9.34
Indeno(1,2,3-c,d)pyrene	SW846 8270C	0.15	RSL	0.05
Naphthalene	SW846 8270C	3.6	RSL	1.2

**TABLE 4-2
 SOIL FIXED LABORATORY PARAMETERS
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND
 PAGE 3 OF 4**

Chemical	Method	Project Action Limit ⁽¹⁾ (mg/Kg)	Project Action Limit Reference ⁽²⁾	PQL ⁽³⁾ (mg/Kg)
Phenanthrene	SW846 8270C	40	RIDEM DEC Res	13.3
Pyrene	SW846 8270C	13	RIDEM DEC Res	4.3
PCBs (mg/kg)				
Aroclor-1016	SW846 8082	0.39	RSL	0.1
Aroclor-1221	SW846 8082	0.14	RSL	0.05
Aroclor-1232	SW846 8082	0.14	RSL	0.05
Aroclor-1242	SW846 8082	0.22	RSL	0.1
Aroclor-1248	SW846 8082	0.22	RSL	0.1
Aroclor-1254	SW846 8082	0.11 ⁽⁵⁾	RSL	0.04
Aroclor-1260	SW846 8082	0.22	RSL	0.1
Total Polychlorinated Biphenyls	SW846 8082	--	--	0.1
GRO and DRO (mg/kg)				
GRO (C6-C10)	8015B	500	RIDEM TPH	166.7
DRO (C8-C40)	8015B	500	RIDEM TPH	166.7
TAL Metals				
Aluminum	SW846 6010C	7700	RSL	2567
Antimony	SW846 6010C	3.1	RSL	1.0
Arsenic	SW846 6010C	0.39	RSL	0.13
Barium	SW846 6010C	1500	RSL	500
Beryllium	SW846 6010C	0.4	RIDEM DEC Res	0.13
Cadmium	SW846 6010C	7	RSL	2.33
Calcium	SW846 6010C	--	--	250
Chromium	SW846 6010C	0.29	RSL	0.1
Cobalt	SW846 6010C	2.3	RSL	0.8
Copper	SW846 6010C	310	RSL	103.3
Iron	SW846 6010C	5500	RSL	1833.3
Lead	SW846 6010C	150	RIDEM DEC Res	50
Magnesium	SW846 6010C	--	--	--
Manganese	SW846 6010C	180	RSL	60
Mercury	SW846 7471A	2.3 ⁽⁹⁾	RSL	0.77
Nickel	SW846 6010C	150	RSL	50
Potassium	SW846 6010C	--	--	--
Selenium	SW846 6010C	39	RSL	13

**TABLE 4-2
 SOIL FIXED LABORATORY PARAMETERS
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND
 PAGE 4 OF 4**

Chemical	Method	Project Action Limit ⁽¹⁾ (mg/Kg)	Project Action Limit Reference ⁽²⁾	PQL ⁽³⁾ (mg/Kg)
Silver	SW846 6010C	39	RSL	13
Sodium	SW846 6010C	--	--	--
Thallium	SW846 6010C	5.5	RIDEM DEC Res	1.83
Vanadium	SW846 6010C	39 ⁽¹⁰⁾	RSL	13
Zinc	SW846 6010C	2300	RSL	766.67

Notes:

- The project action limit (PAL) is the lowest required quantification for each analyte, so that the data collected can be used at any phase of the CERCLA process.
- The determination of the project action limits (lowest criteria) is provided in Section 4.1.1
 PAL Reference Sources:
 RSL: U.S. Environmental Protection Agency Regional Screening Level for Residential Soil (EPA, 2010). Non-cancer RSLs are divided by 10 to correspond to a Hazard Quotient of 0.1.
 RIDEM DEC Res: Rhode Island Department of Environmental Management Residential Direct Exposure Criteria (RIDEM, 2004)
- The Project Quantitation Limit (PQL) is selected to meet the project data quality objectives. The PQL is set at a concentration of one-third or less than the project action level, if achievable by available analytical methods and laboratories.
- RIDEM classifies this compound as a semivolatile compound.
- One-tenth of the non-carcinogenic screening level is less than the carcinogenic screening level; therefore, the 1/10th non-carcinogenic value is presented.
- Value for 1,3-dichloropropene is presented.
- Value for acenaphthene is used as a surrogate value.
- Value for pyrene is used as a surrogate value.
- Value for Mercuric Chloride (and Other Mercury Salts) is presented.
- Value for Vanadium and Compounds is presented.

mg/Kg - milligrams per kilogram (dry weight)
 DRO - Diesel-range organics
 GRO - Gasoline-range organics
 PCBs - Polychlorinated biphenyls
 -- Not Available

Method References:

- SW846 - Test Methods for Evaluating Solid Wastes. EPA Office of Solid Waste. Third Edition, including all promulgated revisions.

**TABLE 4-3
 SOIL GAS - VOLATILE CONTAMINANTS OF CONCERN AND OTHER TARGET ANALYTES
 VOLATILE ORGANIC COMPOUNDS EPA METHOD TO-15 - LOW CONCENTRATION
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA, NEWPORT, RHODE ISLAND
 PAGE 1 OF 2**

Chemical	CAS Number	Method ⁽¹⁾	Project Action Limit (AF=0.01) ⁽²⁾ (µg/m3)	Project Action Limit (AF=0.1) ⁽³⁾ (µg/m3)	LOQ Goal (µg/m3)	Laboratory Limits		
						LOQ (µg/m3)	LOD (µg/m3)	DL (µg/m3)
Volatile Organic Compounds								
1,1,1-Trichloroethane	71-55-6	TO-15	2.20E+05	2.20E+04	7.30E+03	0.11	0.27	0.011
1,1,1,2-Tetrachloroethane	79-34-5	TO-15	4.2	0.42	0.14	0.14	0.34	0.014
1,1,2-Trichloroethane	79-00-5	TO-15	15	1.5	0.5	0.11	0.27	0.011
1,1-Dichloroethane	75-34-3	TO-15	5.00E+04	5.00E+03	1.70E+04	0.082	0.02	0.004
1,1-Dichloroethene	75-35-4	TO-15	2.00E+04	2.00E+03	6.66E+02	0.040	0.02	0.012
1,2,4-Trichlorobenzene	120-82-1	TO-15	2.00E+04	2.00E+03	6.60E+02	3.8	0.37	0.21
1,2,4-Trimethylbenzene	95-63-6	TO-15	600	60	20	0.50	0.25	0.11
1,2-Dibromoethane (EDB)	106-93-4	TO-15	1.1	0.11	0.037	0.78	0.38	0.14
1,2-Dichlorobenzene	95-50-1	TO-15	2.00E+04	2.00E+03	6.60E+02	0.61	0.3	0.13
1,2-Dichloroethane*	107-06-2	TO-15	9.4	0.94	0.31	0.08	0.02	0.008
1,2-Dichloropropane	78-87-5	TO-15	400	40	13	0.47	0.23	0.2
1,3,5-Trimethylbenzene	108-67-8	TO-15	600	60	20	0.50	0.25	0.044
1,3-Butadiene	106-99-0	TO-15	0.87	0.087	0.029	0.22	0.11	0.17
1,3-Dichlorobenzene	541-73-1	TO-15	1.10E+04	1.10E+03	366	0.61	0.3	0.11
1,4-Dichlorobenzene	106-46-7	TO-15	8.00E+04	8.00E+03	2.70E+03	0.61	0.3	0.14
2-Butanone (Methyl Ethyl Ketone)	78-93-3	TO-15	1.00E+05	1.00E+04	3.30E+03	0.30	0.29	0.18
2-Hexanone	591-78-6	TO-15	--	--	--	2.0	0.2	0.1
4-Ethyl Toluene	622-96-8	TO-15	--	--	--	0.50	0.25	0.11
4-Methyl-2-pentanone (Methyl Isobutyl Ketone)	108-10-1	TO-15	8000	800	266	0.42	0.2	0.078
Acrylonitrile	107-13-1	TO-15	3.6	0.36	0.12	1.10	NA	NA
Allyl Chloride (3-chloropropene)	107-05-1	TO-15	--	--	--	1.60	0.31	0.18
Benzene	71-43-2	TO-15	31	3.1	1.03	0.16	0.16	0.003
Benzyl chloride	100-44-7	TO-15	5	0.5	0.17	0.53	0.26	0.15
Bromodichloromethane	75-27-4	TO-15	14	1.4	0.47	0.68	0.34	0.11
Bromoform	75-25-2	TO-15	220	22	7.33	1.0	0.52	0.022
Bromomethane (Methyl Bromide)	74-83-9	TO-15	500	50	16.7	0.39	0.39	0.24
Carbon Tetrachloride	56-23-5	TO-15	16	1.6	0.53	0.64	3.1	0.21

**TABLE 4-3
 SOIL GAS - VOLATILE CONTAMINANTS OF CONCERN AND OTHER TARGET ANALYTES
 VOLATILE ORGANIC COMPOUNDS EPA METHOD TO-15 - LOW CONCENTRATION
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA, NEWPORT, RHODE ISLAND
 PAGE 2 OF 2**

Chemical	CAS Number	Method ⁽¹⁾	Project Action Limit (AF=0.01) ⁽²⁾ (µg/m3)	Project Action Limit (AF=0.1) ⁽³⁾ (µg/m3)	LOQ Goal (µg/m3)	Laboratory Limits		
						LOQ (µg/m3)	LOD (µg/m3)	DL (µg/m3)
Chlorobenzene	108-90-7	TO-15	6000	600	200	0.47	0.23	0.14
Chloroethane	75-00-3	TO-15	1.00E+06	1.00E+05	3.30E+04	0.27	0.26	0.26
Chloroform	67-66-3	TO-15	11	1.1	0.37	0.50	0.24	0.083
Chloromethane (Methyl Chloride)	74-87-3	TO-15	240	24	8	0.21	0.1	0.099
cis-1,2-Dichloroethene*	156-59-2	TO-15	3500	350	116	0.080	0.02	0.008
cis-1,3-Dichloropropene	10061-01-5	TO-15	61	6.1	2.03	0.46	0.23	0.1
Cyclohexane	110-82-7	TO-15	--	--	--	0.35	0.17	0.11
Dibromochloromethane	124-48-1	TO-15	--	--	--	0.86	0.43	0.25
Dichlorodifluoromethane (F12)	75-71-8	TO-15	2.00E+04	2.00E+03	6.60E+02	0.50	0.25	0.069
Dichlorotetrafluoroethane	76-14-2	TO-15	--	--	--	0.71	0.35	0.18
Ethylbenzene	100-41-4	TO-15	220	22	7.33	0.088	0.22	0.009
Heptane	142-82-5	TO-15	--	--	--	0.42	0.2	0.094
Hexachlorobutadiene	87-68-3	TO-15	11	1.1	0.37	5.4	0.53	0.4
Hexane	110-54-3	TO-15	2.00E+04	2.00E+03	6.60E+02	0.36	0.18	0.11
m,p-Xylene	179601-23-1	TO-15	7.00E+05	7.00E+04	2.30E+04	0.18	0.22	0.009
Methylene Chloride	75-09-2	TO-15	520	52	17.3	0.71	0.17	0.11
Methyl-tert-butyl ether	1634-04-4	TO-15	3.00E+05	3.00E+04	100	0.37	0.18	0.007
o-Xylene	95-47-6	TO-15	7.00E+05	7.00E+04	2.30E+04	0.088	0.22	0.009
Styrene	100-42-5	TO-15	1.00E+05	1.00E+04	3.30E+03	0.43	0.21	0.094
Tetrachloroethene	127-18-4	TO-15	81	8.1	2.7	0.14	0.34	0.014
Tetrahydrofuran	109-99-9	TO-15	--	--	--	1.5	0.15	0.25
Toluene	108-88-3	TO-15	4.00E+04	4.00E+03	1.30E+03	0.076	0.19	0.008
trans-1,2-Dichloroethene	156-60-5	TO-15	7000	700	233	0.40	0.2	0.012
trans-1,3-Dichloropropene	10061-02-6	TO-15	61	6.1	2.03	0.46	0.23	0.086
Trichloroethene*	79-01-6	TO-15	2.2	0.22	0.073	0.11	0.27	0.011
Trichlorofluoromethane	75-69-4	TO-15	7.00E+04	7.00E+03	2.30E+03	0.57	0.28	0.14
Trichlorotrifluoroethane	76-13-1	TO-15	--	--	--	0.78	0.38	0.18
Vinyl Bromide	593-60-2	TO-15	--	--	--	2.20	NA	NA
Vinyl Chloride	75-01-4	TO-15	28	2.8	0.93	0.026	0.13	0.008

* Compound is a site contaminant.

-- = Not available

(1) Laboratory may propose analysis in SIM mode to achieve LOQs or LODs below the Project Action Limit.

(2) EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway for Groundwater and Soils, November 2002, (EPA 2002)

(3) The PAL using attenuation factor of 0.1 is for comparison purposes only. It is anticipated that the EPA 2002 guidance document will be revised in the near future.

**TABLE 4-4
 FIELD SAMPLING QC SAMPLES
 ORGANIC AND INORGANIC ANALYSES, SOIL/SEDIMENT/GROUNDWATER
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Matrix / No. of Sample Locations:	Soil/43 Groundwater/8 Sediment/40					
QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Trip Blank	1 per cooler (VOCs and GRO only)	No target analytes > ½ QL (>QL for common laboratory contaminants), unless target analytes in field samples are > 10x those in trip blank.	Qualify data or re-sample	Data validator, Field Operations Leader (FOL)	Bias / contamination	No target analytes > ½ QL (>QL for common laboratory contaminants), unless target analytes in field samples are > 10x those in trip blank.
Rinsate Blank	1/20 field samples	No target analytes > ½ QL (>QL for common laboratory contaminants), unless target analytes in field samples are > 10x those in rinsate blank.	Qualify data or re-sample	Data validator, FOL	Bias / contamination	No target analytes > ½ QL (>QL for common laboratory contaminants), unless target analytes in field samples are > 10x those in rinsate blank.
Field Blank	1 per water source	No target analytes ≥ ½ QL (> QL for common laboratory contaminants)	Qualify data or re-sample	Data validator, FOL	Bias / contamination	No target analytes ≥ ½ QL (> QL for common laboratory contaminants)
Field Duplicates (Organic Analyses)	1/10 field samples	GW: RPD ≤ 30%. Soil: RPD ≤ 50%. If sample results are < 2x PQL, professional judgment is used.	Qualify data	Data validator	Precision	GW: RPD ≤ 30%. Soil: RPD ≤ 50%. If sample results are < 2x PQL, professional judgment is used.
Field Duplicates (Metals Analysis)	1/10 field samples	GW: RPD ≤ 30%. Soil: RPD ≤ 50%. For results < 5x PQL, absolute difference ≤ 2x PQL (GW) or ≤ 4x PQL (soil/sediment).	Qualify data	Data validator	Precision	GW: RPD ≤ 30%. Soil: RPD ≤ 50%. For results < 5x PQL, absolute difference ≤ 2x PQL (GW) or ≤ 4x PQL (soil/sediment).

Notes:

RPD = Relative Percent Difference

**TABLE 4-5
 LABORATORY SOIL/GROUNDWATER VOC QC SAMPLES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND
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Analysis/ Method:	VOCs/ EPA SW-846 Method 8260B					
Laboratory QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Temperature Blank	1 per cooler	>0°C – 6°C	Notify TtNUS Project Chemist or PM who will address the impact to the project and determine the appropriate action	Laboratory Sample Receiver, TtNUS Chemist or PM, Data Validator	Precision / Representativity / Bias	>0°C – 6°C
Method Blank	One every 12 hours prior to sample analysis	No target compounds > ½ RL except common lab contaminants which should be < RL	Reclean, retest, re-extract, reanalyze, and/or qualify data	Analyst, Laboratory Supervisor and Data Validator	Bias / Contamination	No target analytes > ½ RL (>RL for common laboratory contaminants), unless target analytes in field samples are > 10x those in method blank.
Storage Blank	1 per SDG	No target compounds ≥RL	Qualify data	Data Validator	Bias / Contamination	No target compounds ≥RL
Surrogates	4 per sample	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) Re-prepare and reanalyze for confirmation of matrix interference when appropriate. (2) If a duplicate or MS/MSD provides confirmation of matrix effect, no reanalysis necessary.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.
Laboratory Control Sample	One per batch of 20 or less	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) Evaluate and reanalyze if possible (2) If an MS/MSD was performed in the same 12 hour clock and acceptable, narrate. (3) If the LCS recoveries are high but the sample results are <QL, narrate otherwise reprepare and reanalyze, if holding time and sample volume remaining.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.
Internal Standards	3 per sample	Retention time ± 30 seconds; EICP area within -50% to +100% of last calibration verification (12 hours) for each IS	(1) Inspect mass spectrometer or GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning (2) If matrix affect demonstrated for a representative sample set, discuss with project chemist.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Retention time ± 30 seconds; EICP area within -50% to +100% of last calibration verification (12 hours) for each IS

**TABLE 4-5
 LABORATORY SOIL/GROUNDWATER VOC QC SAMPLES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND
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Analysis/ Method:	VOCs/ EPA SW-846 Method 8260B					
Laboratory QC Sample:	Frequency/ Number	Laboratory QC Sample:	Frequency/ Number	Laboratory QC Sample:	Frequency/ Number	Laboratory QC Sample:
Matrix spike / Matrix spike duplicate	One per SDG or every 20 samples.	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met (2) If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.

Notes:

PQL = Project Quantitation Limit
 RL = Reporting Limit

QL = Quantitation Limit
 MS/MSD = Matrix Spike/Matrix Spike Duplicate

**TABLE 4-5A
 LABORATORY SOIL GAS VOC QC SAMPLES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Analysis/ Method:	VOCs/ Method TO-15					
Laboratory QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Tuning Criteria	Every 12 hours	SW – 846 tune criteria.	Lab analyst will correct problem then repeat tune.	Analyst, Laboratory		SW – 846 tune criteria
Method Blank	One every 12 hours prior to sample analysis	No target compounds > ½ PQL except common lab contaminants which should be < RL	Inspect system and reanalyze, and/or qualify data	Analyst, Laboratory Supervisor and Data Validator	Bias / Contamination	No target compounds > ½ PQL except common lab contaminants which should be < RL
Surrogates	3 per sample, standard and blank	70 - 130%.	For blanks: inspect the system and reanalyze the blank. For samples: re-analyze the sample unless obvious matrix interference is documented. If the %R is within limits in the reanalysis, report the second analysis. If %R is out-of-limits a second time, then narrate results.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	70 - 130%.
Laboratory Control Sample	After each initial calibration curve, and daily, prior to sample analysis.	Recoveries for 90% of "Standard" compounds must be 70-130%; for 80% of "Non-standard" compounds, recoveries must be 60-140%. No recovery may be <50%.	Check the system and reanalyze the standard. Re-prepare the standard if necessary. Recalibrate the instrument if the criteria cannot be met.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Recoveries for 90% of "Standard" compounds must be 70-130%; for 80% of "Non-standard" compounds, recoveries must be 60-140%. No recovery may be <50%.
Internal Standards	3 per sample, standard and blank	Retention time for blanks and samples must be within ± 0.33 minutes of the RT in the CCV and within ± 40% of the area counts of the daily CCV internal standards.	For blanks: inspect the system and reanalyze the blank. For samples: re-analyze the sample. If the ISS are within limits in the re-analysis, report the second analysis. If ISS are out-of-limits a second time, dilute the sample until ISS are within acceptance limits and narrate.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Retention time for blanks and samples must be within ± 0.33 minutes of the RT in the CCV and within ± 40% of the area counts of the daily CCV internal standards.

Notes:

PQL = Project Quantitation Limit QL = Quantitation Limit
 RL = Reporting Limit MS/MSD = Matrix Spike/Matrix Spike Duplicate

Note: The information contained in this table may be altered after a laboratory is procured.

**TABLE 4-6
 LABORATORY SOIL/GROUNDWATER PAH QC SAMPLES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Analysis/ Method:		SVOCs/ EPA SW-846 Method 8270C				
Laboratory QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Temperature Blank	1 per cooler	>0°C – 6°C	Notify TtNUS Project Chemist or PM who will address the impact to the project and determine the appropriate action	Laboratory Sample Receiver, TtNUS Chemist or PM, Data Validator	Precision / Representatively/ Bias	>0°C – 6°C
Method Blank	One per batch of 20 or less	No target compounds > ½ RL except common lab contaminants which should be < RL	Reclean, retest, re-extract, reanalyze, and/or qualify data	Analyst, Laboratory Supervisor and Data Validator	Bias / Contamination	No target analytes > ½ RL (>RL for common laboratory contaminants), unless target analytes in field samples are > 10x those in method blank.
Surrogates	6 per sample	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) Re-prepare and reanalyze for confirmation of matrix interference, when appropriate. (2) If a duplicate or MS/MSD provides confirmation of matrix effect, no reanalysis necessary.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.
Laboratory Control Sample (LCS)	One per batch of 20 or less	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) Evaluate and reanalyze if possible (2) If an MS/MSD was performed in the same 12 hour clock and acceptable narrate. (3) If the LCS recoveries are high but the sample results are <QL narrate otherwise reprep and reanalyze, if holding time and sample volume remaining.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.
Internal Standards	6 per sample	Retention time ± 30 seconds; EICP area within -50% to +100% of last calibration verification (12 hours) for each IS	(1) Inspect mass spectrometer or GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning (2) If matrix affect demonstrated for a representative sample set, discuss with project chemist.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Retention time ± 30 seconds; EICP area within -50% to +100% of last calibration verification (12 hours) for each IS

Analysis/ Method:		SVOCs/ EPA SW-846 Method 8270C				
Laboratory QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Matrix spike / Matrix spike duplicate	One per SDG or every 20 samples.	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met (2) If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.

Notes:

RPD = Relative Percent Difference
 PQL = Project Quantitation Limit

RL = Reporting Limit
 QL = Quantitation Limit

MS/MSD = Matrix Spike/Matrix Spike Duplicate

**TABLE 4-7
 LABORATORY SOIL PCBs QC SAMPLES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Analysis/ Method:	Pesticides/EPA SW-846 Method 8081; PCBs/EPA SW-846 Method 8082					
Laboratory QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Temperature Blank	1 per cooler	>0°C – 6°C	Notify TtNUS Project Chemist or Project Manager who will address the impact to the project and determine the appropriate action	Laboratory Sample Receiver, TtNUS Chemist or PM, Data Validator	Precision / Representativity/ Bias	>0°C – 6°C
Method Blank	One per 20 samples or less	No target compounds > ½ RL except common lab contaminants which should be < RL	Reclean, retest, re-extract, reanalyze, and/or qualify data	Analyst, Laboratory Supervisor and Data Validator	Bias / Contamination	No target analytes > ½ RL (>RL for common laboratory contaminants), unless target analytes in field samples are > 10x those in method blank.
Surrogates	2 per sample (DCB only for 8082)	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) Reprep and reanalyze for confirmation of matrix interference when appropriate.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.
Laboratory Control Sample (LCS)	One per 20 samples or less	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) Evaluate and reanalyze if possible (2) If an MS/MSD was performed in the same 12 hour clock and acceptable narrate. (3) If the LCS recoveries are high but the sample results are <QL narrate otherwise reprep and reanalyze, if holding time and sample volume remaining.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.
Matrix spike (MS) / Matrix spike duplicate (MSD)	One per Sample Data Group (SDG) or every 20 samples.	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.	(1) CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met (2) If both the LCS and MS/MSD are unacceptable reprep the samples and QC.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	Limits as provided by DoD QSM version 4 Appendix G. If not available, laboratory limits will be used.

Notes:

RPD = Relative Percent Difference RL = Reporting Limit MS/MSD = Matrix Spike/Matrix Spike Duplicate

PQL = Project Quantitation Limit QL = Quantitation Limit

TABLE 4-8
LABORATORY SOIL METALS LABORATORY QC SAMPLES
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, RHODE ISLAND

Analysis/Method:		TAL Metals/ EPA SW-846 Methods 6010B/7471A				
QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	One per digestion batch of 20 or fewer samples.	No target compounds > ½ RL except common lab contaminants which should be < RL	1) Investigate source of contamination. Redigest and reanalyze all associated samples if sample concentration ≥ RL and <10x the blank concentration.	Laboratory Supervisor	Bias / Contamination	No target analytes > ½ RL (>RL for common laboratory contaminants), unless target analytes in field samples are > 10x those in method blank.
Laboratory Control Sample (LCS)	One per digestion batch of 20 or fewer samples.	Recovery within ± 20% of true value, unless vendor-supplied or statistical limits have been established.	1) Investigate source of problem. 2) Redigest and reanalyze all associated samples, if holding time and sample volume remaining.	Laboratory Supervisor	Accuracy / Bias / Contamination	Recovery within ± 20% of true value, unless vendor-supplied or statistical limits have been established.
Laboratory Duplicate Sample	One per digestion batch of 20 or fewer samples.	RPD ≤20%	Qualify results	Analyst, Laboratory Supervisor and Data Validator	Precision	RPD ≤20%
Matrix Spike (MS)	One per digestion batch of 20 or fewer samples.	Recovery ± 20% of true value, if sample < 4x spike added.	Qualify results.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	Recovery ± 20% of true value, if sample < 4x spike added.
ICP Serial Dilution	One per digestion batch.	If original sample result is at least 50x LOQ, 5-fold dilution must agree within ± 10% of the original result.	Qualify result or dilute and reanalyzed sample to eliminate interference.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	If original sample result is at least 50x LOQ, 5-fold dilution must agree within ± 10% of the original result.

Notes:

- RPD = Relative Percent Difference
- PQL = Project Quantitation Limit
- RL = Reporting Limit
- QL = Quantitation Limit
- MS/MSD = Matrix Spike/Matrix Spike Duplicate

**TABLE 4-9
 GROUNDWATER METALS LABORATORY QC SAMPLES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Method Blank	One per digestion batch of 20 or fewer samples.	No target compounds > ½ RL except common lab contaminants which should be < RL	1) Investigate source of contamination. Redigest and reanalyze all associated samples if sample concentration ≥ RL and <10x the blank concentration.	Laboratory Supervisor	Bias / Contamination	No target analytes > ½ RL (> RL for common laboratory contaminants), unless target analytes in field samples are > 10x those in method blank.
Laboratory Control Sample (LCS)	One per digestion batch of 20 or fewer samples.	Recovery within ± 20% of true value.	1) Investigate source of problem. 2) Redigest and reanalyze all associated samples, if holding time and sample volume remaining.	Laboratory Supervisor	Accuracy / Bias / Contamination	Recovery within ± 20% of true value.
Laboratory Duplicate Sample	One per digestion batch of 20 or fewer samples.	RPD ≤20%	Qualify results	Analyst, Laboratory Supervisor and Data Validator	Precision	RPD ≤20%..
Matrix Spike (MS)	One per digestion batch of 20 or fewer samples.	Recovery ± 20% of true value, if sample < 4x spike added.	Qualify results.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	Recovery ± 20% of true value, if sample < 4x spike added.
ICP Serial Dilution	One per digestion batch.	If original sample result is at least 50x LOQ, 5-fold dilution must agree within ± 10% of the original result.	Qualify result or dilute and reanalyze sample to eliminate interference.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	If original sample result is at least 50x LOQ, 5-fold dilution must agree within ± 10% of the original result.

Notes:

- RPD = Relative Percent Difference
- PQL = Project Quantitation Limit
- RL = Reporting Limit
- QL = Quantitation Limit
- MS/MSD = Matrix Spike/Matrix Spike Duplicate

**TABLE 4-10
 SOIL GRO/DRO LABORATORY QC SAMPLES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Analysis/ Method:	GRO/DRO/EPA SW-846 Method 8015B					
Laboratory QC Sample:	Frequency /Number	Method/SOP QC Acceptance Limits	Corrective Action (CA)	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
Temperature Blank	1 per cooler	>0°C – 6°C	Notify TtNUS Project Chemist or PM who will address the impact to the project and determine the appropriate action	Laboratory Sample Receiver, TtNUS Chemist or PM, Data Validator	Precision / Representativity / Bias	>0°C – 6°C
Method Blank	One per batch of 20 or less, prior to sample analysis	No target compounds $\geq \frac{1}{2}$ RL	Reclean, retest, re-extract, reanalyze, and/or qualify data	Analyst, Laboratory Supervisor and Data Validator	Bias / Contamination	No target analytes > $\frac{1}{2}$ RL, unless target analytes in field samples are > 10x those in method blank.
Surrogates	1 per sample	50%-150% Recovery.	(1) Reprepare and reanalyze for confirmation of matrix interference when appropriate.	Analyst, Laboratory Supervisor and Data Validator	Accuracy / Bias	50%-150% Recovery.
Laboratory Control Sample (LCS)/ Laboratory Control Sample Duplicate (LCSD)	One per batch of 20 or less	50%-150% Recovery.	(1) Evaluate and reanalyze if possible (2) If an MS/MSD was performed in the same 12 hour clock and acceptable, narrate. (3) If the LCS recoveries are high but the sample results are <RL, narrate otherwise reprepare and reanalyze, if holding time and sample volume remaining.	Analyst, Laboratory Supervisor and Data Validator	Precision / Accuracy / Bias	50%-150% Recovery.

Notes:

- RPD = Relative Percent Difference
- PQL = Project Quantitation Limit
- RL = Reporting Limit
- QL = Quantitation Limit
- MS/MSD = Matrix Spike/Matrix Spike Duplicate

**TABLE 4-11
 ANALYTICAL INSTRUMENT CALIBRATION
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference ¹
Gas Chromatography/ Mass Spectroscopy (GC/MS)	Minimum five point calibration for all analytes	Instrument receipt, instrument change (new trap, column, etc.), when CCV does not meet criteria or when manual tune performed.	RSD for each CCC < 30%, minimum mean RF for each SPCC as noted in 7.3.5 of method 8260B or 7.3.4 of method 8270C. If RSD for an analyte is > 15%, Linear correlation coefficient >0.995, Quadratic correlation coefficient >0.99 (min. 6 pts)	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP201/SOP202
Gas Chromatography/ Electron Capture Detector (GC/ECD)	Minimum five point calibration for all analytes	Instrument receipt, instrument change (column, etc.), when CCV does not meet criteria.	20% RSD, Linear correlation coefficient >0.995, Quadratic correlation coefficient >0.99 min. 6 pts	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP211
Gas Chromatography/ Flame Ionization Detector (GC/FID)	Minimum five point calibration for all analytes	Instrument receipt, instrument change (column, etc.), when CCV does not meet criteria.	20% RSD, Linear correlation coefficient >0.995, Quadratic correlation coefficient >0.99 min. 6 pts	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP219
Inductively Coupled Plasma (ICP)	Minimum one high standard and a calibration blank.	At the beginning of each day or if QC is out of criteria.	One point calibration per manufacturer's guidelines; analytes run at their calibration levels must fall within 90-110% of True Values	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards.	Analyst/ Supervisor	SOP105
Flow Injection Mercury System (FIMS)	Minimum five point calibration and a calibration blank.	At the beginning of each day or if QC is out of criteria.	Correlation coefficient ≥ 0.995	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards.	Analyst/ Supervisor	SOP103/SOP104

Notes:

- ¹ Refer to laboratory SOPs include in Appendix E
 QC – Quality Control
 CCC - Continuing calibration compound
 RSD – Relative Standard Deviation
 CCV – Continuing calibration verification

SPCC– System performance check compounds
SOP – Standard Operating Procedure

**TABLE 4-12
 ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference ¹
Gas Chromatography/ Mass Spectroscopy (GC/MS)	Check pressure and gas supply daily. Bake out trap and column, manual tune if BFB not in criteria, change septa as needed, cut column as needed, change trap as needed.	VOC Analysis	Initial Calibration	Instrument receipt, instrument change (new trap, column, etc.), when CCC does not meet criteria or when manual tune per.	RSD for each CCC \leq 30%, minimum mean RF for each SPCC as noted in 7.3.5 of method 8260B. If RSD for an analyte is > 15%, Linear correlation coefficient >0.995, Quadratic correlation coefficient >0.99 (min. 6 pts)	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP202
	Same as above	VOC Analysis	Initial Calibration Verification (2 nd Source)	Immediately following initial calibration and prior to sample analysis.	20 %D	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP202
	Same as above	VOC Analysis	Continuing Calibration	At beginning of each 12 hour shift immediately following BFB tune.	%D for each CCC \leq 20%, minimum RF for each SPCC as noted in 7.3.5 of method 8260B.	If %D is high and sample result is ND, qualify/narrate with project approval. If %D is low or project approval not received, reanalyze all samples since last successful CCV.	Analyst/ Supervisor	SOP202

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference ¹
Gas Chromatography/ Mass Spectroscopy (GS/MS)	Check pressure and gas supply daily. Bake out column, manual tune if DFTPP not in criteria, change septa as needed, cut column as needed.	SVOC Analysis	Initial Calibration	Instrument receipt, instrument change (new column, etc.), when CCV does not meet criteria or when manual tune per.	RSD for each CCC \leq 30%, minimum mean RF for each as noted in 7.3.4 of method 8270C. If RSD for an analyte is $>$ 15%, Linear correlation coefficient $>$ 0.995, Quadratic correlation coefficient $>$ 0.99 (min. 6 pts)	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP201
	Same as above	SVOC Analysis	Initial Calibration Verification (2 nd Source)	Immediately following initial calibration and prior to sample analysis.	20 %D	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP201
	Same as above	SVOC Analysis	Continuing Calibration	At beginning of each 12 hour shift immediately following DFTPP tune.	%D for each CCC \leq 20%, minimum RF for each SPCC as noted in 7.3.4 of method 8270C.	If %D is high and sample result is ND, qualify/narrate with project approval. If %D is low or project approval not received, reanalyze all samples since last successful CCV.	Analyst/ Supervisor	SOP201
Inductively Coupled Plasma (ICP)	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, replace peristaltic pump tubing as needed.	Metals Analysis	Initial Calibration	At the beginning of each day or if QC is out of criteria.	ICP uses single point calibration. If three point plus blank, linear Correlation coefficient \geq 0.995.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards	Analyst/ Supervisor	SOP105

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference ¹
	Same as above.	Metals Analysis	Initial Calibration Verification/ Continuing Calibration Verification	Immediately after instrument calibration (2 nd Source) then after every 10 samples and at end of analytical sequence.	90-110% of true value for ICP	Check problem, recalibrate and reanalyze all samples since last successful CCV. If %D > 110% and sample result is ND, narrate with project approval.	Analyst/ Supervisor	SOP105
Gas Chromatography/ Electron Capture Detector (GC/ECD)	Check pressure and gas supply daily. Bake out column, change septa as needed, cut column as needed.	Pest/PCBs	Initial Calibration	Instrument receipt, instrument change (new column, etc.), when CCV does not meet criteria	20% RSD, Linear Correlation coefficient ≥0.995, Quadratic Correlation coefficient >0.99 min. 6 pts.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP211
	Same as above	Pest/PCBs	Initial Calibration Verification (2 nd Source)	Immediately following initial calibration and prior to sample analysis.	20 %D	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP211
	Same as above	Pest/PCBs	Continuing Calibration Verification	Prior to sample analysis, after every 10 field samples and at the end of the analytical sequence.	20 %D	If %D is high and sample result is ND, qualify/narrate with project approval. If %D is low or project approval not received, reanalyze all samples since last successful CCV.	Analyst/ Supervisor	SOP211
Gas Chromatography/ Flame Ionization Detector (GC/FID)	Check pressure and gas supply daily. Bake out column, change septa as needed, cut column as needed.	TPH GRO/DRO	Initial Calibration	Instrument receipt, instrument change (new column, etc.), when CCV does not meet criteria	20% RSD, Linear Correlation coefficient ≥0.995, Quadratic Correlation coefficient >0.99 min. 6 pts.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP219

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference ¹
	Same as above	Pest/PCBs	Initial Calibration Verification (2 nd Source)	Immediately following initial calibration and prior to sample analysis.	20 %D	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst/ Supervisor	SOP219
	Same as above	TPH GRO/DRO	Continuing Calibration	Prior to sample analysis, after every 10 field samples and at the end of the analytical sequence.	20 %D	If %D is high and sample result is ND, qualify/narrate with project approval. If %D is low or project approval not received, reanalyze all samples since last successful CCV.	Analyst/ Supervisor	SOP219
Flow Injection Mercury System (FIMS)	Change tubing, change filter, clean windows, check gas flow, check reagents and standards	Hg Analysis	Initial Calibration	At the beginning of each day or when QC is outside criteria	R ≥ 0.995	Recalibrate and/or perform necessary maintenance, check calibration standards	Analyst/ Supervisor	SOP103/SOP104
	Same as above	Hg Analysis	Initial Calibration Verification (2 nd source)/ Continuing Calibration Verification	Immediately after instrument calibration (2 nd Source) then after every 10 samples and at end of analytical sequence.	90%-110% of true value for the ICV and 80%-120% of true value for CCV	Check problem, recalibrate and reanalyze all samples since last successful CCV. If %D > 120% and sample result is ND, narrate with project approval.	Analyst/ Supervisor	SOP103/SOP104

Notes:

¹ Refer to laboratory SOPs include in Appendix E
 %D – percent difference
 RSD – Relative Standard Deviation
 CCC- Continuing calibration compound
 BFB – Bromofluorobenzene
 DFTPP - Decafluorotriphenylphosphine
 QC – Quality Control
 QC – Quality Control
 CCC- Continuing calibration compound
 RSD – Relative Standard Deviation
 CCV – Continuing calibration verification

SPCC – System performance check compounds
 SOP – Standard Operating Procedure
 CAS – Columbia Analytical Services
 SVOC – Semivolatile Organic Compounds
 VOC – Volatile Organic Compounds
 RF – Response factor
 PCB – Polychlorinated biphenyls
 MS – Mass Spectroscopy
 Hg – Mercury
 R – Correlation Coefficient
 ICV – Initial calibration verification

**TABLE 4-13
 ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Timeframe for Response
Field sampling system audit	Audit checklist and written audit finding summary	PM TtNUS, FOL TtNUS, and Program management TtNUS	Dependant on findings, if major a stop work maybe issued immediately, however if minor within 1 week of audit	Written memo	QAM TtNUS, Auditor TtNUS, Program Manager TtNUS	Within 4 weeks of notification
Laboratory systems Audit	Written audit report	Laboratory QAM	Not specified by NFESC	Letter	NFESC	Specified by NFESC

TABLE 4-14
QA MANAGEMENT REPORTS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, RHODE ISLAND

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Data Validation Report	Per sample delivery group (SDG)	Once validation is complete	Tetra Tech DVM or designee	Tetra Tech PM, project file
Major Analysis Problem Identification (internal memo)	When persistent analysis problems are detected	Immediately	Tetra Tech CLEAN QAM	Tetra Tech PM, CLEAN QAM, Program Manager, and project file
Laboratory QA Report	When significant plan deviations result from unanticipated circumstances	Immediately	Laboratory QAM	Tetra Tech PM, project file

**TABLE 5-1
 VERIFICATION PROCESS
 ON SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, RHODE ISLAND**

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Sample Tables	Proposed samples verified to have been collected and are documented on the chain of custody forms.	Internal	FOL or Designee TtNUS
Sample Coordinates	Sample locations have been verified to be correct and in accordance with the QAPP (overlay maps proposed locations against actual locations)	Internal	FOL or Designee TtNUS
Data Package	Verify that the data package contains all the elements required by the scope of work, this occurs as part of the data validation process	Internal	Data validator, TtNUS
Sample Logsheets	Logsheets completed by field personnel as the samples are collected are verifies for accuracy, completeness and are compiled for inclusion in the final SI report	Internal	PM, or Designee TtNUS

FIGURES



BASE MAP IS A PORTION OF THE FOLLOWING 7.5 X 15 MINUTE U.S.G.S. QUADRANGLE:
 PRUDENCE ISLAND, RHODE ISLAND, 1955, PHOTOREVISED 1970 AND 1975



QUADRANGLE LOCATION

SITE LOCUS	
STUDY AREA SCREENING EVALUATION	
ON-SHORE DERECKTOR SHIPYARD	
NAVSTA NEWPORT, RHODE ISLAND	
DRAWN BY:	D. W. MACDOUGALL
CHECKED BY:	T. CAMPBELL
SCALE:	AS NOTED
REV.:	0
DATE:	OCTOBER 5, 2010
ACAD NAME:	\02125\PP.DR\DER_LOCUS.DWG

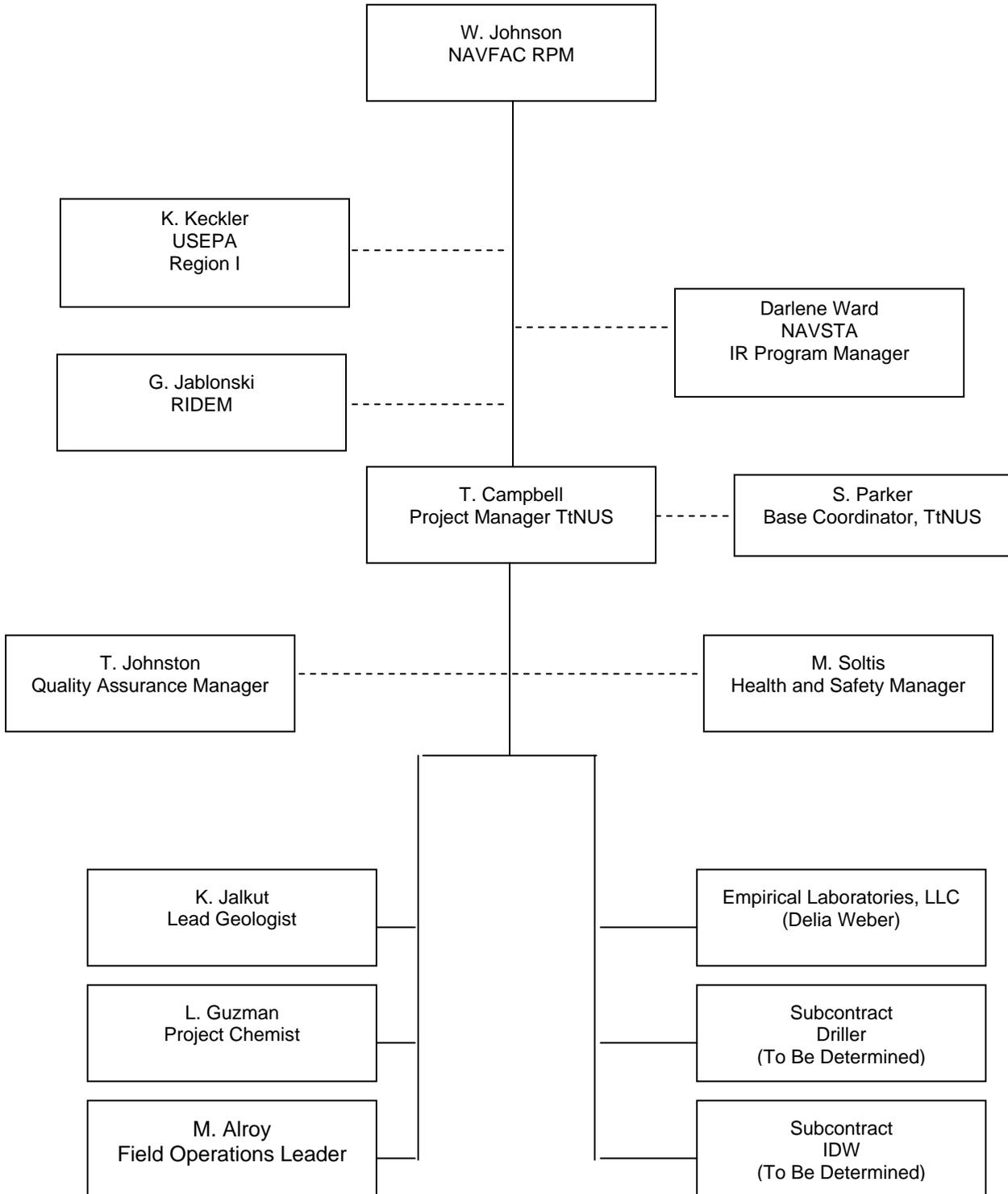
FIGURE 1-1A

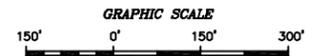
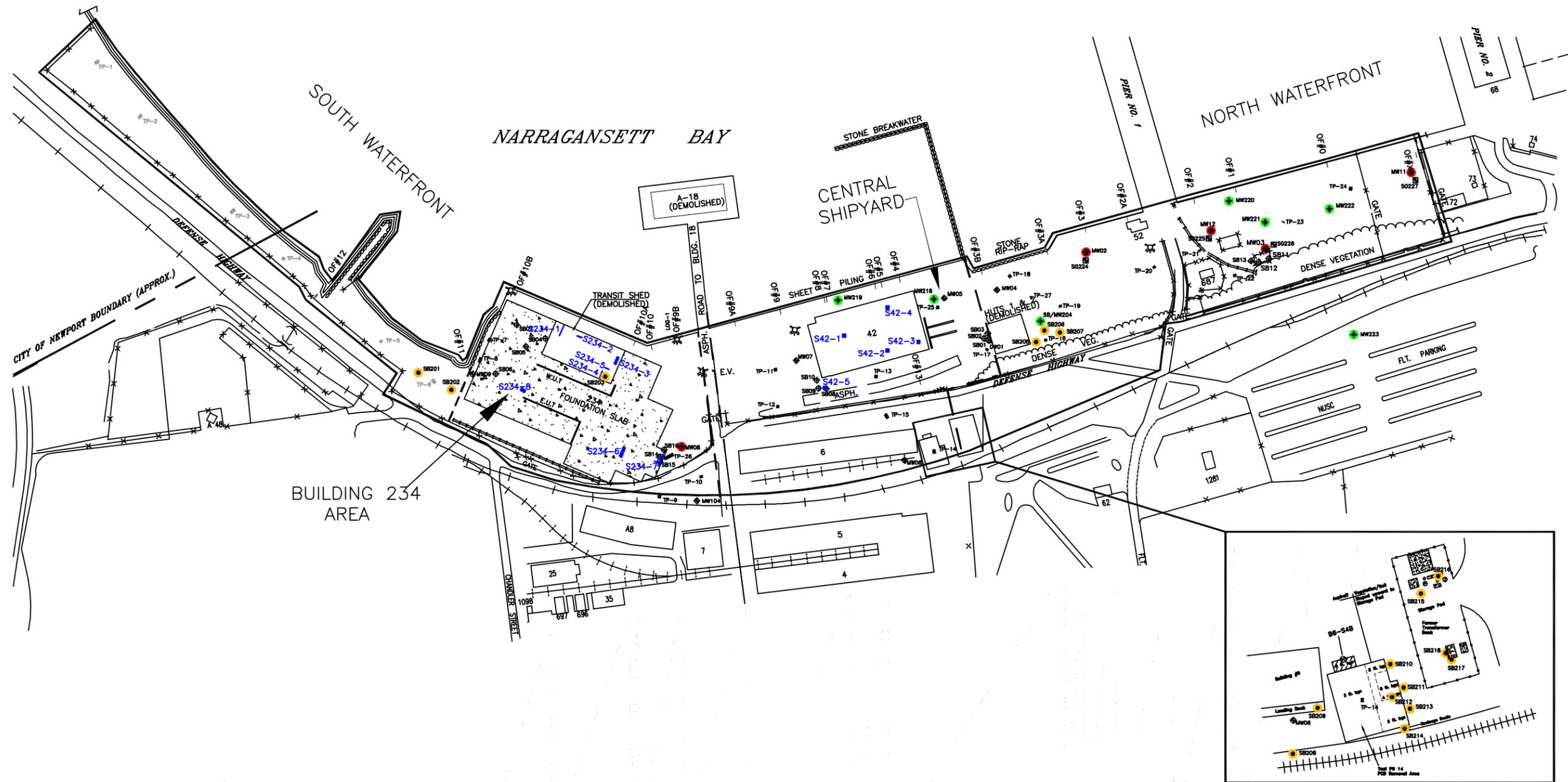
TETRA TECH NUS, INC.

55 Jonspin Road Wilmington, MA 01887
 (978)474-8400

FIGURE 1-2

PROJECT ORGANIZATIONAL CHART
ON SHORE DERECKTOR
NAVSTA NEWPORT, RHODE ISLAND



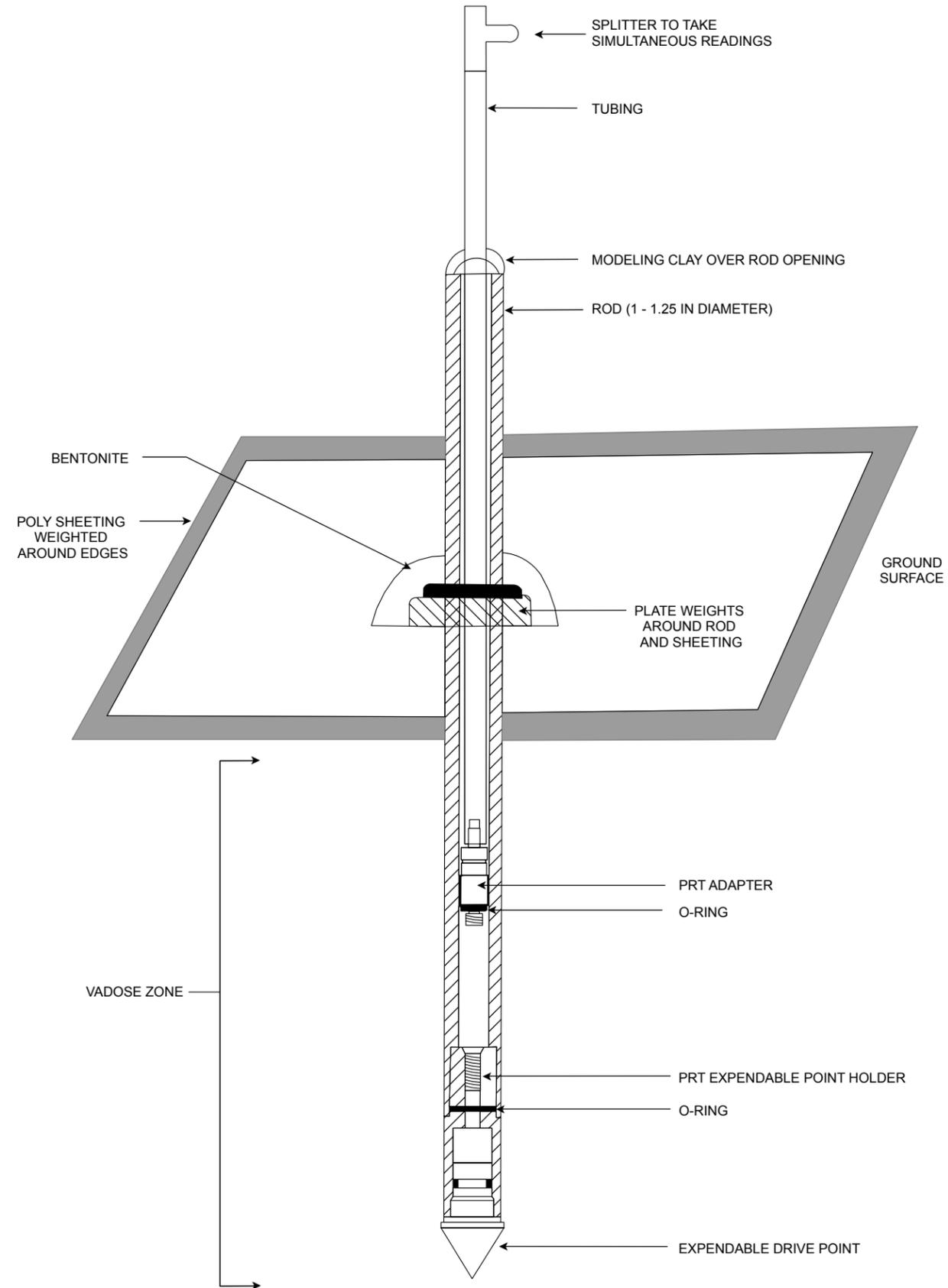


NOTES:
 1. ALL LOCATIONS TO BE CONSIDERED APPROXIMATE.
 2. PLAN NOT TO BE USED FOR DESIGN.
 3. COMPILED FROM ACTUAL FIELD SURVEY PLAN BY LOUIS FEDERICI & ASSOC., PROVIDENCE, RI AND U.S. NAVY PLANS

LEGEND		BUILDING AND NUMBER		PROPOSED SOIL BORING	
	FENCE		A-18		PROPOSED SOIL BORING
	SUMP WITH IDENTIFIER		SB16		PROPOSED MONITORING WELL
	OUTFALL LOCATION WITH IDENTIFIER		TP-5		EXISTING MONITORING WELL TO BE SAMPLED
	HYDRANT LOCATION		MW11		PROPOSED SOIL GAS SAMPLE LOCATION

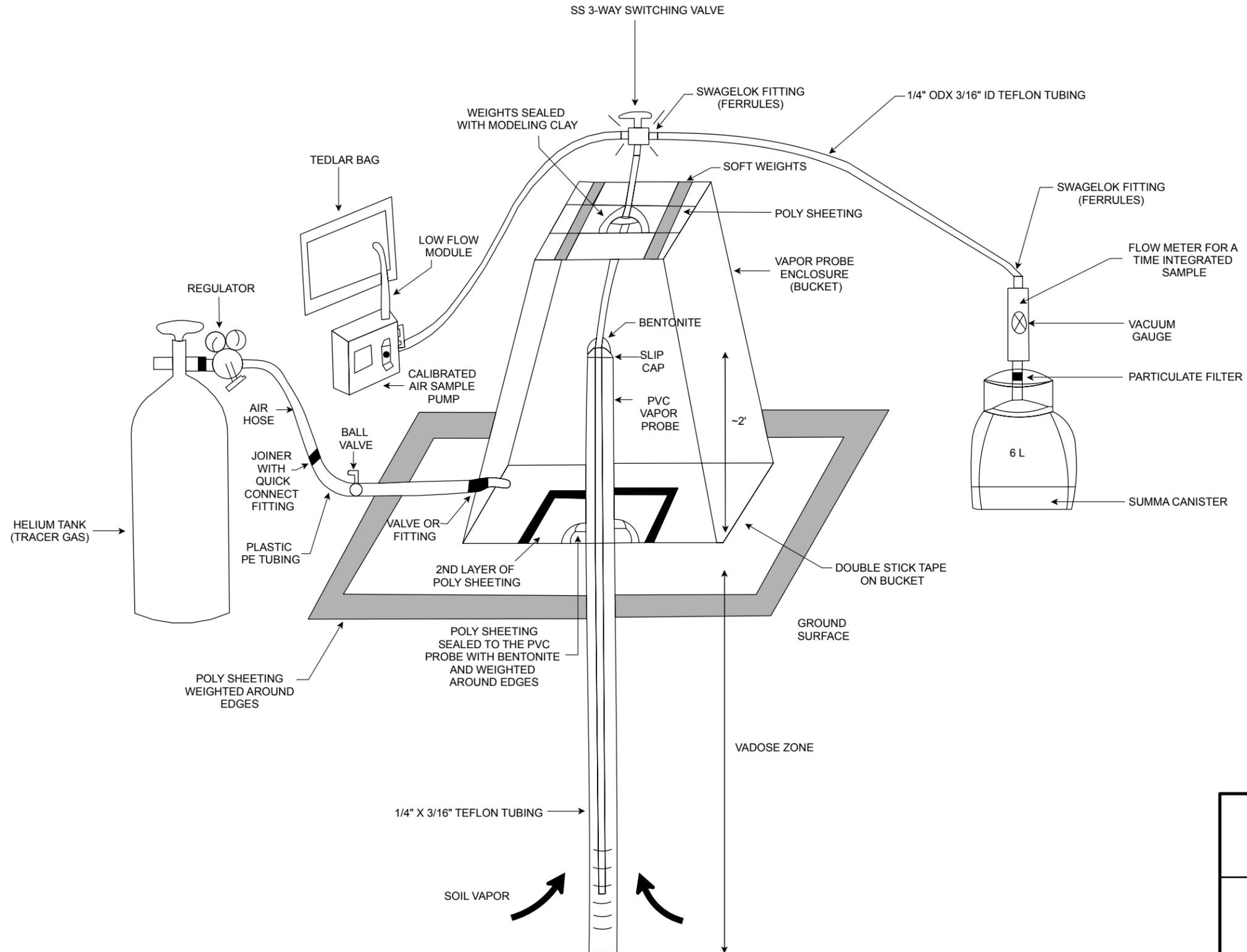
DRAWN BY: D.W. MACDOUGALL	TITLE: PROPOSED SAMPLE LOCATIONS STUDY AREA SCREENING EVALUATION ON-SHORE DERECKTOR SHIPYARD NAVSTA NEWPORT, RHODE ISLAND		
PREPARED BY: T. CAMPBELL	SOURCE: BASE PLAN BY SEE NOTE 3		
CHECKED BY: T. CAMPBELL	SCALE: AS NOTED	DATE: DECEMBER 2, 2010	PROJ. NO: 02125
PROJECT MANAGER: S. PARKER	DRAWING NO: 3-2A	ACFILE NAME: \2125\PP\FIGURE 3-2A.DWG	REV: 1
PROGRAM MANAGER: J. TREPANOWSKI			

TETRA TECH
 250 ANDOVER STREET SUITE 200
 WILMINGTON, MASSACHUSETTS 01887
 (978)658-7899



Note: Drawing not to scale.

 Tetra Tech NUS, Inc.	
TYPICAL PRT SYSTEM CROSS-SECTION FOR SOIL VAPOR FIELD SCREENING STUDY AREA SCREENING EVALUATION WORK PLAN ADDENDUM ON-SHORE DERECKTOR SHIPYARD NAVSTA NEWPORT, RHODE ISLAND	
FILE	PRT_SYSTEM_CROSS_SECTION.MXD
SCALE	AS NOTED
FIGURE NUMBER	FIGURE NO. 3-7
REV	0
DATE	10/05/10



Note: Drawing not to scale.

 Tetra Tech NUS, Inc.	
SOIL VAPOR PROBE SAMPLING SCHEMATIC STUDY AREA SCREENING EVALUATION WORK PLAN ADDENDUM ON-SHORE DERECKTOR SHIPYARD NAVSTA NEWPORT, RHODE ISLAND	
FILE	SCALE
SOIL_VAPOR_PROBE.MXD	AS NOTED
FIGURE NUMBER	REV
FIGURE NO. 3-8	0
	DATE
	10/04/10

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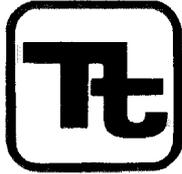
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APPENDIX A
SELECTED FIELD STANDARD OPERATING PROCEDURES



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	GH-1.5	Page	1 of 20
Effective Date	06/99	Revision	1
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>DS</i>		

Subject
BOREHOLE AND SAMPLE LOGGING

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	Revision 1	Effective Date 06/99

1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

Subject BOREHOLE AND SAMPLE LOGGING	Number GH-1.5	Page 6 of 20
	Revision 1	Effective Date 06/99

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).

This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inch Φ -1/2 inch Φ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

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Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

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5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite (CaCO_3). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

FIGURE 4**GRAIN SIZE CLASSIFICATION FOR ROCKS**

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

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5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the words "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

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The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

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5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

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5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine-grained
Tr - Trace		

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.
- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)



BORING LOG

PROJECT NAME: NSB - SITE BORING NUMBER: SB/MW1
 PROJECT NUMBER: 9594 DATE: 3/8/96
 DRILLING COMPANY: SOILTEST CO. GEOLOGIST: SJ CONTI
 DRILLING RIG: CME-55 DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION			U S C S *	Remarks	PID/FID Reading (ppm)			
					Soil Density/ Consistency or Rock Hardness	Color	Material Classification			Sample	Sampler BZ	Borehole**	Driller BZ**
S-1 e 0800	0.0 2.0	7 6 10	1.5/2.0		M DENSE	BRN TO BLK	SILTY SAND - SOME ROCK FR. - TR BRICKS (FILL)	SM	MOIST SL. ORG. ODOR FILL TO 4'±	5	0	0	0
S-2 e 0810	4.0 6.0	5 7 8	2.9/2.0	4.0	M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE SB01-0406 FOR ANALYSIS	10	0	-	-
S-3 e 0820	8.0 10.0	6 8 17 16	1.9/2.0	7.0 8.0	DENSE	TAN BRN	FINE TO COARSE SAND TR. F. GRAVEL	SW	WET HIT WATER: 7'±	0	0	0	0
S-4 e 0830	12.0 14.0	7 6 8	1.6/2.0	12.0	STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	5	-	-
	15.0			15.0					AUGER REF @ 15'				
	16.0			16.0	M HARD	BRN	SILTSTONE	VER	WEATHERED				
	17.0			17.0					LO *JNTS @ 15.5 WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
	18.0			18.0					LOSING SOME				
	19.0			19.0	HARD	GRAY	SANDSTONE - SOME SILTSTONE	BR	DRILL H2O @ 17'±				
	20.0			20.0					SET TEMP 6" CAS TO 15.5				
	21.0			21.0					SET 2 1/2" Ø PVC SCREEN 16-25	0	0	0	0
	22.0			22.0					SAND 14-25				
	23.0			23.0					PELLETS 12-14				

* When rock coring, enter rock brokenness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Remarks: CME-55 RIG, 4 1/4" ID HSA - 9" OD ± • 1-20Z Drilling Area
 2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP 1-80Z Background (ppm):
 NIX CORE IN BEDROCK RUN (1) = 25 min, RUN (2) = 15 min

Converted to Well: Yes No Well I.D. #: MW-1

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- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:
 - Trace: 0 - 10 percent
 - Some: 11 - 30 percent
 - And/Or: 31 - 50 percent
- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:
 - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.
 - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
 - Particle shape - flat, elongated, or flat and elongated.
 - Maximum particle size or dimension.
 - Water level observations.
 - Reaction with HCl - none, weak, or strong.
- Additional comments:
 - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
 - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.
 - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.
 - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

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- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.
- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.
- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.
- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.
- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.
- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.
- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.
- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
 - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
 - Indicate calcareous zones, description of any cavities or vugs.
 - Indicate any loss or gain of drill water.
 - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
 - Type and size of core obtained.
 - Depth casing was set.
 - Type of rig used.
- As a final check the boring log shall include the following:
 - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
 - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

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5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

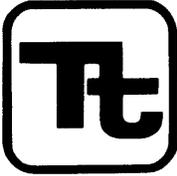
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ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.



TETRA TECH NUS,
INC.

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
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Subject
SAMPLE NOMENCLATURE

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix
- Sorting of data by depth
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints (maximum of 20 characters)

2.0 SCOPE

The methods described in this SOP shall be used consistently for all projects requiring electronic data. Other contract- or project-specific sample nomenclature requirements may also be applicable.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Program Manager - It shall be the responsibility of the Project Manager (or designee) to inform contract-specific Project Managers (PMs) of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of the PM to determine the applicability of this SOP based on: (1) program-specific requirements and (2) project size and objectives. It shall be the responsibility of the PM (or designee) to ensure that sample nomenclature requirements are thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and are consistent with this SOP if relevant. It shall be the responsibility of the PM to ensure that the FOL is familiar with the sample nomenclature system.

Field Operations Leader (FOL) - It shall be the responsibility of the FOL to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP and the project-specific sample nomenclature system. It shall be the responsibility of the FOL to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

General personnel qualifications for sample nomenclature activities in the field include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for field documentation, handling, packaging, and shipping.

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5.0 PROCEDURES

5.1 INTRODUCTION

The sample identification (ID) system can consist of as few as eight but not more than 20 distinct alphanumeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the laboratory has three segments and shall be as follows, where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3 or 4 Characters	AAA 2 or 3 Characters	A or N 3 to 6 Characters
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

- (1) Soil and sediment sample ID

A or N 3 or 4 Characters	AAA 2 or 3 Characters	A or N 3 to 6 Characters	NNNN 4 Characters
Site identifier	Sample type	Sample location	Sample depth

- (2) Aqueous (groundwater or surface water) sample ID

A or N 3 or 4 Characters	AAA 2 or 3 Characters	A or N 3 to 6 Characters	NN 2 Characters	-A 1 Character
Site identifier	Sample type	Sample location	Round number	Filtered sample only

- (3) Biota sample ID

A or N 3 or 4 Characters	AAA 2 or 3 Characters	A or N 3 to 6 Characters	AA 2 Characters	NNN 3 Characters
Site identifier	Sample type	Sample location	Species identifier	Sample group number

5.2 SAMPLE IDENTIFICATION FIELD REQUIREMENTS

The various fields in the sample ID include but are not limited to the following:

- Site identifier
- Sample type
- Sample location
- Sample depth
- Sampling round number
- Filtered
- Species identifier
- Sample group number

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The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary because many facilities/sites have multiple individual sites, Solid Waste Management Units (SWMUs), Operable Units (OUs), etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six characters (alpha, numeric, or a mixture). The six characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to three characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet or boring log, in the logbook, etc.

A two-digit round number will be used to track the number of aqueous samples collected from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three-digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001, and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 EXAMPLE SAMPLE FIELD DESIGNATIONS

Examples of each of the fields are as follows:

Site identifier - Examples of site numbers/designations are as follows:

- A01 - Area of Concern (AOC) 1
- 125 - SWMU 125
- 000 - Base- or facility-wide sample (e.g., upgradient well)
- BBG - Base background

The examples cited are only suggestions. Each PM (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample type - Examples of sample types are as follows:

- AH - Ash Sample

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- AS - Air Sample
- BM - Building Material Sample
- BSB - Biota Sample Full Body
- BSF - Biota Sample Fillet
- CP - Composite Sample
- CS - Chip Sample
- DS - Drum Sample
- DU - Dust Sample
- FP - Free Product
- IDW - Investigation-Derived Waste Sample
- LT - Leachate Sample
- MW - Monitoring Well Groundwater Sample
- OF - Outfall Sample
- RW - Residential Well Sample
- SB - Soil Boring Sample
- SD - Sediment Sample
- SC - Scrape Sample
- SG - Soil Gas Sample
- SL - Sludge Sample
- SP - Seep Sample
- SS - Surface Soil Sample
- ST - Storm Sewer Water Sample
- SW - Surface Water Sample
- TP - Test Pit Sample
- TW - Temporary Well Sample
- WC - Well Construction Material Sample
- WP - Wipe Sample
- WS - Waste/Solid Sample
- WW - Wastewater Sample

Sample location - Examples of the location field are as follows:

- 001 - Monitoring well 1
- N32E92 - Grid location 32 North and 92 East
- D096 - Investigation-derived waste drum number 96

Species identifier - Examples of species identifier are as follows:

- BC - Blue Crab
- GB - Blue Gill
- CO - Corn
- SB - Soybean

5.4 EXAMPLES OF SAMPLE NOMENCLATURE

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

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A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full-body analysis, the first time a minnow trap was checked at grid location A25 of SWMU 1415, three small blue gills were captured, collected, and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415), the sample ID would be 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash (-F).

5.5 FIELD QA/QC SAMPLE NOMENCLATURE

Field Quality Assurance (QA)/Quality Control (QC) samples are designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC type	Date	Sequence number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
 RB = Rinsate Blank (Equipment Blank)
 FD = Field Duplicate
 AB = Ambient Conditions Blank
 WB = Source Water Blank

The sampling time recorded on the chain-of-custody form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log Sheet (see SOP SA-6.3, Field Documentation).

5.6 EXAMPLES OF FIELD QA/QC SAMPLE NOMENCLATURE

The first duplicate of the day for a filtered groundwater sample collected on June 3, 2000, would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003, would be designated as FD11170303.

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The first trip blank associated with samples collected on October 12, 2000, would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001, would be designated as RB11170101.

6.0 DEVIATIONS

Any deviation from this SOP must be addressed in detail in the site-specific planning documents.

**STANDARD OPERATING PROCEDURE
CALIBRATION OF FIELD INSTRUMENTS**
(temperature, pH, dissolved oxygen, conductivity/specific conductance,
oxidation/reduction potential [ORP], and turbidity)

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1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for groundwater and surface water. Water quality parameters include temperature, pH, dissolved oxygen, specific conductance, oxidation/reduction potential [ORP], and turbidity. This SOP supplements, but does not replace, EPA analytical methods listed in 40 CFR 136 and 40 CFR 141 for temperature, dissolved oxygen, conductivity/specific conductance, pH and turbidity.

This SOP is written for instruments that measure temperature, pH, dissolved oxygen, specific conductance, turbidity, and/or oxidation/reduction potential [ORP] and the probe readings for pH, dissolved oxygen, and specific conductance are automatically corrected for temperature.

For groundwater monitoring, the instrument must be equipped with a flow-through-cell and the display/logger or computer display screen needs to be large enough to simultaneously contain the readouts of each probe in the instrument. Turbidity is measured using a separate instrument. It must not be measured in a flow-through-cell because the flow-through-cell acts as a sediment trap. This procedure is applicable for use with the *EPA Region 1 Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*.

2.0 HEALTH AND SAFETY WARNINGS

Read all labels on the standards and note any warnings on the labels. Wear appropriate personal protection equipment (e.g., gloves, eye shields, etc.) when handling the standards. If necessary, consult the Material Safety Data Sheets (MSDS) for additional safety information on the chemicals in the standards.

3.0 GENERAL

All monitoring instruments must be calibrated before they are used to measure environmental samples. For instrument probes that rely on the temperature sensor (pH, dissolved oxygen, specific conductance, and oxidation/reduction potential [ORP]), each temperature sensor needs to be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST). Before any instrument is calibrated or used to perform environmental measurements, the instrument must stabilize (warm-up) according to manufacturer's instructions and must have no air bubbles lodged between the probe and probe guard.

Most projects will require at least two standards to bracket the expected measurement range. This means that one standard is less than the expected value and one is higher. When an environmental sample measurement falls outside the calibration range, the instrument must be re-calibrated to bracket the new range before continuing measurements. Otherwise, the measurements that are outside the calibration range will need to be qualified.

This SOP requires that the manufacturer's instruction manual (including the instrument specifications) accompany the instrument into the field.

4.0 FREQUENCY OF CALIBRATION

At a minimum, the instrument is calibrated prior to use on the day the measurements are to be performed. A post calibration check at the end of the day is performed to determine if the instrument drifted out of calibration. Some projects may require more frequent calibration checks throughout the day in addition to the check at the end of the day. For these checks, the instrument can be recalibrated during the day if the instrument drifted out of calibration and only the data measured prior to the check would need to be qualified. The calibration/post calibration data information is recorded in Table 1.

Instruments (e.g., sonde) that monitor continuously over a period of time are calibrated before deployment. When these instruments are recovered, the calibration is checked to determine if any of them drifted out of calibration.

Some instruments lose their calibration criteria when they are turned off. Those instruments can either be left on all day (battery dependent) or calibrated at each sampling location. If they are calibrated at each sampling location, a post calibration check is not needed.

Ideally, the temperature of the standards should be close to the temperature of the ambient water that is being measured.

5.0 CALIBRATION PROCEDURES

Prior to calibration, all instrument probes and cable connections must be cleaned and the battery checked according to the manufacturer's instructions. Failure to perform these steps (proper maintenance) can lead to erratic measurements.

If a multi-probe instrument is to be used, program the instrument to display the parameters to be measured (e.g., temperature, pH, percent dissolved oxygen, mg/L dissolved oxygen, specific conductance, and ORP).

The volume of the calibration solutions must be sufficient to cover both the probe and temperature sensor (see manufacturer's instructions for the volume to be used).

Check the expiration date of the standards. Do not use expired standards.

All standards are stored according to manufacturer instructions.

5.1 TEMPERATURE

Most instrument manuals state there is no calibration of the temperature sensor, but the temperature sensor must be checked to determine its accuracy. This accuracy check is performed at least once per year and the accuracy check date/information is kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was over a year, the temperature sensor accuracy needs to be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor must be checked. This procedure is not normally performed in the field. If the instrument is obtained from a rental company, the rental company should perform the calibration check and include with the instrument documentation that it was performed.

Verification Procedure

1. Fill a container with water and adjust the water temperature to below the water body's temperature to be measured. Use ice or warm water to adjust the temperature.
2. Place a thermometer that is traceable to the National Institute of Standards and Technology (NIST) and the instrument's temperature sensor into the water. Wait for both temperature readings to stabilize.
3. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g., $\pm 0.2^{\circ}\text{C}$). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.
4. Adjust the water temperature to a temperature higher than the water body to be measured.
5. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g.,

$\pm 0.2^{\circ}\text{C}$). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

5.2 pH (electrometric)

The pH of a sample is determined electrometrically using a glass electrode.

Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. If the water body's pH is unknown, then three standards are needed for the calibration: one close to seven, one at least two pH units below seven, and the other at least two pH units above seven. Instruments that will not accept three standards will need to be re-calibrated if the water sample's pH is outside the initial calibration range described by the two standards.

Calibration Procedure

1. Allow the buffered standards to equilibrate to the ambient temperature.
2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor.
3. Remove probe from its storage container, rinse with deionized water, and remove excess water.
4. Select measurement mode. Immerse probe into the initial standard (e.g., pH 7).
5. Wait until the readings stabilize. If the reading does not change within 30 seconds, select calibration mode and then select "pH". Enter the buffered standard value into instrument.
6. Remove probe from the initial standard, rinse with deionized water, and remove excess water.
7. Immerse probe into the second standard (e.g., pH 4). Repeat step 5.
8. Remove probe from the second standard, rinse with deionized water, and remove excess water. If instrument only accepts two standards, the calibration is complete. Go to step 11. Otherwise continue.
9. Immerse probe in third buffered standard (e.g., pH 10) and repeat step 5.

10. Remove probe from the third standard, rinse with deionized water, and remove excess water.
11. Select measurement mode, if not already selected. To ensure that the initial calibration standard (e.g., pH 7) has not changed, immerse the probe into the initial standard. Wait for the readings to stabilize. The reading should read the initial standard value within the manufacturer's specifications. If not, re-calibrate the instrument. If re-calibration does not help, the calibration range may be too great. Reduce calibration range by using standards that are closer together.
12. The calibration is complete. Rinse the probe with deionized water and store the probe according to manufacturer's instructions.
13. Record the calibration information on Table 1.

5.3 DISSOLVED OXYGEN

Dissolved oxygen (DO) content in water is measured using a membrane electrode. To insure proper operation, the DO probe's membrane and electrolyte should be replaced prior to calibration for the sampling event. The new membrane may need to be conditioned before it is used; consult manufacturer's manual on how the conditioning is to be performed. Failure to perform this step may lead to erratic measurements. Before performing the calibration/measurements, inspect the membrane for air bubbles and nicks.

Note: some manufacturers require an altitude correction instead of a barometric correction. In that case, enter the altitude correction according to the manufacturer's directions in Step 5 and then proceed to Step 6.

Note: some instruments have a built-in barometer. Follow the manufacturer's instructions for entering the barometric value in step 5.

Calibration Procedure

1. Gently dry the temperature sensor and remove any water droplets from the DO probe's sensor membrane according to manufacturer's instructions. Note that the evaporation of moisture on the temperature sensor or DO probe may influence the readings during calibration.
2. Create a 100 percent water-saturated air environment by placing a wet sponge or a

wet paper towel on the bottom of the DO calibration container. Place the DO probe into the calibration container. The probe is loosely fitted into the calibration container to prevent the escape of moisture evaporating from the sponge or paper towel while maintaining ambient pressure (see manufacturer's instructions). Note that the probe and the temperature sensor must not come in contact with these wet items.

3. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). During this time, turn on the instrument to allow the DO probe to warm-up. Select the measurement mode. Check the temperature readings. Readings must stabilize before continuing to the next step.
4. Select calibration mode; then select "DO %".
5. Enter the local barometric pressure (usually in mm of mercury) for the sampling location into the instrument. This measurement must be determined from an on-site barometer. Do not use barometric pressure obtained from the local weather services unless the pressure is corrected for the elevation of the sampling location. [Note: inches of mercury times 25.4 mm/inch equals mm of mercury or consult Oxygen Solubility at Indicated Pressure chart attached to the SOP for conversion at selected pressures].
6. The instrument should indicate that the calibration is in progress. After calibration, the instrument should display percent saturated DO.
7. Select measurement mode and set the display to read DO mg/L and temperature. Compare the DO mg/L reading to the Oxygen Solubility at Indicated Pressure chart attached to the SOP. The numbers should agree. If they do not agree within the accuracy of the instrument (usually ± 0.2 mg/L), repeat calibration. If this does not work, change the membrane and electrolyte solution.
8. Remove the probe from the container and place it into a 0.0 mg/L DO solution (see footnote). Check temperature readings. They must stabilize before continuing.
9. Wait until the "mg/L DO" readings have stabilized. The instrument should read less than 0.5 mg/L (assuming an accuracy of ± 0.2 mg/L). If the instrument reads above 0.5 mg/L or reads negative, it will be necessary to clean the probe, and change the membrane and electrolyte solution. If this does not work, try a new 0.0 mg/L DO solution. If these changes do not work, contact the manufacturer. Note: some projects and instruments may have different accuracy requirements. The 0.5 mg/L

value may need to be adjusted based on the accuracy requirements of the project or instrument.

10. After the calibration has been completed, rinse the probe with tap or deionized water and store the probe according to manufacturer's instructions. It is important that all of the 0.0 mg/L DO solution be rinsed off the probe so as not to effect the measurement of environmental samples.
11. Record calibration information on Table 1.

Note: You can either purchase the 0.0 mg/L DO solution from a vendor or prepare the solution yourself. To prepare a 0.0 mg/L DO solution, follow the procedure stated in Standard Methods (Method 4500-O G). The method basically states to add excess sodium sulfite (until no more dissolves) and a trace amount of cobalt chloride (read warning on the label before use) to water. This solution is prepared prior to the sampling event. Note: this solution can be made without cobalt chloride, but the probe will take longer to respond to the low DO concentration.

5.4 SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25°C.

Most instruments are calibrated against a single standard which is near the specific conductance of the environmental samples. The standard can be either below or above the specific conductance of the environmental samples. A second standard is used to check the linearity of the instrument in the range of measurements.

When performing specific conductance measurement on groundwater or surface water and the measurement is outside the initial calibration range defined by the two standards, the instrument will need to be re-calibrated using the appropriate standards.

Specific Conductance Calibration Procedure

1. Allow the calibration standards to equilibrate to the ambient temperature.
2. Fill calibration containers with the standards so each standard will cover the probe and temperature sensor. Remove probe from its storage container, rinse the probe with deionized water or a small amount of the standard (discard the rinsate), and place the

- probe into the standard.
3. Select measurement mode. Wait until the probe temperature has stabilized.
 4. Select calibration mode, then specific conductance. Enter the specific conductance standard value. Make sure that the units on the standard are the same as the units used by the instrument. If not, convert the units on the standard to the units used by the instrument.
 5. Select measurement mode. The reading should remain within manufacturer's specifications. If it does not, re-calibrate. If readings continue to change after re-calibration, consult manufacturer or replace calibration solution.
 6. Remove probe from the standard, rinse the probe with deionized water or a small amount of the second standard (discard the rinsate), and place the probe into the second standard. The second standard will serve to verify the linearity of the instrument. Read the specific conductance value from the instrument and compare the value to the specific conductance on the standard. The two values should agree within the specifications of the instrument. If they do not agree, re-calibrate. If readings do not compare, then the second standard may be outside the linear range of the instrument. Use a standard that is closer to the first standard and repeat the verification. If values still do not compare, try cleaning the probe or consult the manufacturer.
 7. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.
 8. Record the calibration information on Table 1.

Note: for projects where specific conductance is not a critical measurement it may be possible to calibrate with one standard in the range of the expected measurement.

5.5 OXIDATION/REDUCTION POTENTIAL (ORP)

The oxidation/reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent.

Calibration or Verification Procedure

1. Allow the calibration standard (a Zobell solution: read the warning on the label before use) to equilibrate to ambient temperature.
2. Remove the probe from its storage container and place it into the standard.
3. Select measurement mode.
4. Wait for the probe temperature to stabilize, and then read the temperature.
5. If the instrument is to be calibrated, do Steps 6 and 7. If the instrument calibration is to be verified, then go to Step 8.
6. Look up the millivolt (mv) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. You may need to interpolate millivolt value between temperatures. Select "calibration mode", then "ORP". Enter the temperature-corrected ORP value into the instrument.
7. Select measurement mode. The readings should remain unchanged within manufacturer's specifications. If they change, re-calibrate. If readings continue to change after re-calibration, try a new Zobell solution or consult manufacturer. Go to Step 9.
8. If the instrument instruction manual states that the instrument is factory calibrated, then verify the factory calibration against the Zobell solution. If they do not agree within the specifications of the instrument, try a new Zobell solution. If it does not agree, the instrument will need to be re-calibrated by the manufacturer.
9. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.
10. Record the calibration information on Table 1.

5.6 TURBIDITY

The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A

turbidimeter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source. Note: the below calibration procedure is for a turbidimeter which the sample is placed into a cuvette.

Some instruments will only accept one standard. For those instruments, the second, third, etc., standards will serve as check points.

Calibration Procedures

1. Allow the calibration standards to equilibrate at the ambient temperature. The use of commercially available polymer primary standards (AMCO-AEPA-1) is preferred; however, the standards can be prepared using Formazin (read the warning on the label before use) according to the EPA analytical Method 180.1. Other standards may be used if they can be shown that they are equivalent to the previously mentioned standards.
2. If the standard cuvette is not sealed, rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe dry the inside of the cuvette because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.
3. Before performing the calibration procedure, make sure the cuvettes are not scratched and the outside surfaces are dry and free from fingerprints and dust. If the cuvette is scratched or dirty, discard or clean the cuvette respectively. Note: some manufacturers require the cuvette to be orientated in the instrument in a particular direction for accurate reading.
4. Select a low value standard such as a zero or 0.02 NTU and calibrate according to manufacturer's instructions. Note: a zero standard (approximately 0 NTU) can be prepared by passing distilled water through a 0.45 micron pore size membrane filter.
5. Select a high standard and calibrate according to manufacturer's instructions or verify the calibration if instrument will not accept a second standard. In verifying, the instrument should read the standard value to within the specifications of the instrument. If the instrument has range of scales, check each range that will be used during the sampling event with a standard that falls within that range.
6. Record the calibration information on Table 1.

6.0 POST CALIBRATION CHECK

After the initial calibration is performed, the instrument's calibration may drift during the measurement period. As a result, you need to determine the amount of drift that occurred after collecting the measurements. This is performed by placing the instrument in measurement mode (not calibration mode) and placing the probe in one or more of the standards used during the initial calibration; for turbidity place the standard in a cuvette and then into the turbidimeter. Wait for the instrument to stabilize and record the measurement (Table 1). Compare the measurement value to the initial calibration value. This difference in value is then compared to the drift criteria or post calibration criteria described in the quality assurance project plan or the sampling and analysis plan for the project. If the check value is outside the criteria, then the measurement data will need to be qualified.

For the dissolved oxygen calibration check, follow the calibration instructions steps one through three while the instrument is in measurement mode. Record dissolved oxygen value (mg/L), temperature, and barometric pressure. Compare the measurement value to the Oxygen Solubility at Indicated Pressure chart attached to this SOP. The value should be within the criteria specified for the project. If measurement value drifted outside the criteria, the data will need to be qualified.

If the quality assurance project plan or the sampling and analysis plan do not list the drift criteria or the post-calibration criteria, use the criteria below.

Measurement	Post Calibration Criteria
Dissolved Oxygen	± 0.5 mg/L of sat. value* < 0.5 mg/L for the 0 mg/L solution, but not a negative value
Specific Conductance	±5% of standard or ± 10 µS/cm (whichever is greater)
pH	± 0.3 pH unit with pH 7 buffer*
Turbidity	± 5% of standard
ORP	± 10 mv*

Note: * Table 8.1, USEPA Region 1 *YSI 6-Series Sondes and Data Logger SOP*, January 30, 2007, revision 9.

7.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All calibration records must be documented in the project's log book or on a calibration log sheet. At a minimum, include the instrument manufacturer, model number, instrument identification number (when more than one instrument of the same model is used), the standards used to calibrate the instruments (including source), the calibration date, the instrument readings, the post calibration check, and the name of the person(s) who performed the calibration. An example of a calibration log sheet is shown in Table 1.

8.0 References

Standard Methods for the Examination of Water and Wastewater, 20th edition, 1998.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Turbidity - Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, August 1993.

USEPA Region 1 YSI 6-Series Sondes and Data Logger SOP, January 30, 2007, revision 9.

USGS Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting, Techniques and Methods 1-D3.

TABLE 1
INSTRUMENT CALIBRATION LOG

Project Name _____ Date _____
Weather _____

Calibrated by _____ Instrument _____
Serial Number _____

Parameters	Morning Calibration	Morning Temperature	End of Day Calibration Check*	End of Day Temperature
Specific Conductance Standard #1				
Specific Conductance Standard #2				
pH (7)				
pH (4)				
pH (10)				
ORP Zobel solution				
Dissolved Oxygen 100% water saturated air mg/L				
Dissolved Oxygen Zero Dissolved Oxygen Solution mg/L				
Barometric Pressure mm Hg		NA		NA
Turbidity Standard #1				
Turbidity Standard #2				
Turbidity Standard #3				

* For each Parameter, chose one standard as your check standard. If possible, choose the one that is closest to the ambient measurement value.

Oxygen Solubility at Indicated Pressure

Temp.	Pressure (Hg)							
	760	755	750	745	740	735	730	mm in
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	
3	13.43	13.34	13.25	13.16	13.07	12.98	12.90	
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	

(Continued)

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

Oxygen Solubility at Indicated Pressure (continued)

Temp. °C	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm in
0	13.89	13.80	13.70	13.61	13.51	13.41	13.32	13.22	mg/l
1	13.51	13.42	13.33	13.23	13.14	13.04	12.95	12.86	
2	13.15	13.06	12.97	12.88	12.79	12.69	12.60	12.51	
3	12.81	12.72	12.63	12.54	12.45	12.36	12.27	12.18	
4	12.47	12.39	12.30	12.21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11.98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.74	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	
40	6.10	6.06	6.01	5.96	5.92	5.86	5.83	5.78	
41	6.00	5.96	5.91	5.87	5.82	5.78	5.73	5.69	
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.60	
43	5.82	5.78	5.73	5.69	5.65	5.60	5.56	5.51	
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

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USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Potentiometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase

liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.

BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection

may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in

the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convection cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or Teflon are preferred. Note: if extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

Teflon or Teflon-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. Note: if tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic "tape", pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity)*, January 19, 2010, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed lay out sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs).

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each

sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),

Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),

Specific Conductance (3%),

Temperature (3%),

pH (± 0.1 unit),

Oxidation/Reduction Potential (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). All during the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

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Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring & Remediation* 27, no. 3: 49-58.

APPENDIX A PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could effect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).
2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.
3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.
4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.
5. Measure water level and record this information.
6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or colored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or colored water is usually from the well being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to

the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

Wait for the well to recharge to a sufficient volume so samples can be collected. This may take awhile (pump maybe removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note,

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

Turbidity (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),

Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),

Specific Conductance (3%),

Temperature (3%),

pH (± 0.1 unit),

Oxidation/Reduction Potential (± 10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record that the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

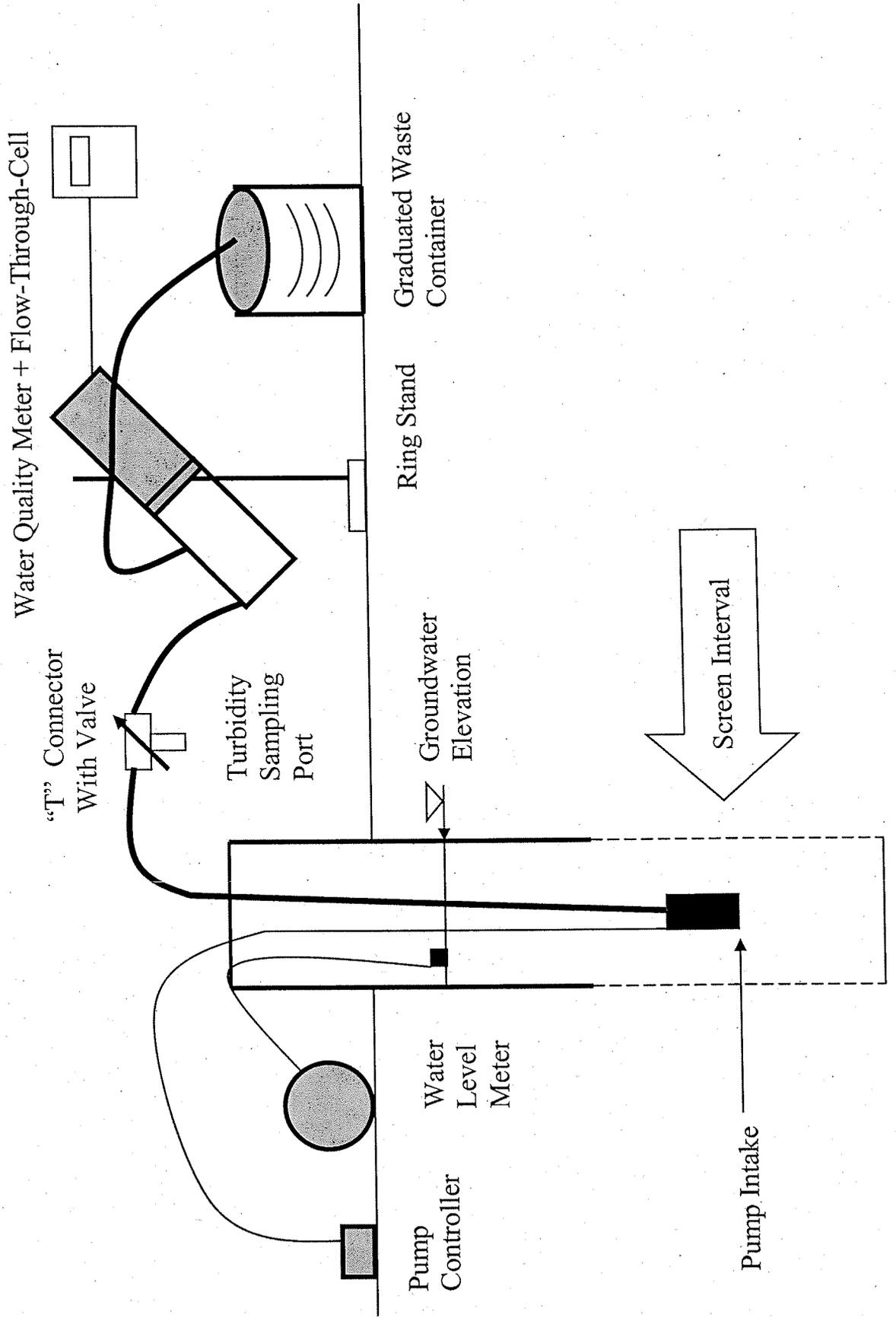
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

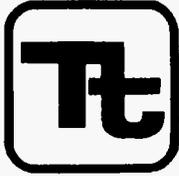
All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram





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Prepared Earth Sciences Department	
Approved D. Senovich <i>[Signature]</i>	

Subject EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

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5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate

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previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

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Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.
2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):
 - Well number.
 - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
 - Time and day of the measurement.
 - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

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5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "popping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

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5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.



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Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS

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1.0 PURPOSE

The purpose of this procedure is to provide a basic understanding of developing contour maps and the approaches used to identify and quantify the direction and rate of groundwater flow and contaminant plume movement.

2.0 SCOPE

This procedure provides only a general overview of the field techniques, mathematical and physical relationships and data handling procedures used for determining groundwater flow direction and rate. The references identified herein can provide a more complete explanation of particular methods cited, as well as a more comprehensive discussion on the interpretation of hydrogeologic data.

3.0 GLOSSARY

Aquifer - A geologic formation capable of transmitting usable quantities of groundwater to a well or other discharge point.

Aquitard - A geologic formation which retards the flow of groundwater due to its low permeability.

Confined Aquifer - An aquifer that is overlain and underlain by zones of lower permeability (aquitards). If the aquifer is "artesian," the potentiometric head of the aquifer at a given point is higher than the top of the zone comprising the aquifer at that point.

Equipotential Line - A line connecting points of equal elevation of the water table or potentiometric surface. Equipotential lines on the water table are also called water table contour lines.

Flow Line - A flow line indicates the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Flow Net - A diagram of groundwater flow showing flow lines and equipotential lines.

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid.

Hydraulic Gradient (i) - The rate of change of hydraulic head per unit distance of flow at a given point and in the downgradient direction.

Hydraulic Head - The height to which water will rise inside a well casing, equal to the elevation head plus the pressure head. In a well screened across the water table, hydraulic head equals the elevation head, as the pressure head equals 0. In wells screened below the water table in an unconfined aquifer or screened at any interval within a confined aquifer, the head is the sum of the elevation of the aquifer (the elevation head) and the fluid pressure of the water confined in the aquifer (the pressure head).

Potentiometric (piezometric) Surface - A hypothetical surface that coincides with the static level of the water in an aquifer (i.e., the maximum elevation to which water will rise in a well or piezometer penetrating the aquifer). The term "potentiometric surface" is usually applied to confined aquifers, although the water table is the potentiometric surface of an unconfined aquifer.

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

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Water Table - The surface in the groundwater system at which the fluid pressure is equal to atmospheric pressure (i.e., the net pressure head is zero) and below which all strata are saturated with water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist (with the concurrence of the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - All supporting field personnel must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

5.0 PROCEDURES

5.1 Potentiometric Surface Mapping

5.1.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day, preferably within 2-3 hours. This is especially important when working in an area where groundwater levels are tidally influenced or influenced by pumping.

The recorded water levels, monitoring-well construction data, site geology, and topographic setting must be reviewed to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this determination. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow; information from many more wells are needed to provide an accurate contour map. Generally, shallow systems require data from more wells than deep systems for accurate contour mapping. Potentiometric surface mapping for shallow flow systems also requires water level measurements from nearby surface water bodies.

5.1.2 Water Level Measurements

After selection of the wells to be used for mapping, the next step in determining the direction of groundwater flow is to obtain water level elevations from the selected points. In addition, any other readily available wells/surface water bodies should be measured to ensure that sufficient data are available for interpretation purposes.

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Elevations are obtained from measurements of the depth to water in a monitoring well or piezometer taken from the top of the well casing (see SOP GH-1.2) and then referencing the elevation of the casing to a chosen and consistent datum point, usually mean sea level. Subtracting the depth to water from the casing elevation provides the elevation of the potentiometric surface. Elevations of points and areas of groundwater discharge or recharge such as springs, seeps, streams, rivers, and lakes also need to be determined, typically through staff gauge measurements. Comparison of these elevations, which represent hydraulic heads, will reveal the direction of flow because groundwater flows from areas of high head to areas of low head.

5.1.3 Construction of Equipotential Lines

Graphical methods available for depicting the flow of groundwater include the use of equipotential lines and flow lines to construct potentiometric surface maps and vertical flow nets. If the hydrogeologic system consists of a water table aquifer and one or more confined aquifers, separate contour maps should be prepared for each aquifer system. Water table maps should be developed using water level measurements obtained from monitoring wells screened at the unsaturated-saturated interface. Water level measurements collected from monitoring wells screened in the deeper portions of an unconfined aquifer should generally be contoured as a separate potentiometric surface map. Surface water discharge or recharge features are contoured in the water table system. Vertical flow nets should be constructed using a cross section aligned parallel to the direction of groundwater flow. All water level measurements along this cross section, both deep and shallow, are used in developing equipotential lines and flow lines for the flow net.

To construct equipotential lines, water level elevations in the chosen wells are plotted on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is the most commonly used technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful rough mapping of large data sets; however, final, detailed mapping must always be performed by hand by an experienced hydrogeologist. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted utilizing the professional judgment of the hydrogeologist in accordance with these features. Closed contours should be avoided unless a known groundwater sink (i.e., pumping well) or mound exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must be evident in the contour plot.

5.1.4 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions (i.e., wells) will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

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5.2 Groundwater Flow Considerations

Groundwater movement is an integral part of the hydrologic cycle. Recharge to the shallow groundwater environment generally occurs by infiltration of precipitation through an upper unsaturated soil zone. Movement is downward under the force of gravity until the water reaches the saturated zone of the water table aquifer. Once water is part of the water table aquifer, movement is controlled by differences in hydraulic head, with movement from areas of high head to areas of low head. Areas of low head include natural discharge areas such as springs, lakes, rivers, and, ultimately, the ocean. These features can be considered as outcrops of the water table. Points of low head also are created by pumping wells.

Local head differences and consequent vertical flow patterns within an aquifer can be detected by well clusters. A well cluster consists of several adjacent wells, generally installed within a few feet of each other, and screened at different depths. Variations in water levels in these closely spaced wells indicates the vertical component of groundwater flow within an aquifer, provided that the wells are all screened within the same aquifer.

The number, location, and extent of geologic units and their properties with regard to aquifer or aquitard characteristics must be understood to properly interpret water level data gathered from the monitoring system. This firm understanding of the hydrogeologic system must be developed through a program of borings, wells, and interpretation of subsurface geology. The adequacy of the positions and depths of borings/wells used to define relevant subsurface hydrogeologic conditions must also be assessed. The location of surface water discharge or recharge points must be considered. Surface water features influence the system, as flow is most likely toward them (if they are discharge points) or away from them (if they are recharge points). Man-made discharge or recharge features such as pumping or injection wells, ditches, and trenches can also affect the flow of groundwater.

5.3 Determination of Flow Rate

Darcy's Law states that the quantity of water flowing through a geologic material is dependent upon the permeability of the material, the hydraulic gradient, and the cross sectional area through which the water flows. This relation is expressed in the equation:

$$Q = KiA$$

where:

- Q = volume of water flowing through the cross sectional area of the formation (L^3/T).
- K = hydraulic conductivity (L/T).
- i = hydraulic gradient (L/L , i.e., dimensionless).
- A = cross sectional area of formation being considered (L^2).

The relation is similar to one used in stream flow measurements where:

$$Q = VA$$

where:

- Q = discharge from the cross sectional area of a stream or pipe (L^3/T).
- V = average velocity of flowing water (L/T).
- A = cross sectional area through which water flows (L^2).

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The velocity of water movement in a geologic formation depends on the specific formation properties and the head differences across the formation. This relation is defined in the equation:

$$V = \frac{Ki}{n}$$

where:

V	=	average linear velocity of groundwater through the formation (L/T)
K	=	hydraulic conductivity (L/T)
i	=	hydraulic gradient (dimensionless)
n	=	porosity (expressed as a fraction).

Values of porosity for several geologic materials are given in Attachment A. More accurate and specific values of porosity can be obtained by laboratory analysis of a formation sample or from an unconfined aquifer pumping test.

Hydraulic conductivity is related to the permeability of the formation and depends on the size and interconnection of the pore spaces. In isotropic and homogeneous formations, the hydraulic conductivity will be the same vertically and horizontally. In anisotropic formations, horizontal and vertical conductivity can be markedly different and the vertical hydraulic conductivity can be up to several orders of magnitude lower than the horizontal hydraulic conductivity. Typically, most formations are anisotropic with horizontal hydraulic conductivities at least several times as high as the vertical hydraulic conductivities.

Generally, hydraulic conductivities are high for sands, gravels, and limestone containing large solution cavities and low for silts, clays, and tightly fractured rock. Attachment A gives values of hydraulic conductivity for several geologic materials. More accurate values can be obtained during field testing of aquifers or from laboratory measurements on undisturbed cores. Results from field testing usually provide higher (and more representative) hydraulic conductivities than laboratory testing because full-scale field testing includes the effects of the formational macrostructure (i.e., secondary permeability due to jointing or fractures) which is not reflected in the testing of a small sample in the laboratory.

The hydraulic gradient, *i*, is determined from field measurements of hydraulic head obtained from water level measuring points. Do not measure gradient from well to well; measure across equipotential lines that are drawn based on the well (and other) data. Once a potentiometric surface map has been generated using the hydraulic head data, the hydraulic gradient can be calculated using the following formula:

$$i = \frac{dh}{dl}$$

where:

dh	=	change in head (L)
dl	=	distance between equipotential lines (L)

The hydraulic gradient along any flow line can be calculated from a potentiometric surface map by dividing the change in head by the length of the flow line, typically beginning and ending at equipotential lines. The longer the distance over which the head change is measured, the more representative the gradient is of overall conditions.

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When chemical solutes are traveling in groundwater, as in cases of groundwater contamination, the calculated groundwater velocity may predict migration rates in excess of what is actually observed. The difference in chemical versus water velocities may be due to attenuation or biodegradation of the chemical species in the aquifer. Attenuation is most often caused by adsorption of the chemical contaminant onto the formation grains or matrix. The result is that the chemical does not appear at the downgradient sampling point as quickly as the velocity calculation predicts. An equation to correct for this attenuation is:

$$V_c = V_w / (1 + K_d P_b / n)$$

where:

- V_c = velocity of the chemical solute flow (L/T)
- V_w = velocity of groundwater flow (L/T)
- P_b = formation mass bulk density (M/L³)
- n = formation porosity (expressed as a fraction)
- K_d = distribution coefficient = (L³/M)

The K_d is equal to the mass of solute per unit mass of solid phase divided by the concentration of solute in solution. The term in the denominator is known as the retardation factor.

Density and/or viscosity differences between water and contaminants can also cause velocity determination errors. Light hydrocarbons such as gasoline are less dense than water and consequently float on the water table. These contaminants can migrate along the water table surface at rates faster or slower than the rate of groundwater movement, depending on specific conditions, and may also volatilize into unsaturated soil pore spaces. Oils are more viscous than water and will typically migrate more slowly due to the viscosity difference. Contaminants denser than water such as heavy hydrocarbons (e.g., coal tar) or chlorinated compounds (e.g., TCE, PCE) tend to sink to the bottom of an aquifer if present in concentrations exceeding their solubility limit (these chemicals are often referred to as dense, nonaqueous phase liquids, or DNAPLs if present as a separate-phase liquid). Here, the contamination may move at faster or slower rates than the overlying groundwater or may actually move in a direction opposite to that of the groundwater, depending on the geologic characteristics of the aquifer base and direction of dip of the underlying aquitard.

Other factors involving the physicochemical interaction between the chemical and the groundwater, such as dilution (mixing contaminated water or chemicals with additional quantities of groundwater) and dispersion (molecular diffusion of the chemical throughout the groundwater regime), can also affect the observed rates of travel of contaminants in groundwater. In addition to such physicochemical characteristics, all of the aquifer and aquitard properties and groundwater flow characteristics described above must be known so that adequate and accurate estimations of the extent and rate of groundwater contaminant migration can be developed.

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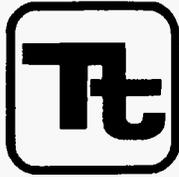
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ATTACHMENT A

**GENERALIZED POROSITY AND HYDRAULIC CONDUCTIVITY
VALUES FOR GEOLOGIC MATERIALS**

Material	Porosity Range (%)	Hydraulic Conductivity Range	
		cm/sec	ft/day
Gravel	30-40	10^{-1} to 10^{-2}	280 to 2.8×10^5
Coarse sand (clean)	30-40	10^{-1} to 1	280 to 2,800
Medium sand (clean)	35-45	10^{-2} to 10^{-1}	28 to 280
Fine sand (clean)	40-50	5×10^{-4} to 10^{-2}	1.4 to 28
Silty sand	25-40	10^{-5} to 10^{-2}	0.03 to 280
Glacial Till	Variable	10^{-10} to 10^{-4}	3×10^{-7} to 0.3
Unweathered Clay/Shale	45-55 (clay)	10^{-7} to 10^{-4}	3×10^{-4} to 0.3 (horizontal)
		10^{-10} to 10^{-6}	3×10^{-7} to 3×10^{-3} (vertical)
Karst Limestone	---	10^{-4} to 10^{-1}	0.3 to 2,800
Fractured Igneous/Metamorphic Rocks	---	10^{-6} to 10^{-1}	3×10^{-3} to 280
Sandstone	5-30	10^{-8} to 10^{-4}	3×10^{-5} to 0.3

Source: References 1 and 2



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Effective Date 09/03	Revision 3
Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved D. Senovich <i>DS</i>	

Subject
GROUNDWATER MONITORING WELL INSTALLATION

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

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5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

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The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

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Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

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5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium-to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

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A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for

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installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to

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remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular

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space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

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U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

- | | |
|------------------------|--------------------|
| 1 Teflon [®] | 5 Lo-Carbon Steel |
| 2 Stainless Steel 316 | 6 Galvanized Steel |
| 3. Stainless Steel 304 | 7 Carbon Steel |
| 4 PVC 1 | |

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton ^{®*}	Silicone	Neoprene	Teflon ^{®*}
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

- | | |
|---------------------------|--------------------------|
| 1 Teflon [®] | 5 PE Conventional |
| 2 Polypropylene (PP) | 6 Plexiglas/Lucite (PMM) |
| 3. PVC Flexible/PE Linear | 7 Silicone/Neoprene |
| 4 Viton [®] | |

* Trademark of DuPont

Source: Barcelona et al., 1983

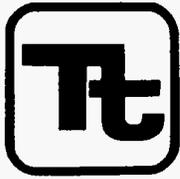
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ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Effective Date	02/04	Revision	3
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>[Signature]</i>		

Subject
NON-RADIOLOGICAL SAMPLE HANDLING

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (y261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (y261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H₂SO₄
- Nitric Acid - HNO₃
- Sodium Hydroxide - NaOH

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Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - Na₂S₂O₃

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

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changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO₃, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H ₂ SO ₄)	1 part concentrated H ₂ SO ₄ : 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO ₃)	Undiluted concentrated HNO ₃	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

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- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.
- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).
- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

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- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.
- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 **Sample Packaging and Shipping**

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)
- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 **Environmental Samples**

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.
- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.
- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.
- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).
- Seal (i.e., tape or tie top in knot) large liner bag.
- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.
- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

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Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

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ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
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WATER

Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days ⁽⁹⁾
	Extractables SVOCs and pesticide/PCBs)	(Low)	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium)	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO ₃ to pH ≤ 2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days

SOIL

Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low)	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium)	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorga nic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction

AIR

Volatile Organics	Low/Medium		Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended
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1 All glass containers should have Teflon cap liners or septa.

2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

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ATTACHMENT B

**ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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INORGANIC TESTS:

Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid ⁽⁵⁾	14 days ⁽⁶⁾
Fluoride	P	None required	28 days
Hardness	P, G	HNO ₃ to pH 2; H ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H ₂ SO ₄ to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

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**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE TWO**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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INORGANIC TESTS (Cont'd):

Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours

METALS:⁽⁷⁾

Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO ₃ to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO ₃ to pH 2	6 months

ORGANIC TESTS:⁽⁸⁾

Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days
Phenols ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Benzidines ^{(11), (12)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction ⁽¹³⁾
Phthalate esters ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines ^{(11), (14)}	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
PCBs ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs) ^{(11), (14)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ ; store in dark	7 days until extraction; 40 days after extraction
Haloethers ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF) ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction

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**ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES
PAGE THREE**

- (1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
- (2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
- (3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
- (4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
- (5) Should only be used in the presence of residual chlorine.
- (6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
- (7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
- (8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
- (9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
- (10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
- (11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
- (12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
- (13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
- (14) For the analysis of diphenylnitrosamine, add 0.008% Na₂S₂O₃ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
- (15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na₂S₂O₃.



TETRA TECH

STANDARD OPERATING PROCEDURES

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Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved Tom Johnston <i>T.E. Johnston</i>	

Subject
GROUNDWATER SAMPLE ACQUISITION AND
ONSITE WATER QUALITY TESTING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 microSiemens per centimeter (mS/cm) at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Groundwater Sample – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 mV from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCl) in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCl) to 205 (3.5 Molar KCl) to 222 mV (1 Molar KCl) at 25°C and are greater at lower temperatures.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

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Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol (⁰/₀₀) is not the same as the percent symbol (%).

Turbidity – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Project Hydrogeologist – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

Field Operations Leader (FOL) – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

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- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas and roadways and along highways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations – To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.

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- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel.** Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- **Face Traffic.** Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 General

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

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Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample. To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

CAUTION

Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

1. If possible, position yourself (and the sampling equipment) upwind of the well head.
2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.
3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid (generally 300 mL per minute or greater), attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

CAUTION

For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:
 - Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.
 - While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

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- Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform to the guidelines in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.
- Field tools and instrumentation
 - Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable)
 - pH Paper
 - Camera and film (if appropriate)
 - Appropriate keys (for locked wells)
 - Water level indicator and/or oil-water interface probe if separate-phase product is expected
- Pumps
 - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.
 - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment – Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).
- Pails – Plastic, graduated.
- Clean paper or cotton towels for cleaning equipment.
- Buckets with lids for collecting purge water.
- Decontamination solutions – Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

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6.3 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

1. Obtain all available information on well construction (location, casing, screen, etc.).
2. Determine well or inner casing diameter.
3. Measure and record static water level (depth below ground level or top of casing reference point).
4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.
5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where: V = Static volume of well in gallons.
T = Linear feet of water in the well.
r = Inside radius of well casing in inches.
0.163 = Conversion factor (compensates for conversion of casing radius from inches to feet and cubic feet to gallons and pi.

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

1. Saturate a paper towel or clean cotton towel with deionized water.
2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.
3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Material Safety Data Sheet (MSDS) is obtained, kept on site at a readily available location with other MSDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the TtNUS Health and Safety Guidance Manual [HSGM], Hazard Communication Program and OSHA Standard 29 CFR 1910.1200).

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6.4 Evacuation of Static Water – Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom. Bailers are comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

Advantages of bailers include the following:

- There are few limitations on size and materials used.
- No external power source is needed.
- Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Splashing the bailer into the water or transfer of sample may cause aeration.
- The use of a bailer does not permit constant in-line monitoring of groundwater parameters.
- Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.

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Safety concerns using a bailer include the following:

- Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.
- Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.
- Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.

Control measures for these hazards are provided in Section 6.6.2.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it will operate from a portable battery source. Safety measures associated with these pumps are provided below.

Air-Lift and Gas-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.

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- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time consuming.

Compressed Gases

Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 psi. If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through an appropriate pressure-reducing regulator.
- When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.
- If the cylinder is designed to accept a valve protection cap, always keep that protection cap in place, except the cylinder is connected for use.
- When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).
- DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential danger of an embolism.

See the project-specific HASP for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of a running car to access the battery as a power source. To control these hazards:

- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

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To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.
- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the HSGM.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ORP
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters

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used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

6.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 Code of Federal Regulations (CFR) 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain MSDSs from the manufacturer for the specific buffer solutions (see Section 4 of the HSGM regarding the Hazard Communication Program)

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- pH indicator paper to cover the pH range 2 through 12.
- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

1. Inspect the instrument and batteries prior to initiation of the field effort.
2. Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.
5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.
6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).
7. Rinse the electrode(s) with deionized water.
8. Store the electrode(s) in an accordance with manufacturer's instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

1. Collect a small portion of sample into a clean container.

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2. Dip the pH paper into this small portion of sample.
3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.
4. Record the pH value from the chart on the sampling log sheet.
5. Discard the used pH paper as trash.
6. Discard the small volume of sample that was used for the pH measurement with the other investigative derived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form.

6.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

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6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.
4. Immerse the electrode in the sample and measure the conductivity.
5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

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6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.
2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

1. Calibrate the instrument according to manufacturer's recommendations prior to use.
2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.
3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 Principles of Equipment Operation

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between

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the two metals, reduction of oxygen to hydroxide ion (OH⁻) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

1. Check the DO meter batteries before going to the field.
2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
5. Rinse the probe with deionized water.
6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.

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7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.
8. Rinse the probe with deionized water.
9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.

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2. Thoroughly rinse the electrode with deionized water.
3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater). Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).
- Calibration solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
2. Check batteries and calibrate the meter before going into the field.

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3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.
5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (e.g., LaMotte 2020) that calibrates easily using test cells with standards of 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution and sample tubes, as specified by the manufacturer.
- Manufacturer's operation manual.

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6.5.7.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization shall be done according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
2. Check batteries and calibrate the instrument before going into the field.
3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.
4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.
5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, and close the lid.
6. Immerse the electrode in the sample and measure the turbidity.
7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated.

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Refer to the project-specific HASP for appropriate information and direction on air monitoring requirements.

- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.
- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP, indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP author.
- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow. Where sampling teams are made up of personnel from multiple locations, personal sampling experiences may vary. Therefore the FOL shall review project-specific requirements, SOPs, and protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are being completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like to sun themselves on concrete well pads. Follow provisions in the project-specific HASP and/or HSGM for addressing natural hazards.
2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases from contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:
 - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.
 - DO NOT place your face or any other part of your body over the well when opening because this may place you in a strike zone.
 - Open the well cover at arms length, then step away and allow the well to off gas and stabilize.

Follow directions provided in the project-specific HASP, Work Plan and/or Sampling Plan pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the sampler

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during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP).

3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.
4. Calculate volume of well water to be removed as described in Section 6.3.
5. Select the appropriate purging equipment (see Attachment A to this SOP) or as designated within your Work Plan/Sampling Plan. If an electric submersible pump with packer is chosen, go to Step 10.
6. Lower the purging equipment or intake into the well to a short distance below the water level or mid-screen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.
7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.
8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
9. Purge a minimum of three to five casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.
10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.
11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this

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occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.
14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.
15. Process sample containers as described in SOP SA-6.1.
16. Decontaminate equipment as described in SOP SA-7.1.

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, polychlorinated biphenyls [PCBs], metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing – Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).

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- Interface probe.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators - ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic compounds (VOCs) per the HASP.

6.7.3 Purging and Sampling Procedure

1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP (typically with a PID or FID).
2. Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.
3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.
4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well
5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.

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6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease or the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.
 7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
 8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.
 9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.
 10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.
 11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:
 - pH ± 0.2 standard units
 - Specific conductance $\pm 10\%$
 - Temperature $\pm 10\%$
 - Turbidity less than 10 NTUs
 - DO $\pm 10\%$
 12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.
- NOTE:** VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.
13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:

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- Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.
- Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.
- Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.
- Prepare samples for shipping as per SOP SA-6.1.

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ATTACHMENT A
PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A
PURGING EQUIPMENT SELECTION
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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
 PP Polypropylene
 PVC Polyvinyl chloride
 SS Stainless steel
 PC Polycarbonate
 EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA Not applicable
 AC Alternating current
 DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

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STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	Tom Johnston <i>T. E. Johnston</i>		

Subject
SURFACE WATER AND SEDIMENT SAMPLING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes procedures and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing or for offsite laboratory analysis.

2.0 SCOPE

The information presented in this document is applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

3.0 GLOSSARY

Analyte – Chemical or radiochemical material whose concentration, activity, or mass is measured.

Composite Sample – A sample representing a physical average of grab samples.

Environmental Sample – A quantity of material collected in support of an environmental investigation that does not require special handling or transport considerations as detailed in SOP SA-6.1.

Grab Sample – A portion of material collected to represent material or conditions present at a single unit of space and time.

Hazardous Waste Sample – A sample containing (or suspected to contain) concentrations of contaminants that are high enough to require special handling and/or transport considerations per SOP SA-6.1.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of soil samples. The Project Manager also has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel in accordance with applicable planning documents.

Field Operations Leader - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that

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custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface water and sediment samples. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling and boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding boring and sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, , container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Precautions to preserve the health and safety of field personnel implementing this SOP are distributed throughout. The following general hazards may also exist during field activities, and the means of avoiding them must be used to preserve the health and safety of field personnel:

Bridge/Boat Sampling – Potential hazards associated with this activity include:

- Traffic – one of the primary concerns as samplers move across a bridge because free space of travel is not often provided. Control measures should include:
 - When sampling from a bridge, if the samplers do not have at least 6 feet of free travel space or physical barriers separating them and the traffic patterns, the HASP will include a Traffic Control Plan.
 - The use of warning signs and high-visibility vests are required to warn oncoming traffic and to increase the visibility of sample personnel.
- Slips, trips, and falls from elevated surfaces are a primary concern. Fall protection shall be worn when or if samplers must lean over a rail to obtain sample material. A Fall Protection Competent

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Person (in accordance with Occupational safety and Health Administration [OSHA] fall protection standards) must be assigned to ensure that fall protection is appropriately and effectively employed

- Water hazards/drowning – if someone enters the water from an elevated surface (such as a bridge or dock) and when sampling from a boat. To minimize this potential, personnel shall wear United States Coast Guard (USCG)-approved floatation devices, and the sampling crew must also have on hand a Type IV Throwable Personal Floatation Device with at least 90 feet of 3/8-inch rope. See Section 5.5.2 of this SOP.
- Within the HASP, provisions will also be provided concerning the requirement of a Safe Vessel Certification or the necessity to conduct a boat inspection prior to use. In addition, the HASP shall also specify requirements as to whether the operator must be certified as a commercial boat operator and whether members of the sampling team must have a state-specific safe boating certification.

Entering Water to Collect Samples – Several hazards are associated with this activity and can be mitigated as follows:

- Personnel must wear a USCG-approved Floatation Device (selected and identified in the HASP). The SSO shall ensure that the device selected is in acceptable condition and suitable for the individual using it. This includes consideration of the weight of the individual.
- Lifelines shall be employed from a point on the shore. This activity will always be conducted with a Buddy. See Section 6.5.2.
- Personnel shall carry a probe to monitor the bottom ahead of them for drop offs or other associated hazards.
- The person in the water shall exercise caution concerning the path traveled so that the lifeline does not become entangled in underwater obstructions such as logs, branches, stumps, etc., thereby restricting its effectiveness in extracting the person from the water.
- Personnel shall not enter waters on foot in situations where natural hazards including alligators, snakes, as well as sharks, gars, and other predators within inland waterways may exist.
- In all cases, working along and/or entering the water during high currents or flood conditions shall be prohibited.
- Personnel shall not enter bodies of water where known debris exists that could result in injuries from cuts and lacerations.

Sampling in marshes or tidal areas in some instances can be accomplished using an all-terrain vehicle (ATV). This is not the primary recommended approach because the vehicle may become disabled, or weather conditions or tidal changes could result in environmental damage as well as loss of the vehicle. The primary approach is recommended to be on foot where minimal disturbance would occur. The same precautions specified above with regard to sediment disturbance apply as well as the previously described safety concerns associated with natural hazards. The natural hazards include alligators, bees (nests in dead falls and tree trunks), snakes, etc. In addition, moving through and over this terrain is difficult and could result in muscle strain and slips, trips, and falls. Common sense dictates that the sampler selects the most open accessible route over moderate terrain. Move slowly and deliberately through challenging terrain to minimize falls. Mud boots or other supportive PPE should be considered and specified in the HASP to permit samplers to move over soft terrain with the least amount of effort. In these situations, it is also recommended, as the terrain allows, that supplies be loaded and transported in a sled over the soft ground.

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Working in these areas, also recognize the following hazards and means of protection against them:

Insects are also a primary concern. These include mosquitoes, ticks, spiders, bees, ants, etc. The HASP will identify those particular to your area. Typical preventative measures include:

- Use insect repellent. Approval of various repellants should be approved by the Project Chemist or Project Manager.
- Wearing light-colored clothing to control heat load due to excessive temperatures. In addition, it makes it easier to detect crawling insects on your clothing.
- Taping pants to boots to deny access. Again, this is recommended to control access to the skin by crawling insects. Consultation with the Project Health and Safety Officer SSO/Health and Safety Manager is recommended under extreme heat loads because this will create conditions of heat stress.
- Performing a body check to remove insects. The quicker you remove ticks, the less likely they will become attached and transfer bacteria to your bloodstream. Have your Buddy check areas inaccessible to yourself. This includes areas such as the upper back and between shoulder blades where it is difficult for you to examine and even more difficult for you to remove.

Safety Reminder

If you are allergic to bee or ant stings, it is especially critical that you carry your doctor-recommended antidote with you in these remote sampling locations due to the extended time required to extract incapacitated individuals as well as the effort required to extract them. In these scenarios, instruct your Buddy in the proper administration of the antidote. In all cases, if you have received a sting, administer the antidote regardless of the immediate reaction, evacuate, and seek medical attention as necessary. The FOL and/or SSO will determine when and if you may return to the field based on the extent of the immune response and hazards or potential hazards identified in these locations. To the FOL and SSO, this is a serious decision you have to make as to whether to take someone vulnerable to these hazards into a remote location where you may not be able to carry them out. Consider it wisely.

Poisonous Plants – To minimize the potential of encountering poisonous plants in the field, at least one member of the field team needs to have basic knowledge of what these plants look like so that they can be recognized, pointed out to other field personnel, and avoided if at all possible. If the field team cannot avoid contact and must move through an area where these plants exist, the level of personal protective equipment (PPE) shall include Tyvek coveralls and enhanced decontamination procedures for the removal of oils from the tooling and/or equipment.

Temperature-Related Stress – Excessively cold temperatures may result in cold stress, especially when entering the water either intentionally or by accident. Provisions for combating this hazard should be maintained at the sample location during this activity. Excessively hot temperatures may result in heat stress especially in scenarios where equipment is packed through the marsh.

Because all of these activities are conducted outside, electrical storms are a significant concern. The following measures will be incorporated to minimize this hazard:

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- Where possible, utilize commercial warning systems and weather alerts to detect storms moving into the area.
- If on or in the water, get out of the water. Move to vehicles or preferably into enclosed buildings with plumbing and wiring.
- Where warning systems are not available, follow the 30/30 Rule (*if there are less than 30 seconds between thunder and lightning, go inside for at least 30 minutes after the last thunder*).

See Section 4.0 of the Health and Safety Guidance Manual (HSGM) for additional protective measures.

6.0 PROCEDURES

6.1 Introduction

Collecting a representative sample of surface water or sediment may be difficult because of water movement, stratification, or heterogeneous distribution of the targeted analytes. To collect representative samples, one must standardize sampling methods related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples. Consult Appendix C for guidance on sampling that should be considered during project planning and that may be helpful to field personnel.

6.1.1 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. In general, the most representative samples are obtained from mid-channel at a stream depth of 0.5 foot in a well-mixed stream; however, project-specific planning documents will address site-specific sampling requirements including sample collection points and sampling equipment. The most frequently used samplers include the following:

- Peristaltic pump
- Bailer
- Dip sampler
- Weighted bottle
- Hand pump
- Kemmerer
- Depth-integrating sampler

The dip sampler and weighted bottle sampler are used most often, and detailed discussions for these devices and the Kemmerer sampler are addressed subsequently in this section.

The criteria for selecting a sampler include:

1. Disposability and/or easy decontamination.
2. Inexpensive cost (if the item is to be disposed).
3. Ease of operation.

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4. Non-reactive/non-contaminating properties - Teflon-coated, glass, stainless-steel or polyvinyl chloride (PVC) sample chambers are preferred (in that order).

Measurements collected for each sample (grab or each aliquot collected for compositing) shall include but not be limited to:

- Specific conductance
- Temperature
- pH
- Dissolved oxygen

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample log sheets (see Attachment A) or an equivalent electronic form(s). These analyses may be selected to provide information on water mixing/stratification and potential contamination. Various types of water bodies have differing potentials for mixing and stratification.

In general, the following equipment if necessary for obtaining surface water samples:

- Required sampling equipment, which may include a remote sampling pole, weighted bottle sampler, Kemmerer sampler, or other device.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.
- Required PPE as directed in the project-specific planning document, which may include:
 - Nitrile surgeon's or latex gloves (layered as necessary).
 - Safety glasses.
 - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).
- Required decontamination equipment.
- Required sample containers.
- Sealable polyethylene bags (e.g., Ziploc[®] baggies).
- Heavy-duty cooler.
- Ice.

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- Paper towels and garbage bags.
- Chain-of-custody records and custody seals.

Dip Sampling

Specific procedures for collecting a dip or grab sample of surface water can vary based on site-specific conditions (e.g., conditions near the shore and how closely a sampler can safely get to the shore). The general procedure for collecting a sample using a pole or directly from the water body is as follows:

1. If using a remote sampling pole, securely attach the appropriate sample container to a pole of sufficient length to reach the water to be sampled. Samples for volatile analysis should be collected first. Use PPE as described in the HASP. When sample containers are provided pre-preserved or if the pole cannot accommodate a particular sample container, use a dedicated, clean, unpreserved bottle/container for sampling and transfer to an appropriately preserved container.
2. Remove the cap. Do not place the cap on the ground or elsewhere where it might become contaminated.
3. Carefully dip the container into the water just below the surface (or as directed by project-specific planning documents), and allow the bottle to fill. Sample bottles for volatile analysis must be filled with no headspace. Avoid contacting the bottom of the water body because this will disturb sediment that may interfere with the surface water sample.
4. Retrieve the container and carefully replace the cap securely. If using a container other than the sample bottle, pour the water from that container into the sample bottle and replace the cap securely.
5. Use a clean paper towel to clean and dry the outside of the container.
6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
7. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

Constituents measured in grab samples collected near the water surface are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration distributed throughout the water column and in the cross section. Therefore, as possible based on site conditions, the sampler may be required to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

CAUTION

In areas prone to natural hazards such as alligators and snakes, etc., always use a buddy as a watch. Always have and use a lifeline or throwable device to extract persons who could potentially fall into the water. Be attentive to the signs, possible mounds indicating nests, and possible slides into the water. Remember that although snakes are typically encountered on the ground, it is not unheard of to see them on low-hanging branches. Be attentive to your surroundings because these may indicate that hazards are nearby.

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Weighted Bottle Sampling

A grab sample can also be collected using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of glass or plastic bottle with a stopper, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
2. When the desired depth is reached, pull out the stopper with a sharp jerk of the stopper line.
3. Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
4. Raise the sampler and cap the bottle.
5. Use a paper towel to clean and dry the outside of the container. This bottle can be used as the sample container as long as the bottle is an approved container type.
6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
7. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

Kemmerer Sampler

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon-coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while it is lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth.
2. When the desired depth is reached, send down the messenger to close the cylinder and then raise the sampler.
3. Open the sampler valve to fill each sample bottle (filling bottles for volatile analysis first).
4. Use a paper towel to clean and dry the outside of the container.
5. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
6. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

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6.1.2 Surface Water Sampling Techniques

Samples collected during site investigations may be grab samples or composite samples. The following general procedures apply to various types of surface water collection techniques:

- If a clean, pre-preserved sample container is not used, rinse the sample container least once with the water to be sampled before the sample is collected. This is not applicable when sample containers are provided pre-preserved because doing so will wash some or all of the preservative out of the bottle.
- For sampling moving water, collect the farthest downstream sample first, and continue sample collection in an upstream direction. In general, work from zones suspected of low contamination to zones of high contamination.
- Take care to avoid excessive agitation of the water because loss of volatile constituents could result.
- When obtaining samples in 40 mL vials with septum-lined lids for volatile organics analysis, fill the container completely (with a meniscus) to exclude any air space in the top of the bottle and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. Turn the vial upside down and tap gently on your wrist to check for air bubbles. If air bubbles rise in the bottle, add additional sample volume to the container.
- Do not sample at the surface, unless sampling specifically for a known constituent that is immiscible and on top of the water. Instead, invert the sample container, lower it to the approximate depth, and hold it at about a 45-degree angle with the mouth of the bottle facing upstream.

6.2 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

6.3 Sediment Sampling

6.3.1 General

If composite surface water samples are collected, sediment samples are usually collected at the same locations as the associated surface water samples. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body, in a depositional area if possible based on sample location restraints (see below), unless the SAP states otherwise.

Generally, coarser-grained sediments are deposited near the headwaters of reservoirs. Bed sediments near the center of a water body will be composed of fine-grained materials that may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathymetry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled, in general, and areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials shall be generally avoided. Follow instructions in the SAP, as applicable.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with

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respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are less than detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

Samples collected for volatile organic compound (VOC) analysis must be collected prior to any sample homogenization. Regardless of the method used for collection, the aliquot for VOC analysis must be collected directly from the sampling device (hand auger bucket, scoop, trowel), to the extent practical. If a device such as a dredge is used, the aliquot should be collected after the sample is placed in the mixing container prior to mixing.

In some cases, the sediment may be soft and not lend itself to collection by plunging Encore™ or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sampling device, (Encore™ barrel or syringe) prior to sample collection, and carefully place the sediment in the device, filling it fully with the required volume of sample.

On active or former military sites, ordnance items may be encountered in some work areas. Care should be exercised when handling site media (such as if unloading a dredge as these materials may be scooped up). If suspected ordnance items are encountered, stop work immediately, move to shore and notify the Project Manager and Health and Safety Manager.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3 and Attachment B or an equivalent electronic form.

6.3.2 Sampling Equipment and Techniques for Bottom Materials

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

SAFETY REMINDER

The following health and safety provisions apply when working on/over/near water:

- At least two people are required to be present at the sampling location in situations where the water depth and/or movement deem it necessary, each wearing a USCG-approved Personal Flotation Devices
- A minimum of three people are required if any of the following conditions are anticipated or observed:
 - Work in a waterway that is turbulent or swift that could sweep a sampler down stream should he or she fall in accidentally.
 - The underwater walking surface (e.g., stream/river bed) is suspected or observed to involve conditions that increase the potential for a worker to fall into the water. Examples include large/uneven rocks or boulders, dense mud or sediment that could entrap worker's feet, etc.
 - Waterway is tidal, and conditions such as those listed above could rapidly change.

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The third person in the above condition must be equipped and prepared to render emergency support [e.g., lifeline, tethered Personal Flotation Device (Throwable Type IV, life saver), skiff, means to contact external emergency response support, etc.]

The following samplers may be used to collect sediment samples:

- Scoop sampler
- Dredge samplers
- Coring samplers

Each type of sampler is discussed below.

In general, the following equipment if necessary for obtaining sediment samples:

- Required sampling equipment, which may include a scoop sampler, dredge sampler, coring sampler, or stainless steel or pre-cleaned disposable trowel.
- Stainless bowl or pre-cleaned disposable bowl to homogenize sample.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.
- Required PPE as directed in the project-specific planning document, which may include:
 - Nitrile surgeon's or latex gloves (layered as necessary).
 - Safety glasses.
 - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.
 - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).
 - Required decontamination equipment.
 - Required sample containers.
 - Sealable polyethylene bags (e.g., Ziploc® baggies).
 - Heavy-duty cooler.
 - Ice.
 - Paper towels and garbage bags.
 - Chain-of-custody records and custody seals.

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Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if the sampler can safely wade to the required location, the easiest and best way to collect a sediment sample is to use a scoop sampler. Scoop sampling also reduces the potential for cross-contamination. The general scoop sampling procedure is as follows:

1. Reach over or wade into the water body.
2. While facing upstream (into the current), scoop the sampler along the bottom in an upstream direction. Although it is very difficult not to disturb fine-grained materials at the sediment-water interface when using this method, try to keep disturbances to a minimum.

Dredge Samplers

Dredges are generally used to sample sediments that cannot easily be obtained using coring devices (e.g., coarse-grained or partially cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger." Some dredges are heavy and may require use of a winch and crane assembly for sample retrieval. The three major types of dredges are Peterson, Eckman and Ponar.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The general procedure for using dredge samplers is as follows:

1. Gently lower the dredge to the desired depth.
2. When the desired depth is reached, send the messenger down to cable to close the cylinder and then carefully raise the sampler.
3. Open the sampler to retrieve the sediment.
4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis *prior to* homogenization. Homogenize the remainder of the sediment collected.
5. Fill the containers for all analyses other and VOCs.

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6. Use a paper towel to clean and dry the outside of each container.
7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

SAFETY REMINDER

Safety concerns using these dredges include lifting hazards, pinches, and compressions (several pinch points exist within the jaws and levers). In all cases, handle the dredge by the rope to avoid capturing fingers/hands.

Coring Samplers

Coring samplers are used to sample vertical columns of sediment. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand-push tubes to electronic vibrational core tube drivers.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines at the sediment-water interface are only minimally disturbed. The sample is withdrawn intact, permitting the removal of only those layers of interest.

In shallow, wadeable waters, the use of a core liner or tube manufactured of Teflon or plastic is recommended for the collection of sediment samples. Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water. The general procedure to collecting a sediment sample with a core tube is as follows:

1. Push the tube into the substrate until 4 inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction.
2. Cap the top of the tube to provide suction and reduce the chance of losing the sample.
3. Slowly extract the tube so as not to lose sediment from the bottom of the tube. Cap the bottom of the tube before removing it from the water. This will also help to minimize loss of sample.
4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis prior to homogenization. Homogenize the remainder of the sediment collected.
5. Fill the containers for all analyses other and VOCs.
6. Use a paper towel to clean and dry the outside of each container.
7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

In deeper, non-wadeable water bodies, sediment cores may be collected from a bridge or boat using different coring devices such as Ogeechee Sand Pounders, gravity cores, and vibrating coring devices.

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All three devices utilize a core barrel with a core liner tube system. The core liners can be removed from the core barrel and replaced with a clean core liner after each sample. Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by turning the core tube to its side and gently pouring the liquid out until fine sediment particles appear in the waste liquid. Post-retrieval processing of samples is the same as above.

7.0 REFERENCES

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**ATTACHMENT B
SOIL & SEDIMENT SAMPLE LOG SHEET**



Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

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Project Site Name: _____	Sample ID No.: _____
Project No.: _____	Sample Location: _____
<input type="checkbox"/> Surface Soil	Sampled By: _____
<input type="checkbox"/> Subsurface Soil	C.O.C. No.: _____
<input type="checkbox"/> Sediment	Type of Sample:
<input type="checkbox"/> Other: _____	<input type="checkbox"/> Low Concentration
<input type="checkbox"/> QA Sample Type: _____	<input type="checkbox"/> High Concentration

GRAB SAMPLE DATA:			
Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time: _____			
Method: _____			
Monitor Reading (ppm): _____			

COMPOSITE SAMPLE DATA:				
Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:			
Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:	MAP:

Circle if Applicable:	Signature(s):
<input type="checkbox"/> MS/MSD <input type="checkbox"/> Duplicate ID No.: _____	

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**APPENDIX C
GUIDANCE ON SAMPLING DESIGN AND SAMPLE COLLECTION**

C.1 Defining the Sampling Program

Many factors are considered in developing a sampling program for surface water and/or sediment, including study objectives, accessibility, site topography, physical characteristics of the water body (e.g., flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on vertical and lateral mixing within the body of water. For sediment, dispersion depends on bottom current or flow characteristics, sediment characteristics (e.g., density, size), and geochemical properties (that affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes but must also understand the role of fluvial-sediment transport, deposition, and chemical sorption.

C.1.1 Sampling Program Objectives

The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., contaminated runoff). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the water body, direct waste disposal (solid or liquid) into the water body, and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompasses the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the locations of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc. shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation include: (1) moving the sampling location far enough downstream to allow for adequate mixing, or (2) collecting integrated samples in a cross section. Also, non-homogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

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C.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes, reservoirs, or larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each contaminant would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining stream flow data by direct or indirect methods. Remember these locations are also where you may encounter natural hazards as these are areas where they hunt. Always exercise extreme caution.

C.1.3 Frequency of Sampling

The sampling frequency and objectives of the sampling event will be defined by the project planning documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of a contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples should be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly and during droughts and floods). Samples of bottom material should generally be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

C.2 Surface Water Sample Collection

C.2.1 Streams, Rivers, Outfalls and Drainage Features

Methods for sampling streams, rivers, outfalls, and drainage features (ditches, culverts) at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

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Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, and discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of dissolved oxygen (DO), pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project planning documents.

C.2.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, measurement of DO, pH, temperature, etc. is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample if a sample representative of the water column is required. These vertical composites are often collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline that is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer that is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several vertical composites with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality because it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, DO, some cations and anions, and light penetration.

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C.2.3 Estuaries

Estuarine areas are, by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Knowledge of the estuary type may be necessary to determine sampling locations. Estuaries are generally categorized into one of the following three types dependent on freshwater inflow and mixing properties:

- Mixed Estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically, this type of estuary is shallow and is found in major freshwater sheet flow areas. Because this type of estuary is well mixed, sampling locations are not critical.
- Salt Wedge Estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally back and forth with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.
- Oceanic Estuary - characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small, with the preponderance of the fresh-saline water mixing occurring near or at the shore line.

Sampling in estuarine areas is normally based on the tidal phase, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical DO and temperature profiles.



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Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved Tom Johnston <i>T.E. Johnston</i>	

Subject
SOIL SAMPLING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE

This document applies to the collection of surface, near-surface, and subsurface soil samples exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites for laboratory testing, onsite visual examination, and onsite testing.

3.0 GLOSSARY

Composite Sample - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall not be collected for volatile organics analysis.

Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.

Grab Sample - One sample collected at one location and at one specific time.

Hand Auger - A sampling device used to extract soil from the ground.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Sample for Non-Volatile Analyses - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches OD. The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).

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Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, selecting proposed sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring, and excavation activities and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation, and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and/or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

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- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard or uneven surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas, along roadways and highways.

Methods of avoiding these hazards are provided below.

Knee injuries – If kneeling is required during soil sampling, this could result in knee injuries from stones/foreign objects and general damage due to stress on the joints. To minimize this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.
- Stretch ligaments, tendons and muscles before, during and after. Take breaks as frequently as necessary.
- Report pre-existing conditions to the SSO if you feel this activity will aggravate an existing condition.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample locations. To minimize these hazards:

- Pre-survey sampling locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations - To prevent cuts and lacerations associated with soil sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.

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- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut – do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken sample jars or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel.** Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket.**

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6.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at hazardous waste sites.

6.2 Soil Sample Collection

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol or sodium bisulfate may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is needed.

Soil samples to be preserved by the laboratory are currently being collected using Method SW-846, 5035. For samples preserved in the field, laboratories are currently performing low-level analyses (sodium bisulfate preservation) and high- to medium-level analyses (methanol preservation) depending on the needs of the end user.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

6.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample shall be

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obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore™ sampler when requested and purchased. Collect the sample in the following manner for each EnCore™ sampler:

1. Scene Safety - Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.
2. Wear the appropriate personal protective equipment (PPE). This will include, at a minimum, safety glasses and nitrile surgeon's gloves. If you must kneel on the ground or place equipment on the surface being sampled, cover the ground surface with plastic to minimize surface contamination of your equipment and clothing. Wear knee pads to protect your knees from kneeling on hard or uneven surfaces.
3. Load the Encore™ sampler into the T-handle with the plunger fully depressed.
4. Expose the area to be sampled using a hand trowel or similar device to remove surface debris.
5. Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.
6. When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.
7. Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.
8. With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.
9. Remove any surface soil from the outside of the sampler and place in the foil bag provided with the sampler. Good work hygiene practices and diligent decontamination procedures prevents the spread of contamination even on the outside of the containers.
10. Label the bag with appropriate information in accordance with SOP SA-6.3.
11. Place the full sampler inside a lined cooler with ice and cool to 4°C ± 2 °C. Make sure any required trip blanks and temperature blanks are also in the cooler. Secure custody of the cooler in accordance with SOP SA-6.3.
12. Typically, collect three Encore™ samplers at each location. Consult the SAP or laboratory to determine the required number of Encore™ samplers to be collected.
13. The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the project planning documents.

Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler.

After the Encore™ samples are collected, they should be placed on ice immediately and delivered to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

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6.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) and high- to medium-level (methanol preservation) methods.

Safety Reminder

When using chemicals in the field to preserve samples, the FOL and/or SSO must ensure that Materials Safety Data Sheets (MSDSs) have been provided with the chemicals to be used. They also must ensure that these chemicals have been added to the Chemical Inventory List contained within Section 5.0, Hazard Communication, of your Health and Safety Guidance Manual (HSGM). Lastly, but most importantly, the FOL and/or SSO must review the hazards with personnel using these chemicals and ensure that provisions are available for recommended PPE and emergency measures (e.g., eyewash, etc.).

Methanol Preservation (High to Medium Level):

Bottles may be pre-spiked with methanol in the laboratory or prepared in the field. Soil samples to be preserved in the field with methanol shall utilize 40 to 60 mL glass vials with septum-lined lids. Each sample bottle shall be filled with 25 mL of demonstrated analyte-free purge-and-trap grade methanol. The preferred method for adding methanol to the sample bottle is by removing the lid and using a pipette or scaled syringe to add the methanol directly to the bottle.

CAUTION

NEVER attempt to pipette by mouth

In situations where personnel are required to spike the septum using a hypodermic needle, the following provisions for handling sharps must be in place:

- Training of personnel regarding methods for handling of sharps
- Hard-sided containers for the disposal of sharps
- Provisions for treatment in cases where persons have received a puncture wound

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer's requirements.

The sample should be collected as follows:

1. Weigh the unused syringe and plunger to the nearest 0.01 gram.
2. Pull the plunger back and insert the syringe into the soil to be sampled.
3. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.
4. Weigh the sample and adjust until obtaining the required amount of sample.

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5. Record the sample weight to the nearest 0.01 gram in the field logbook and/or on the sample log sheet.
6. Extrude the weighed soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.
7. If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.
8. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.
9. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

CAUTION

Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as Encore™ or 2-ounce jar.

Bottles may be prepared in the laboratory or in the field with sodium bisulfate solution. Samples to be preserved in the field using the sodium bisulfate method are to be prepared and collected as follows:

1. Add 1 gram of sodium bisulfate to 5 mL of laboratory-grade deionized water in a 40 to 60 mL glass vial with septum-lined lid.
2. Collect the soil sample and record the sample weight to the nearest 0.01 gram in the field logbook or on the sample log sheet as described for methanol preservation
3. Add the weighed sample to the sample vial.
4. Collect duplicate samples using the methanol preservation method on a one-for-one sample basis because it is necessary for the laboratory to perform both low-level and medium-level analyses.
5. Place the samples on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

NOTE

If lower detection limits are necessary, an option to field preserving with sodium bisulfate may be to collect EnCore™ samplers at a given sample location. Consult the planning documents to determine whether this is required. If it is, collect samples in accordance with the Encore™ sampling procedure above and then send all samplers to the laboratory to perform the required preservation and analyses.

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

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1. With a stainless steel trowel or other approved tool, transfer a portion of soil to be sampled to a stainless steel bowl or disposable inert plastic tray.
2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.
3. Thoroughly mix the soil in the bowl or tray to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases, it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.
4. Transfer the mixed soil to the appropriate sample containers and close the containers.
5. Label the sample containers in accordance with SOP SA-6.3.
6. Place the containers in a cooler of ice as soon after collection as possible.
7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

NOTE

Cooling may not be required for some samples depending on the scheduled analyses. Consult the planning documents if in doubt regarding correct sample preservation conditions. When in doubt – Cool to 4° C.

NOTE

Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

6.2.3 Procedure for Collecting Undisturbed Soil Samples

NOTE

Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly used.

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:

1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:
 - Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.

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REMEMBER

If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.

- Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the HASP.
 - Review the Safe Work Permit prior to conducting the activity.
 - Review the activity to be conducted.
2. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

CAUTION

The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.

3. Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.
4. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.
5. A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.
6. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.
7. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.
8. Remove disturbed material in the upper end of the tube and measure the length of sample again.
9. After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.

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10. Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.
11. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.
12. Mark the "up" direction on the side and upper end of the tube with indelible ink.
13. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).
14. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

CAUTION

To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.

CAUTION

A primary concern in the preparation of the wax plugs is the potential for the heat source and melted wax to cause a fire and/or burns. Follow the directions below to prevent injury or fire.

Electrical Heating

Using hot plates to melt the wax is acceptable. In an outdoor setting, make sure a Ground Fault Circuit Interrupter (GFCI) is employed within the electrical circuit. If a portable generator is used, ensure that the generator is an adequate distance from the sampling operation (at least 50 feet). Ensure that the extension cord is rated for the intended load and for outdoor use and is free from recognizable damage. Ensure flammable preservatives are not employed or stored near the hot plate. Although a Hot Work Permit is not required, scene safety evaluation by site personnel of the above elements is. As always, if a fire potential exists, the provisions for extinguishing must be immediately accessible as well as any provisions for first aid measures.

Open Flame

If an open flame is used, the following provisions are necessary:

- Complete a Hot Work Permit and any local permit required for elevated temperature applications. The Hot Work Permit, provided in your HASP, will aid the FOL and/or the SSO in ensuring that fire protection provisions (extinguishers, fire watches, etc.) are in place as well as ensuring that local requirements have been addressed.
- Ensure that water is available to address any wax splashes or contact. If possible, immerse the contacted area. Where this is not possible, run water over the area and apply cold compresses. The need for medical attention or first aid shall be determined on site under the direction of the SSO.

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6.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.

NOTE

Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.

For the purposes of instruction, the terms “surface soil” and “near-surface soil” are used in this SOP as follows:

- Surface soil - 0 to 6 inches bgs
- Near-surface soil - 6 to 18 inches bgs

If these intervals are defined differently in the planning documents, substitute the appropriate depth ranges.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Stainless steel hand auger, soil corer, or shovel.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in project planning document.
- Required PPE.
 - Nitrile surgeon’s or latex gloves may be used, layered as necessary.
 - Safety glasses
 - Other – Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP)
- Required decontamination equipment
- Required sample container(s)
- Wooden stakes or pin flags

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- Sealable polyethylene bags (e.g., Ziploc® baggies)
- Heavy duty cooler
- Ice
- Chain-of-custody records and custody seals

When acquiring surface soil samples, use the following procedure:

1. Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross- contamination.
2. Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.
3. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the planning document.
4. Using decontaminated sampling tools, thoroughly mix in place a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.
5. Transfer the sample into those containers utilizing a stainless steel trowel.
6. Cap and securely tighten all sample containers.
7. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.
9. Site restoration – Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas when pedestrian traffic may exist.

6.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.

To obtain near-surface soil samples, the following protocol shall be used:

1. With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.
2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

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3. Follow steps 1 through 9 of Section 6.3.

6.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-inch lengths), and a T-handle connected to extension rods and to the auger bucket. A larger-diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes)
- Stainless steel mixing bowls
- The equipment listed in Section 6.3
- Miscellaneous hand tools as required to assemble and disassemble the hand auger units

CAUTION

Potential hazards associated with hand augering include:

- Muscle strain and sprain due to over twisting and/or over compromising yourself.
- Equipment failure due to excessive stress on the T-handle or rods through twisting. Failure of any of these components will result in a sudden release and potential injury due to that failure.

As in all situations, any intrusive activities that could damage underground utilities shall be preceded by a Dig/Excavation permit/ticket. Call the Utility Locating service in the area or your Project Health and Safety Officer for more information. When in doubt – **Get the Ticket!**

To obtain soil samples using a hand auger, use the following procedure:

1. Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.
2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).
3. Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.
4. As the auger bucket fills with soil, periodically remove any unneeded soil.

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5. Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.
6. After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.
7. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.
8. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.
9. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.
10. Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.
11. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.
12. Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl.
13. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.
14. Follow steps 4 through 7 listed in Section 6.3.

6.5.1 Sampling Using Stainless Steel Soil Corers

A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.

Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.

SAFETY REMINDER

Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such as the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:

- Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).

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- Job rotation – Share the duties so that repetitive actions do not result in fatigue and injury.
- Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.
- Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.
- Do not over compromise yourself when applying force to the soil corer or hand auger. If there is a sudden release, it could result in a fall or muscle injury due to strain.

6.6 Subsurface Soil Sampling with a Split-Barrel Sampler

A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.

Safety Reminder

It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Equipment listed in Section 6.3.

The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):

1. Attach the split-barrel sampler to the sampling rods.

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2. Lower the sampler into the borehole inside the hollow stem auger bits.
3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.
4. When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.
5. Detach the sampler from the drill rods.
6. Place the sampler securely in a vise so it can be opened using pipe wrenches.

CAUTION

Pipe wrenches are used to separate the split spoon into several components. The driller's helper should not apply excessive force through the use of cheater pipes or push or pull in the direction where, if the wrench slips, hands or fingers will be trapped against an immovable object.

7. Remove the drive head and nosepiece with the wrenches, and open the sampler to reveal the soil sample.
8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.
9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings were encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).
10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl.
11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).
12. Follow steps 4 through 7 in Section 6.3.

6.7 Subsurface Soil Sampling Using Direct-Push Technology

Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

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6.8 Excavation and Sampling of Test Pits and Trenches

6.8.1 **Applicability**

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

CAUTION

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise from the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden, steel, or aluminum support structures or through sloping and benching. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments; therefore, monitoring will be conducted by the Competent Person to determine if it is safe to enter. Any entry into a trench greater than 4 feet deep will constitute a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. In all cases involving entry, substantial air monitoring, before entry, appropriate respiratory gear and protective clothing determination, and rescue provisions are mandatory. There must be at least three people present at the immediate site before entry by one of the field team members. This minimum number of people will increase based on the potential hazards or complexity of the work to be performed. The reader shall refer to OSHA regulations 29 CFR 1926.650, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146. High-hazard entries such as this will be supported by members of the Health Sciences Group professionally trained in these activities.

Excavations are generally not practical where a depth of more than about 15 to 20-feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15-feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

6.8.2 **Test Pit and Trench Excavation**

Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).

Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration

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- The space required for efficient excavation
- The chemicals of concern
- The economics and efficiency of available equipment

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.

Equipment	Typical Widths, in Feet
Trenching machine	0.25 to 1.0
Backhoe/Track Hoe	2 to 6

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, the following field conditions may necessitate revisions to the initial plans:

- Subsurface utilities
- Surface and subsurface encumbrances
- Vehicle and pedestrian traffic patterns
- Purpose for excavation (e.g., the excavation of potential ordnance items)

The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.

No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example,

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samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.

Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

Where possible excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:

- Trench covers/street plates
- Fences encompassing the entire excavation intended to control access
- Warning signs warning personnel of the hazards
- Amber flashing lights to demarcate boundaries of the excavation at night

Excavations left open will have emergency means to exit should someone accidentally enter.

6.8.3 Sampling in Test Pits and Trenches

6.8.3.1 General

Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the project-specific HASP.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

6.8.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

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- Backhoe or other excavating machinery.
- Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.
- Sample container - bucket with locking lid for large samples; appropriate bottle ware for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample containers; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps, and right angle adapter for conduit (see Attachment D).

6.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.

- Excavate the trench or pit in several 0.5- to 1.0-foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.
- After each increment:
 - the operator shall wait while the sampler inspects the test pit from grade level
 - the sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet or where lithological changes are noted.
- The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:
 - Any fluid phase, including groundwater seepage, is encountered in the test pit
 - Any drums, other potential waste containers, obstructions, or utility lines are encountered
 - Distinct changes of material being excavated are encountered

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.
- Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)

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- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:
 - a. The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.
 - b. The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.
 - c. After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.
 - d. When signaled by the operator that it is safe to do, the sampler will approach the bucket.
 - e. The soil shall be monitored with a photoionization or flame ionization detector (PID or FID) as directed in the project -specific planning documents.
 - f. The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.
- If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

CAUTION

Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.

- Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:
 - a. Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bucket.
 - b. Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.
 - c. Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.
- Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.

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6.8.3.4 In-Pit Sampling

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There are no practical alternative means of obtaining such data.
- The SSO and Competent Person determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.
- A company-designated Competent Person determines that the pit/trench is stable through soil classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.

If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.

A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self rescue or assisted self rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon.

6.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.
- Suitable driving (e.g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

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Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.

A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to remove the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SOPs SA-6.3 and SA-6.1.

6.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.

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If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

6.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs if required
- Groundwater levels
- PID/FID/LEL/O₂ meter readings
- Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists

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- Soil type classification

7.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

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USEPA, November 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.

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**ATTACHMENT A
SOIL & SEDIMENT SAMPLE LOG SHEET**



Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

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Project Site Name: _____	Sample ID No.: _____
Project No.: _____	Sample Location: _____
<input type="checkbox"/> Surface Soil	Sampled By: _____
<input type="checkbox"/> Subsurface Soil	C.O.C. No.: _____
<input type="checkbox"/> Sediment	Type of Sample:
<input type="checkbox"/> Other: _____	<input type="checkbox"/> Low Concentration
<input type="checkbox"/> QA Sample Type: _____	<input type="checkbox"/> High Concentration

GRAB SAMPLE DATA:			
Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time: _____			
Method: _____			
Monitor Reading (ppm): _____			

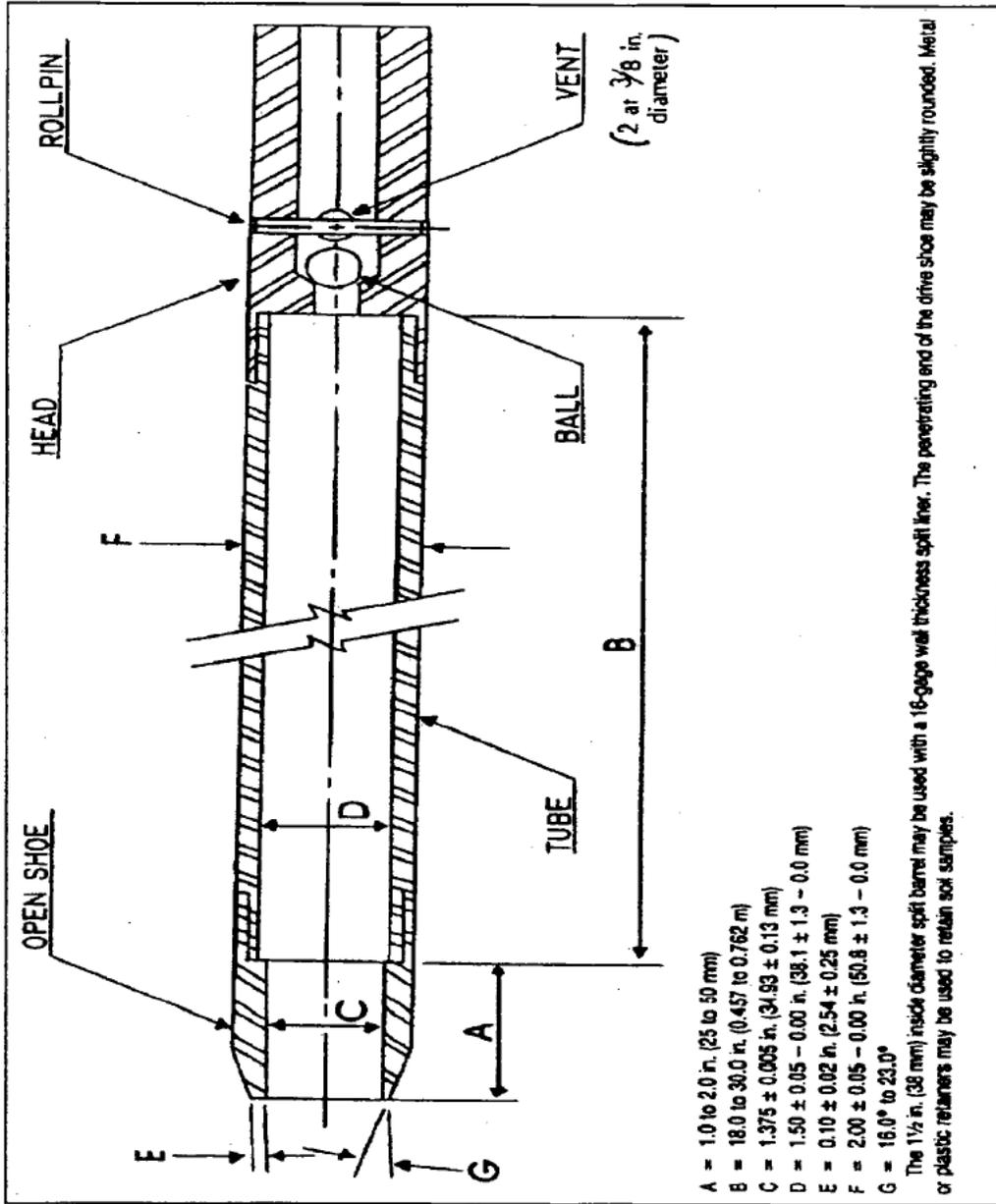
COMPOSITE SAMPLE DATA:				
Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:			
Analysis	Container Requirements	Collected	Other

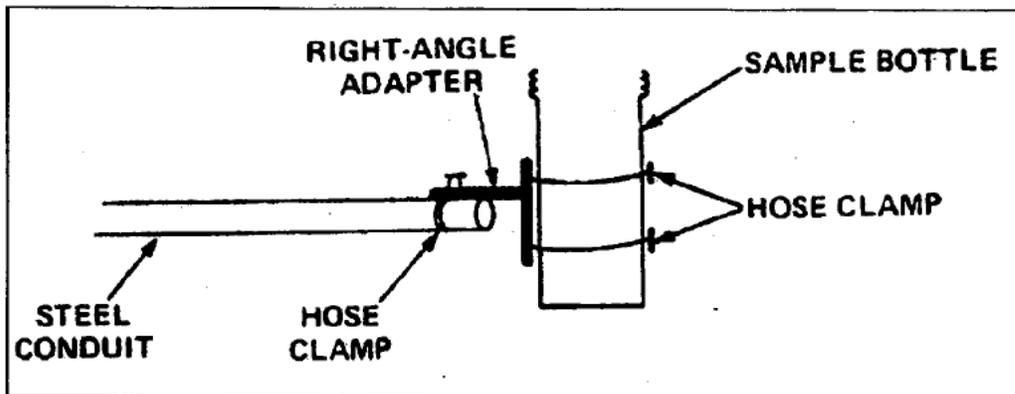
OBSERVATIONS / NOTES:	MAP:

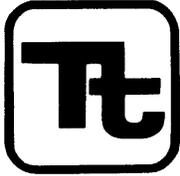
Circle if Applicable:	Signature(s):
MS/MSD Duplicate ID No.:	

**ATTACHMENT B
SPLIT-SPOON SAMPLER**



**ATTACHMENT D
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING**





TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Effective Date	03/09/09	Revision	3
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	Tom Johnston <i>T.E. Johnston</i>		

Subject
FIELD DOCUMENTATION

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting Tetra Tech NUS, Inc. (TtNUS) field activities.

2.0 SCOPE

Documents presented within this SOP (or equivalents) shall be used for all TtNUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager (PM) - The PM is responsible for obtaining hardbound controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The FOL is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports included in this SOP (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time frame.

General personnel qualifications for field documentation activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 SITE LOGBOOK

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, record or reference the following activities/events (daily) in the site logbook:

- All field personnel present
- Arrival/departure times and names of site visitors
- Times and dates of health and safety training
- Arrival/departure times of equipment
- Times and dates of equipment calibration

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- Start and/or completion of borehole, trench, monitoring well installation activities, etc.
- Daily on-site activities
- Sample pickup information
- Health and safety issues (level of protection, personal protective equipment [PPE], etc.)
- Weather conditions

Maintain a site logbook for each project and initiate it at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Make entries every day that on-site activities take place involving TtNUS or subcontractor personnel. Upon completion of the fieldwork, provide the site logbook to the PM or designee for inclusion in the project's central file.

Record the following information on the cover of each site logbook:

- Project name
- TtNUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, either record the measurements and equipment used in the site logbook or reference the field notebook in which the measurements are recorded (see Attachment A).

Make all logbook, notebook, and log sheet entries in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, cross out the entry with a single strike mark, initial, and date it. At the completion of entries by any individual, the logbook pages used must be signed and dated by the person making the entries. The site logbook must also be signed by the FOL at the end of each day.

5.1.2 Photographs

Sequentially number movies, slides, or photographs taken of a site or any monitoring location to correspond to logbook/notebook entries. Enter the name of the photographer, date, time, site location, site description, and weather conditions in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided because they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend on the subject matter, type of camera (digital or film), and the processing it requires. Follow chain-of-custody procedures for film used for aerial photography, confidential information, or criminal investigation. After processed, consecutively number the slides of photographic prints and label them according to the logbook/notebook descriptions. Docket the site photographs and associated negatives and/or digitally saved images to compact disks into the project's central file.

5.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a

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separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 FIELD FORMS

All TtNUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (<http://intranet.ttnus.com>) under Field Log Sheets. Forms may be altered or revised for project-specific needs, subject to client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOPs.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample log sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. Complete a sample log sheet for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Complete the required information on the adhesive labels and apply them to every sample container. Obtain sample labels from the appropriate program/project source, request that they be electronically generated in house, or request them the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record

The chain-of-custody record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used as follows for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site:

- Retain one carbonless copy of the completed chain-of custody form in the field.
- Send one copy is sent to the PM (or designee)
- Send the original to the laboratory with the associated samples. Place the original (top, signed copy) of the chain-of custody form inside a large Ziploc[®]-type bag taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one chain-of custody form, send the form with the cooler containing vials for volatile organic compound (VOC) analysis or the cooler with the air bill attached. Indicate on the air bill how many coolers are included with that shipment.

An example of a chain-of-custody form is provided as Attachment C. After the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed chain-of custody form (any discrepancies between the sample labels and chain-of custody form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the TtNUS PM). The chain-of custody form is signed and copied. The laboratory will retain the copy, and the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label that is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. Sign and date custody seals

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and affix them across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). Obtain custody seals from the laboratory (if available) or purchase them from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Complete Field Analytical Log Sheets to record geochemical and/or natural attenuation field test results.

5.3.2 **Hydrogeological and Geotechnical Forms**

5.3.2.1 Groundwater Level Measurement Sheet

Complete a Groundwater Level Measurement Sheet for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. Use a Pumping Test Data Sheet to facilitate this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be established in advance.

5.3.2.3 Packer Test Report Form

Complete a Packer Test Report Form for each well at which a packer test is conducted.

5.3.2.4 Boring Log

Complete a Summary Log of Boring, or Boring Log for each soil boring performed to document the materials encountered, operation and driving of casing, and locations/depths of samples collected. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a photoionization detector [PID] or flame ionization detector [FID]), enter these readings on the boring log at the appropriate depth. When they become available, enter the laboratory sample number, concentrations of key contaminants, or other pertinent information in the "Remarks" column. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

Complete a Monitoring Well Construction Details Form for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

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5.3.2.7 Miscellaneous Monitoring Well Forms

Miscellaneous monitoring well forms that may be required on a project-specific basis include the Monitoring Well Materials Certificate of Conformance and Monitoring Well Development Record. Use a Monitoring Well Materials Certificate of Conformance to document all materials utilized during each monitoring well installation. Use a Monitoring Well Development Record to document all well development activities.

5.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Miscellaneous field forms/checklists forms that may be required on a project-specific basis include the following:

- Container Sample and Inspection Sheet – use this form when a container (drum, tank, etc.) is sampled and/or inspected.
- QA Sample Log Sheet – use this form when a QA sample such as an equipment rinsate blank, source blank, etc. is collected.
- Field Task Modification Request (FTMR) – use this form to document deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Maintain copies of all FTMRs with the on-site planning documents, and place originals in the final evidence file.
- Field Project Daily Activities Checklist and Field Project Pre-Mobilization Checklist – used these during both the planning and field effort to ensure that all necessary tasks are planned for and completed. These two forms are not requirements but are useful tools for most field work.

5.3.3 **Equipment Calibration and Maintenance Form**

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure the proper operation and response of the equipment, to document the accuracy, precision, or sensitivity of the measurements, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log, which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. Maintain an Equipment Calibration Log for each electronic measuring device used in the field; make entries for each day the equipment is used or in accordance with manufacturer recommendations.

5.4 **FIELD REPORTS**

The primary means of recording on-site activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation but are not easily used for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain on site for extended periods of time and are thus not accessible for timely review by project management. Other reports useful for tracking and reporting the progress of field activities are described below.

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5.4.1 Daily Activities Report

To provide timely oversight of on-site contractors, complete and submit Daily Activities Reports (DARs) as described below.

5.4.1.1 Description

The DAR documents the activities and progress for each day's field work. Complete this report on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring that involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the DAR to the FOL for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DARs are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the PM.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

In addition to those described herein, other summary reports may also be contractually required.

All TtNUS field forms can be found on the company's intranet site at <http://intranet.ttnus.com> under Field Log Sheets.

6.0 LISTING OF FIELD FORMS ON THE TtNUS INTRANET SITE

- Boring Log
- Container Sample and Inspection Sheet
- Daily Activities Checklist
- Daily Activities Record
- Equipment Calibration Log
- Field Task Modification Request
- Field Analytical Log sheet - Geochemical Parameters
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Hydraulic Conductivity Test Data Sheet
- Low Flow Purge Data Sheet
- Bedrock Monitoring Well Construction (Stick Up)
- Bedrock Monitoring Well Construction Flush Mount
- Bedrock Monitoring Well Construction Open Hole
- Confining Layer Monitoring Well Construction
- Monitoring Well Development Record

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- Monitoring Well Materials Certificate of Conformance
- Overburden Monitoring Well Construction Flush Mount
- Overburden Monitoring Well Construction Stick Up
- Packer Test Report Form
- Pumping Test Data Sheet
- QA Sample Log Sheet
- Soil/Sediment Sample Log Sheet
- Surface Water Sample Log Sheet
- Test Pit Log
- Field Project Pre-Mobilization Checklist

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**ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY**

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL: _____

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenny and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ____ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

Field Operations Leader

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**ATTACHMENT B
SAMPLE LABEL**

	Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090		Project:
			Site:
		Location:	
Sample No:		Matrix:	
Date:	Time:	Preserve:	
Analysis:			
Sampled by:		Laboratory:	

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**ATTACHMENT D
CHAIN-OF-CUSTODY SEAL**

<u>Signature</u> <hr/> <u>Date</u> <hr/> CUSTODY SEAL		CUSTODY SEAL <hr/> <u>Date</u> <hr/> <u>Signature</u>
--	--	--



STANDARD OPERATING PROCEDURES

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Effective Date 01/28/2009	Revision 6
Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved Tom Johnston <i>T.E. Johnston</i>	

Subject DECONTAMINATION OF FIELD EQUIPMENT

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1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment, chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent - A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

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4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

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- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities

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- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:
 - Well removed from pedestrian/vehicle thoroughfares.
 - Avoidance of areas where control/custody cannot be maintained.
 - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.
 - Avoidance of potentially contaminated areas.
 - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

The selected decontamination site should include the following, where possible:

- Areas where potable water and electricity are provided.

Safety Reminder

When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:

- All power is routed through a Ground Fault Circuit Interrupter (GFCI).
- All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.

In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

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- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.
- Areas that offer sufficient size to carry out the specific decontamination sequence.
- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:
 - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.
 - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.
 - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.
 - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.
 - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:
 - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

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- Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.
- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.
2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.
3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.
4. Remove the pump and tubing/bailer from the container
5. Rinse external pump components using tap water.

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6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents –
Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.
8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.
9. Drain residual deionized water to the extent possible.
10. Allow components of the equipment to air dry.
11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.
12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

SAFETY REMINDER

Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

NOTE

In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

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7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.
- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:
 1. Wash with soap and water
 2. Rinse with tap water
 3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 **Downhole Drilling Equipment**

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

CAUTION

Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

CAUTION

In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

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4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol
5. To the extent possible, allow components to air dry.
6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.
7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 °F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0° tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40° fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.
2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.
3. Always wear PPE as specified in the HASP such as:
 - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.
4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.
5. Do not modify equipment unless the manufacturer has approved the modifications.

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7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.
3. Rinse the equipment with tap water.

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.
5. Rinse the equipment with deionized water.
6. To the extent possible, allow components to air dry.
7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.
8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device
- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.
- Extract the dredge and wash it in soap and water per the project-specific planning documents.

CAUTION

When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

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7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

NOTE

Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.
2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).
4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:
 - Enclose areas accessible by the general public using construction fencing and signs.
 - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
 - Maintain the retaining bolt and label on the outside of storage containers where readily visible.
 - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.
 - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.
 - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

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- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

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CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 Decontamination Evaluation

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.
- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:
 - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.
 - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.
 - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:
 - Per decontamination method
 - Per disposable article/batch number of disposable articles

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NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.



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Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved Tom Johnston <i>T.E. Johnston</i>	

Subject DECONTAMINATION OF FIELD EQUIPMENT

Attachment A iDW Label

INVESTIGATION DERIVED WASTE

GENERATOR INFORMATION:

SITE _____ JOB NO. _____

LOCATION _____

DATE _____

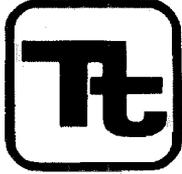
DRUM# _____

CONTENTS _____

VOLUME _____

CONTACT _____

EMERGENCY PHONE NUMBER _____



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>ds</i>		

Subject: SITE RECONNAISSANCE

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1.0 PURPOSE

The purpose of a site reconnaissance is to collect both general and technical information which will support the scoping, scheduling, implementing project activities, and writing reports for an environmental investigation. This procedure is not intended as a guide for Phase I investigations or for Environmental Baseline Survey activities.

2.0 SCOPE

This procedure is applicable to the performance of a site reconnaissance for initial site characterization. The steps necessary to develop and carry out a site reconnaissance are presented here. These steps include a list of equipment and items which may be needed, areas of special interest during field observations, and methods by which the field observation team can ensure that necessary and appropriate observations have been made.

3.0 GLOSSARY

Site reconnaissance. An onsite inspection program used to identify site-specific conditions that control scheduling, manpower, and affect costs. A site reconnaissance usually consists of visual observations and, often, the use of field monitoring instruments to identify potential health and safety threats and potential sampling locations for site evaluation during subsequent field investigations.

4.0 RESPONSIBILITIES

Field Operations Leader (FOL) is responsible for ensuring that the survey is carried out in sufficient detail. To accomplish this, the FOL must assign the proper personnel and equipment to characterize the site adequately, in accordance with the requirements defined in this procedure and best engineering practices. Other disciplines which may be applicable include (but are not limited to): Geology/Hydrogeology; Health and Safety; Ecological Specialists; and/or Engineering. In addition, the FOL is responsible for supervising equipment preparation, including necessary calibrations, and supervising field data collection and documentation in accordance with the methods described in all referenced standard operation procedures.

Project Manager is responsible for the following:

- Supervising the retrieval and examination of available, applicable information regarding the site.
- Obtaining appropriate program approvals and ensuring the preparation of a site Health and Safety plan for the site reconnaissance.
- Coordinating the field activities with the client and regulatory agencies, as applicable.

Field Personnel are primarily responsible for observing and documenting, either through written documentation or photographic evidence, the site reconnaissance. Field personnel will take direction from the FOL.

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5.0 PROCEDURES

5.1 Equipment Items/Needed

Below is a list of items that may be useful when conducting a site reconnaissance. All, or a portion of these items may be required, depending upon the objective of the site reconnaissance.

- Health and Safety equipment and information as required by the Site Safety Officer.
- Maps (U.S.G.S. quadrangle, geologic maps, street and highway maps, and client facility maps).
- Geologic tools (compass, tape measure, hand level, camera, etc.).
- Physical monitoring equipment, if applicable (PID, Immunoassay Test Kits, etc.)
- Regional publications (U.S.G.S reports, water well surveys, U.S.D.A. soil conservation surveys, etc.).
- Site-specific publications by previous investigators (EPA aerial photographic analyses, remedial investigation reports, data on waste disposal practices, boring logs, etc.).
- Marking items (ink markers, surveyor's flagging, spray paint, pin flags, wooden stakes).
- Field notebooks.
- Local telephone book with yellow pages (for obtaining utilities, site trailer, living accommodations, etc.).

Sufficient time will be required in order to obtain some of the aforementioned material. In general, most publications can be obtained in time to be used in the site reconnaissance if ordered approximately 2 weeks before the actual site visit takes place.

5.2 Observations

A site reconnaissance usually requires one to two days, however, additional time may be needed depending upon the objective, site size, etc. The following observations, when applicable, should be documented either on a site map, field notebook, or photographed.

- General Site Access. It should be noted whether site roads provide access to all proposed work locations, or if it will be necessary to prepare access roads with either a backhoe, dozer, chain saws, etc., in order to get drill rigs, excavators, or other work vehicles to specific locations. If temporary driveways must be constructed from existing public roads, regulatory permits may be required. Military facilities may have specific security requirements which require detailed clearance procedures.
- Location of the Command Post or Site Trailer and Sanitary Facilities. The ideal location for the site trailer and sanitary facilities is a level area, within an uncontaminated zone, and centralized in order to provide easy access to work areas on the site. However, certain utility companies may require that the site trailer be placed within a specified radius (usually 100 feet), of the nearest utility pole. Contact the necessary utility companies and inquire about the requirements regarding service before conducting the site reconnaissance. Information that may be required by the utility companies is: type of electric service needed (inquire with trailer vendor for this information); and utility pole number of interest (pole numbers are usually stamped on a brass plate on the pole).

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- Potable Water Sources. Local fire departments may allow access to fire hydrants. Private water delivery companies may also be available in the area.
- Sources of Possible Contamination. Drums, tanks, sludge areas, areas of stressed vegetation, fill areas, and leachate seeps may indicate where sources of contamination exist. Filler pipes protruding from the ground surface may indicate the presence of underground storage tanks. Areas where the original ground surface has been reworked may be contaminated fill areas that have since been buried and covered with natural material. Previous environmental investigations may also identify source areas.
- Location of Decon Areas and Storage/Disposal Areas for Equipment and Wastes Generated by Field Activities.
- Locations of Surface Water Bodies. The locations of surface water bodies, both man-made and natural, and their relation to topographic highs may give an indication of the groundwater flow direction in the area (groundwater flow typically follows topography with the topographic highs serving as groundwater recharge areas, and the surface waters at topographic lows serve as groundwater discharge areas). Visible signs of contamination, the existence of aquatic life, flow rates, and approximate levels should also be observed and noted. Check if the surface water bodies could potentially be impacted by field activities. If so, appropriate sedimentation and erosion controls will be required.
- Existing Wells. Existing monitoring wells, or domestic wells within the site and off site, should be noted on a map, and access checked to see if the wells can be used for data collection.
- Outcrops. Outcrops can be useful in providing hydrogeologic data (lithologic description, strike and dip information, fracture and joint system analysis, identification of moist zones, etc.) Outcrops may occur naturally or be a part of a man-made feature such as a road-cut.
- Lineaments. A lineament is a straight lengthy feature on the earth's surface which is expressed topographically as a line of depression. Stream beds, vegetation patterns or soil characteristics may be aligned or controlled by this feature. Lineaments are due in some cases to the presence of intense jointing or faults beneath the ground surface. Groundwater in the bedrock may follow lineaments. Lineaments should be noted on site maps and described in the field notebooks.
- Bench or Property Markers. Benchmarks or property markers should be marked with paint or surveyor's flagging if encountered during a site reconnaissance. Surveyors may need to use these markers as a reference point when surveying. Benchmarks are typically a brass plate secured in concrete in the ground with numbering on the top. Property markers can range from a stake driven into the ground to a rock protruding from the ground surface. Facility contacts may also be aware of local benchmarks used during the course of other environmental or public work projects.
- Metal Cultural Effects. Overhead power lines, railroad tracks, junk automobiles, fences, etc. will greatly affect certain geophysical surveys. These features should be noted while conducting a site reconnaissance.

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6.0 RECORDS

The data collected during a site reconnaissance may have to be compiled into a trip report when returning from the field. This trip report can then be distributed to the project team. A site reconnaissance checklist is located in Attachment A which can be copied and used while conducting the site reconnaissance.

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ATTACHMENT A

SITE RECONNAISSANCE CHECKLIST

SITE SKETCH

Include the following as appropriate:

- Site Name
- Site location
- Site Boundaries
- Entrance locations
- Access Roads and Security Requirements
- Disposal locations
- Storage areas
- Office areas
- Well locations
- Treatment facility locations
- Surface drainage, outcrops, general topography descriptions
- Cultural interferences

CHEMICAL STORAGE FACILITIES DESCRIPTION

- Storage tanks - numbers, volumes, condition, contents, etc.
- Drums - number, conditions, labeling, etc.
- Lagoons and surface pits - number, size, use of liner, contents, etc.

TREATMENT SYSTEMS

Note the presence of any treatment systems. These can be difficult to evaluate visually. One should appraise general appearance, maintenance and visual integrity; ask operators for any monitoring records; note presence of odors; and visually characterize any effluents or residues. Describe type of wastes and volumes treated.

- Incinerators
- Flocculation/filtration
- Chemical/physical treatment
- Biological treatment
- Volume reduction
- Waste recycling
- Compositing
- Other

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SITE RECONNAISSANCE CHECKLIST
PAGE TWO**

DISPOSAL FACILITIES

Note the presence and use of any of the following operations. Include a description of the size, use of liners, soil type, and the presence of leachate. Provide a description of management practices. Interview site workers if possible. Describe waste types.

- Landfills
- Land forms
- Open dump
- Surface impoundment
- Underground injection
- Incineration

Also, records for disposal of concentrated/containerized waste should be reviewed.

HAZARDOUS SUBSTANCE CHARACTERISTICS

Ask facility contacts for manifests, inventories, or monitoring reports. Note markings on containers.

- Chemical identities
- Quantities
- Hazard characteristics (toxic, explosive, flammable, etc.)
- Container markings
- Monitoring data, other analytical data
- Physical state (liquid, solid, gas, sludge)

CHEMICAL PROCESS INFORMATION

- Manufacturing processes and chemicals
- Off-specification or by-product disposal processes
- Housekeeping practices
- Locations of Plant Operations

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**ATTACHMENT A
SITE RECONNAISSANCE CHECKLIST
PAGE THREE**

HYDROGEOLOGIC ASSESSMENT

Look for situations that promote hazardous substance migration, i.e., porous soils, fractured bedrock formations, shallow water table and karst features.

- Soil type
- Surface water features
- Surface drainage pattern
- Outcrop studies
- Water wells (use, water depth, and construction details)
- Erosion potential
- Flooding potential
- Climatology

IDENTIFICATION OF SENSITIVE RECEPTORS

- Number and locations of private homes
- Public buildings including tenant usage
- Areas of dead or dying vegetation or animals
- Presence of sensitive ecosystems (wetlands, tidal marshes, etc.)
- Other public use areas (roads, parks, etc.)
- Natural areas



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Prepared	Earth Sciences Department		
Approved	D. Senovich <i>ds</i>		

Subject
SOIL AND ROCK DRILLING METHODS

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FIGURE

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1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

The sampling methods described within this procedure are applicable to collecting surface and subsurface soil samples, and obtaining rock core samples for lithologic and hydrogeologic evaluation, excavation/foundation design, remedial alternative design and related civil engineering purposes.

3.0 GLOSSARY

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternative to conventional coring, this technique is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique, the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and the known or suspected geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

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Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the site geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

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5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.
- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.
- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.
- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which may be the prime objective of the borehole construction). With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Rotasonic
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall

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also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table. Backfilling requirements may also be driven by state or local regulations.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque

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and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air-rotary drill rigs are large and heavy.
- Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air-rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.

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- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Groundwater samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.

5.2.4 Rotosonic Drilling

The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.

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The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.

Advantages of this method include:

- Sampling and well installation are faster as compared to other drilling methods.
- Continuous sampling, with larger sample volume as compared to split-spoon sampling.
- The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.
- Reduction of IDW by an average of 70 to 80 percent.
- Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.

Disadvantages include:

- The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.
- Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.
- There are a limited number of Rotosonic drilling contractors at the present time.

5.2.5 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.

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Disadvantages include:

- Double-wall, reverse-circulation drill rigs are rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.6 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split-barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.7 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be

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expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added. When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.
- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobble or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).
- When casing is used, the casing seals formation water out of the hole, preventing down hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.
- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.
- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).
- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.8 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

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Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.9 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

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5.2.10 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

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This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:
 - Hand augers and lightweight motorized augers.
 - Retractable plug samplers--driven by hand (hammer).
 - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."
- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.
- Small truck-mounted drilling equipment using a Jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.
- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.
- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on vehicles having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

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- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:
 - Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.
 - Barge-mounted drill rigs.
 - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.
 - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (± 2 -pound) hammer dropping 30 inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

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Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

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For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.
- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.
- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.
- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the site geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the

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depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of

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a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

The CME continuous sample tube system provides a method of sampling soil continuously during hollow-stem augering. The 5-foot sample barrel fits within the lead auger of a hollow-auger column. The sampling system can be used with a wide range of I.D. hollow-stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required. Rotosonic drilling methods also provide a continuous soil sample.

5.7 Rock Sampling (Coring) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

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FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line ___/___/	1 7/8	1	1.875	1.000
BX Wire line ___/___/	2 3/8	1 7/16	2.345	1.437
NX Wire line ___/___/	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.
 ___/___/ Wire line dimensions and designations may vary according to manufacturer.

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FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
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Size Designations		Casing O.D., Inches	Casing Coupling		Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings		O.D., Inches	I.D., Inches				Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	---	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	---	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	---	5.500			5.650	---	---	---	---
SW	---	6.625			6.790	---	---	---	---
UW	---	7.625			7.800	---	---	---	---
ZW	---	8.625			8.810	---	---	---	---
---	AX ___\	---	---	---	---	1.875	1.750	1.000	---
---	BX ___\	---	---	---	---	2.345	2.250	1.437	---
---	NX ___\	---	---	---	---	2.965	2.813	1.937	---

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___\ Wire line dimensions and designations may vary according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES.
(DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-
D-2889

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5.7.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be omitted.
- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.
- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.
- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.
- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

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After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name.
- Project number.
- Boring number.
- Run numbers.
- Footage (depths).
- Recovery.
- RQD (%).
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

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ATTACHMENT A
DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	---
	7 1/4	6 1/4	3 1/4	---
	13 1/4	12	6	---
Thin Wall Tube Samplers (Ref. 7)	---	2	1 7/8	---
	---	2 1/2	2 3/8	---
	---	3	2 7/8	---
	---	3 1/2	3 3/8	---
	---	4 1/2	4 3/8	---
	---	5	4 3/4	---
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

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**ATTACHMENT A
DRILLING EQUIPMENT SIZES
PAGE TWO**

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

TtNUS STANDARD OPERATING PROCEDURE		
PRT SOIL VAPOR SAMPLING WITH HELIUM LEAK TEST	Number:	Page: 1 of 5
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1.0 PURPOSE

This SOP discusses how to collect a soil vapor sample and to perform a helium leak test prior to sample collection.

2.0 SCOPE

This SOP applies to setup and collection of a soil vapor sample using Post Run Tubing (PRT) System and SUMMA canisters. Attachment 1 explains and diagrams the PRT system setup.

3.0 RESPONSIBILITIES

The Field Samplers are responsible for recording the initial pressure of the SUMMA canisters upon receipt from the laboratory. The laboratory should be contacted prior to sampling to determine post sampling vacuum requirements. Laboratories may require certain residual vacuum in the canister to conduct laboratory QA/QC procedures. In addition, they are responsible for collecting samples and conducting a leak test in accordance with this procedure, including instrument calibration verification and record keeping.

4.0 PROCEDURES

A direct push drilling setup or similar equipment will be used to drive the probe rod to the desired sampling depth. After vapor probe installation, the vapor probe will be sealed to prevent short circuiting from the atmosphere to the probe. A leak test will be conducted using helium to verify the integrity of the seal of the soil vapor probe. Three probe volumes (volume of the sample probe and tubing) will be purged using a vacuum pump. The pump will be calibrated to a rate matching that at which the sample will later be collected, 200 milliliters per minute (ml/min), to ensure collection of representative samples. The purge volumes should be consistent for all samples collected. A PID will be used to screen the soil vapor for total VOCs. A grab sample or passive, time-integrated sample will be collected in the appropriate SUMMA canister.

Sampling of soil vapor will not be performed during or immediately following a significant rainfall event, as precipitation may affect the collection of soil vapor samples. Infiltration from rainfall can potentially impact soil vapor concentrations by displacing the soil vapor, dissolving volatile organic compounds, and by creating a "cap" above the soil vapor. In most settings, infiltration from large storms only penetrates into the uppermost vadose zone. Soil vapor samples collected at depths greater than 3 to 5 feet below ground surface (bgs) under foundations or areas with surface cover are unlikely to be significantly affected. However, soil vapor samples collected closer to the surface (<3 feet) with no surface cover may be affected. If the moisture has penetrated to the sampling zone, it typically can be recognized by difficulty in collecting soil vapor samples. If high vacuum readings are encountered when collecting a sample, or drops of moisture are evident in the sampling system or sample, measured values should be considered as minimum values. Measurement of percent moisture of the soil may also be useful if shallow sampling is performed during or shortly after significant rainfall (>1.0 inch).

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PRT SOIL VAPOR SAMPLING WITH HELIUM LEAK TEST	Number:	Page: 2 of 5
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4.1 PRT System Setup

The PRT system will be advanced as described in Attachment A to the project and location-specific sampling depth.

4.2 SUMMA Canister Setup

Upon receipt of the SUMMA canisters from the lab, remove the nut and attach either the pressure gauge or the flow regulator. Check the pressure of the SUMMA canisters to ensure there was not leakage during shipment.

To setup for sampling remove the nut and attach the pressure gauge/flow regulator securely. Attach the tubing, using a ferrule, to the SUMMA canister securely. Record the SUMMA canister number and if collecting an integrated sample, the flow controller number, on a log sheet.

4.3 Helium Leak Test Setup

After the PRT system is advanced (Attachment A) to the appropriate sampling depth, a helium leak test will be conducted to ensure that ambient air is not mixing with the soil vapor sample. The following consumables and equipment are recommended to perform the helium leak test:

- Poly sheeting
- Modeling clay
- 5 gallon bucket/small trash can with 1/4" hole through the center of the bottom and barbed fitting for helium tubing on one side
- Double sided tape
- Teflon lined tubing
- Ankle weights and 5 lb barbell weights
- Ball Valve
- Tubing to connect the helium tank
- Helium Tank
- Dual regulator (not necessary but helpful to regulate helium flow)
- Tedlar Bag
- Vacuum pump with low flow module
- Swagelok three way valve, "T", and extra nuts
- Extra ferrules
- Helium detector
- PID

To set-up the helium leak test, follow these steps:

1. Place bentonite or modeling clay around the base of the PRT system rods and the ground surface and place ample amount of modeling clay over the opening at the top of the rod.
2. Cut a hole in the poly sheeting and place over the PRT system rods.
3. Apply more modeling clay around the rods and on top of the poly sheeting.

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4. Insert and thread the Teflon lined tubing into the PRT sampling setup. Place ample amounts of modeling clay around the tubing, blocking off all openings.
5. Place double sided tape along the edges of the bucket.
6. Place the bucket over the PRT system, carefully pulling the tubing through the ¼" hole in the center of the bottom and firmly securing the double sided tape to the ground, pulling up on the edges of the poly sheeting.
7. Place modeling clay around where the ¼" comes out of the bucket, layer with 5 lb barbell weight (tubing through the center of the weight) and then more modeling clay.
8. Place modeling clay around the base of the bucket.
9. Place ankle weights on top of the bucket.
10. Attach the helium tank, with ball valve inline to the side of the bucket.
11. Attach Swagelok three-way valve to the ¼" tubing.
12. Attach vacuum pump (using 1/4" dedicated tubing) to one side of the valve and attach Tedlar bag to vacuum pump.
13. Attach SUMMA canister with pressure gauge (grab sample) or flow regulator (integrated sample) to the other side of the valve with dedicated ¼" tubing. Make sure both the SUMMA canister and the three-way valve are closed. See attached pictures of sampling setup.

4.4 Helium Leak Test

Before beginning the helium leak test, confirm that the three way valve connected to the vacuum pump and the SUMMA canister is closed, as well as the SUMMA canister.

1. Open the ball valve connected to the helium tank.
2. Turn the helium on and allow it to fill the bucket.
3. Monitor breakthrough along the edge of the bucket (ground surface) with the helium detector.
4. Readings should be greater than 10 percent (100,000 parts per million). This signifies that all of the air inside the bucket has been displaced.
5. Turn off helium and close ball valve.
6. Open the valve to the vacuum pump and purge three probe volumes into a Tedlar bag.

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PRT SOIL VAPOR SAMPLING WITH HELIUM LEAK TEST	Number:	Page: 4 of 5
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7. Measure the Tedlar bag with a helium detector to evaluate seal issues.
8. If more than 1 percent (10,000 ppm) helium is detected, the seal needs to be re-adjusted (begin again).
9. If less than 1 percent helium is detected, measure organic vapor levels with a PID.
10. Close valve to the vacuum pump.

4.5 Soil Vapor Sample Collection

After the successful completion of the helium test (less than 1 percent helium detected in the Tedlar bag), follow these steps:

1. Open the three-way valve to the SUMMA canister.
2. Open the valve on the SUMMA canister.
3. Ensure the canister is filling at an appropriate rate.
4. Record the initial canister pressure and the time sampling begins.
5. Record time and vacuum pressure in 20-minute intervals (for integrated samples).
6. Record the final pressure. Note that a small amount of vacuum (check with laboratory), approximately 5 psi mercury, should remain.
7. Close the SUMMA canister valve when sampling is completed.
8. Field duplicate samples will be collected using a "T"-fitting to properly split the sample between SUMMA canisters.
9. Breakdown sampling setup and complete sample labels and chain-of-custody.
10. Attach sample labels to each canister. The canisters should have a tied on label supplied, do not attach sample labels directly to the canister.
11. Package the canister and the flow controller/gauge in the shipping container supplied by the laboratory for return shipment, including all appropriate forms in shipping containers.
12. The SUMMA canister does not require preservation with ice during shipment.

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PRT SOIL VAPOR SAMPLING WITH HELIUM LEAK TEST	Number:	Page: 5 of 5
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5.0 QUALITY CONTROL

1. Calibrate the PID and helium detector per manufactures' recommendations in the morning before taking measurements, and check the calibration mid-day, and at the end of the day after all measurements are taken.
2. Analyze one in every 10 samples in duplicate.

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7.0 RECORDS

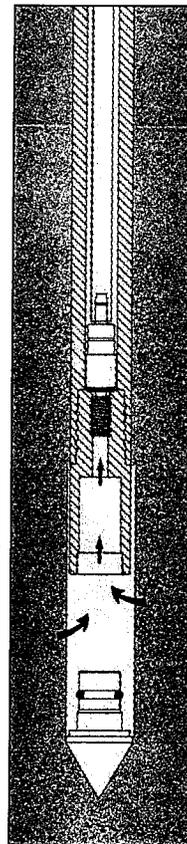
The soil vapor sample log sheet and chain-of-custody must be filled out completely.

Soil Gas Sampling – PRT System Operation

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Soil Gas Sampling — PRT System Operation

Basics

Using the Post-Run Tubing System, one can drive probe rods to the desired sampling depth, then insert and seal an internal tubing for soil gas sampling. The usual Geoprobe probe rods and driving accessories and the following tools are required:

- PRT Expendable Point Holder
- PRT Adapter
- Selected PRT Tubing

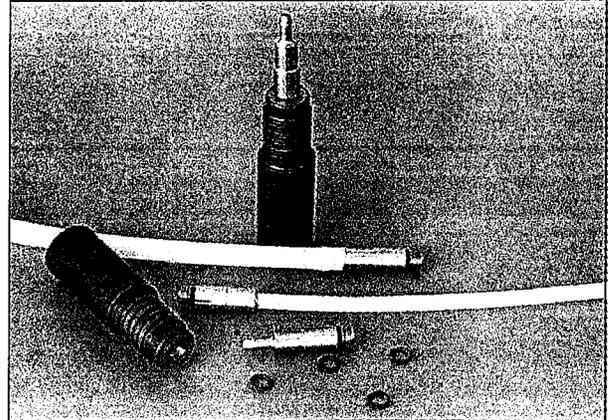
Preparation

1. Clean all parts prior to use. Install O-rings on the PRT Expendable Point Holder and the PRT adapter.
2. Inspect the probe rods and clear them of all obstructions.
3. TEST FIT the adapter with the PRT fitting on the expendable point holder to assure that the threads are compatible and fit together smoothly.

NOTE: PRT fittings are left-hand threaded.

4. Push the adapter into the end of the selected tubing. Tape may be used on the outside of the adapter and tubing to prevent the tubing from spinning freely around the adapter during connection – especially when using Teflon tubing (Figure 1).

REMEMBER: The sample will not contact the outside of the tubing or adapter.



PRT SYSTEM PARTS
PRT Expendable Point Holder, PRT Adapters, Tubing, and O-rings.



Figure 1. Securing adapter to tubing with tape. **NOTE:** Tape does not contact soil gas sample.

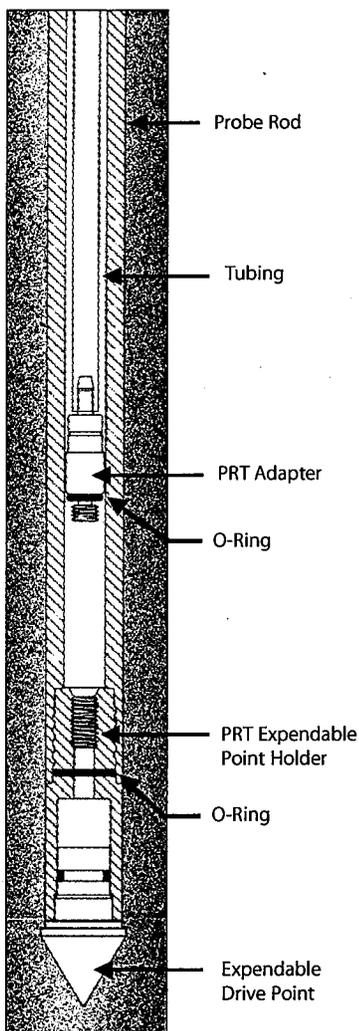


Figure 2. Insertion of tubing and PRT adapter.



Figure 3. Engaging threads by rotating tubing.

Soil Gas Sampling — PRT System Operation



A cross section of probe rods driven to depth and then retracted to allow for soil gas sampling. The PRT adapter and tubing are now fed through the rods and rotated to form a vacuum-tight connection at the point holder. The result is a continuous run of tubing from the sample level to the surface.

Probing

Drive the PRT tip configuration into the ground. Connect probe rods as necessary to reach the desired depth. After depth has been reached, disengage the expendable point by pulling up on the probe rods. Remove the pull cap from the top probe rod, and position the Geoprobe unit to allow room to work.

Connection

1. Insert the adapter end of the tubing down the inside diameter of the probe rods (**Figure 2**).
2. Feed the tubing down the rod bore until it hits bottom on the expendable point holder. Allow about 2 ft. (610 mm) of tubing to extend out of the hole before cutting it.
3. Grasp the excess tubing and apply some downward pressure while turning it in a counterclockwise motion to engage the adapter threads with the expendable point holder (**Figure 3**).
4. Pull up lightly on the tubing to test engagement of the threads. (Failure of adapter to thread could mean that intrusion of soil may have occurred during driving of probe rods or disengagement of drive point.)



Soil Gas Sampling — PRT System Operation

Sampling

1. Connect the outer end of the tubing to the Silicone Tubing Adapter and vacuum hose (or other sampling apparatus).
2. Follow the appropriate sampling procedure for collecting a soil gas sample (**Figure 1**).

Removal

1. After collecting a sample, disconnect the tubing from the vacuum hose or sampling system.
2. Pull up firmly on the tubing until it releases from the adapter at the bottom of the hole. (Taped tubing requires a stronger pull.)
3. Remove the tubing from the probe rods. Dispose of polyethylene tubing or decontaminate Teflon tubing as protocol dictates.
4. Retrieve the probe rods from the ground and recover the expendable point holder with the attached PRT adapter.
5. Inspect the O-ring at the base of the PRT adapter to verify that proper sealing was achieved during sampling. The O-ring should be compressed. This seal can be tested by capping the open end of the point holder applying vacuum to the PRT adapter.
6. Prepare for the next sample.



Figure 1. Taking a soil gas sample for direct injection into a GC with the PRT system.



Project Site Name: _____	Sample ID Number: _____
Project Number: _____	Sampled By: _____
Sample Location: _____	_____

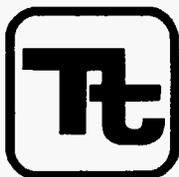
DESCRIPTION OF SAMPLE LOCATION	
Indoor	Outdoor
Location: _____	Location: _____
Basement: yes / no	Depth to Water (ft): _____
Room size (ftxft): _____	Soil type: _____
Floor material: concrete / wood / dirt / other	Odor: _____
Slab Thickness (ft): _____	Color: _____
Visible Cracks: yes / no	
Subslab Material: dirt / gravel	

PROBE INSTALLATION	LOCATION SKETCH
Date: _____	
Method: _____	
Diameter: _____	
Depth: _____	
Packing Material: _____	
Initial PID Reading: _____	
Post PID Reading: _____	

PURGE	
Date: _____	
Time: _____	
Rate: _____	
Volume: _____	

SAMPLE COLLECTION	
Start Time: _____	End Time: _____
Starting Pressure: _____	End Pressure: _____
Rate: _____	
Volume: _____	
Canister Description: _____ L Summa	

OBSERVATIONS / NOTES:
<div style="border: 1px solid black; width: 300px; height: 40px; margin-left: auto; margin-right: auto; padding: 5px;">Signature(s):</div>



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Effective Date 12/03	Revision 2
Applicability Tetra Tech NUS, Inc.	
Prepared Health & Safety	
Approved D. Senovich	

Subject
UTILITY LOCATING AND EXCAVATION CLEARANCE

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

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4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

Site Personnel – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.
- 2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scars and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility

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locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.
4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.
5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain
6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.
7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.
8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

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5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

<u>Nominal Voltage</u>	<u>Minimum Clearance</u>
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

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Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting

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debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough to be at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand excavation. It is important to note that a post-hole digger must not be used in this type of hand excavation activity.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily-available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a non-conductive tile probe, should always be in conjunction with suitable utility locating detection equipment.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.
2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.
4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

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5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4
 OSHA 29 CFR 1926(b)(2)
 OSHA 29 CFR 1926(b)(3)
 TtNUS Utility Locating and Clearance Policy
 TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
 TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
 TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

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**ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES**



American Public Works Association
2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625
Phone (816) 472-6100 • Fax (816) 472-1610
Web www.apwa.net • E-mail apwa@apwa.net

**ONE-CALL SYSTEMS INTERNATIONAL
CONDENSED DIRECTORY**

<p>Alabama Alabama One-Call 1-800-292-8525</p> <p>Alaska Locate Call Center of Alaska, Inc. 1-800-478-3121</p> <p>Arizona Arizona Blue Stake 1-800-782-5348</p> <p>Arkansas Arkansas One Call System, Inc. 1-800-482-8998</p> <p>California Underground Service Alert North 1-800-227-2600 Underground Service Alert of Southern California 1-800-227-2600</p> <p>Colorado Utility Notification Center of Colorado 1-800-922-1987</p> <p>Connecticut Call Before You Dig 1-800-922-4455</p> <p>Delaware Miss Utility of Delmarva 1-800-282-8555</p> <p>Florida Sunshine State One-Call of Florida, Inc. 1-800-432-4770</p> <p>Georgia Underground Protection Center, Inc. 1-800-282-7411</p> <p>Hawaii Underground Service Alert North 1-800-227-2600</p> <p>Idaho Dig Line Inc. 1-800-342-1585 Kootenai County One-Call 1-800-428-4950 Shoshone - Benewah One-Call 1-800-398-3285</p> <p>Illinois JULIE, Inc. 1-800-892-0123 Digger (Chicago Utility Alert Network) 312-744-7000</p> <p>Indiana Indiana Underground Plant Protection Service 1-800-382-5544</p>	<p>Iowa Iowa One-Call 1-800-292-8989</p> <p>Kansas Kansas One-Call System, Inc. 1-800-344-7233</p> <p>Kentucky Kentucky Underground Protection Inc. 1-800-752-6007</p> <p>Louisiana Louisiana One Call System, Inc. 1-800-272-3020</p> <p>Maine Dig Safe System, Inc. 1-888-344-7233</p> <p>Maryland Miss Utility 1-800-257-7777 Miss Utility of Delmarva 1-800-282-8555</p> <p>Massachusetts Dig Safe System, Inc. 1-888-344-7233</p> <p>Michigan Miss Dig System, Inc. 1-800-482-7171</p> <p>Minnesota Gopher State One Call 1-800-252-1168</p> <p>Mississippi Mississippi One-Call System, Inc. 1-800-227-6477</p> <p>Missouri Missouri One-Call System, Inc. 1-800-344-7483</p> <p>Montana Utilities Underground Protection Center 1-800-424-5555 Montana One Call Center 1-800-551-8344</p> <p>Nebraska Diggers Hotline of Nebraska 1-800-331-5666</p> <p>Nevada Underground Service Alert North 1-800-227-2600</p> <p>New Hampshire Dig Safe System, Inc. 1-888-344-7233</p>	<p>New Jersey New Jersey One Call 1-800-272-1000</p> <p>New Mexico New Mexico One Call System, Inc. 1-800-321-2537 Las Cruces- Dona Ana Blue Stakes 1-888-526-0400</p> <p>New York Dig Safely New York 1-800-862-7962 New York City- Long Island One Call Center 1-800-272-4480</p> <p>North Carolina The North Carolina One-Call Center, Inc. 1-800-632-4949</p> <p>North Dakota North Dakota One-Call 1-800-795-0555</p> <p>Ohio Ohio Utilities Protection Service 1-800-362-2764 Oil & Gas Producers Underground Protect'n Svc 1-800-925-0988</p> <p>Oklahoma Call Okie 1-800-522-6543</p> <p>Oregon Oregon Utility Notification Center/One Call Concepts 1-800-332-2344</p> <p>Pennsylvania Pennsylvania One Call System, Inc. 1-800-242-1776</p> <p>Rhode Island Dig Safe System, Inc. 1-888-344-7233</p> <p>South Carolina Palmetto Utility Protection Service Inc. 1-888-721-7877</p> <p>South Dakota South Dakota One Call 1-800-781-7474</p> <p>Tennessee Tennessee One-Call System, Inc. 1-800-351-1111</p>
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ATTACHMENT 1 (Continued)

Texas

Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah

Blue Stakes of Utah
1-800-662-4111

Vermont

Dig Safe System, Inc.
1-888-344-7233

Virginia

Miss Utility of Virginia
1-800-552-7001
Miss Utility (Northern Virginia)
1-800-257-7777

Washington

Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating
Council
509-456-8000

West Virginia

Miss Utility of West Virginia, Inc.
1-800-245-4848

Wisconsin

Diggers Hotline, Inc.
1-800-242-8511

Wyoming

Wyoming One-Call System, Inc.
1-800-348-1030
Call Before You Dig of Wyoming
1-800-849-2476

District of Columbia

Miss Utility
1-800-257-7777

Alberta

Alberta One-Call Corporation
1-800-242-3447

British Columbia

BC One Call
1-800-474-6886

Ontario

Ontario One-Call System
1-800-400-2255

Quebec

Info-Excavation
1-800-663-9228

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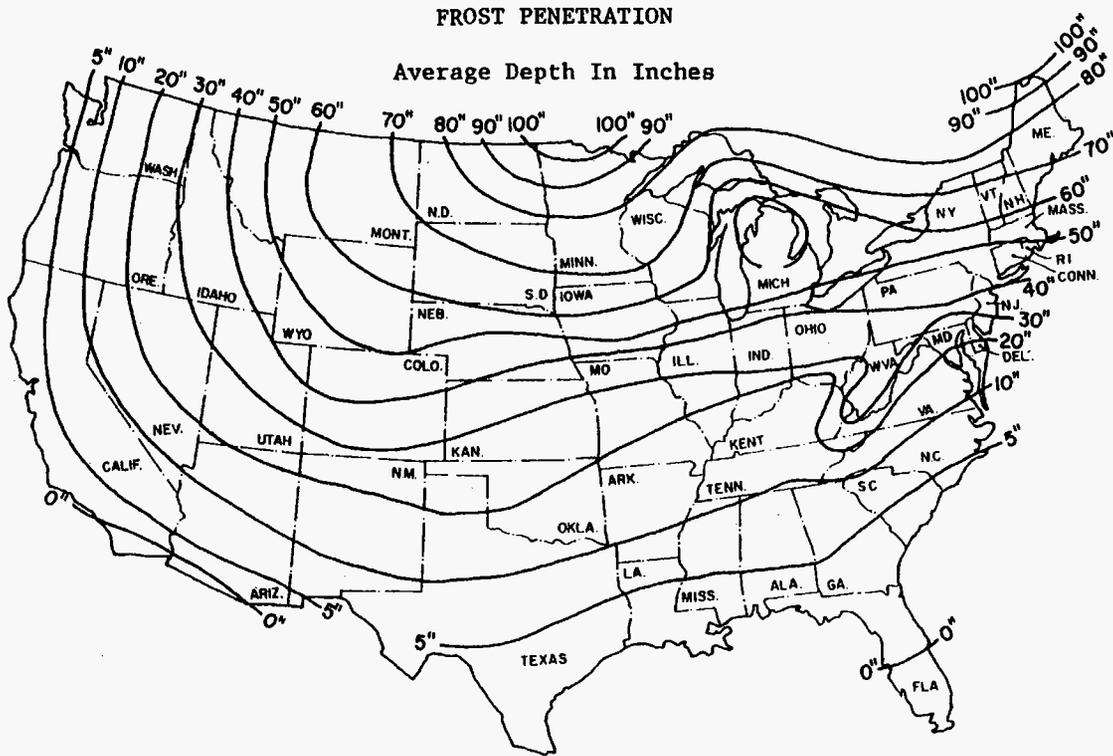
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ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



Courtesy U.S. Department Of Commerce

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**ATTACHMENT 3
UTILITY CLEARANCE FORM**

Client: _____ Project Name: _____
 Project No.: _____ Completed By: _____
 Location Name: _____ Work Date: _____
 Excavation Method/Overhead Equipment: _____

1. Underground Utilities Circle One
- a) Review of existing maps? yes no N/A
 - b) Interview local personnel? yes no N/A
 - c) Site visit and inspection? yes no N/A
 - d) Excavation areas marked in the field? yes no N/A
 - e) Utilities located in the field? yes no N/A
 - f) Located utilities marked/added to site maps? yes no N/A
 - g) Client contact notified yes no N/A
 Name _____ Telephone: _____ Date: _____
 - g) State One-Call agency called? yes no N/A
 Caller: _____
 Ticket Number: _____ Date: _____
 - h) Geophysical survey performed? yes no N/A
 Survey performed by: _____
 Method: _____ Date: _____
 - i) Hand excavation performed (with concurrent use of utility
 detection device)? yes no N/A
 Completed by: _____
 Total depth: _____ feet Date: _____
 - j) Trench/excavation probed? yes no N/A
 Probing completed by: _____
 Depth/frequency: _____ Date: _____

2. Overhead Utilities Present Absent
- a) Determination of nominal voltage yes no N/A
 - b) Marked on site maps yes no N/A
 - c) Necessary to lockout/insulate/re-route yes no N/A
 - d) Document procedures used to lockout/insulate/re-route yes no N/A
 - e) Minimum acceptable clearance (SOP Section 5.2): _____

3. Notes:

Approval: _____
 Site Manager/Field Operations Leader Date

c: PM/Project File
 Program File

Subject UTILITY LOCATING AND EXCAVATION CLEARANCE	Number HS-1.0	Page 13 of 15
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**ATTACHMENT 4
OSHA LETTER OF INTERPRETATION**

Mr. Joseph Caldwell
Consultant
Governmental Liaison
Pipeline Safety Regulations
211 Wilson Boulevard
Suite 700
Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

***Question:** Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.*

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

Background

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651 (Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

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ATTACHMENT 4 (Continued)

When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means. (emphasis added).

Therefore, “acceptable means” must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either “other acceptable means” or “safe and acceptable means.” The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified “careful probing or hand digging” as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language “to allow other, *equally effective means* of locating such installations.” The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used where the utilities have not been marked and detection equipment is not being used – “probing with hand-held tools.” This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

OSHA received two comments * * * and input from ACCSH [OSHA’s Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping ‘such as probing with hand-held tools’ from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of “acceptable means” in the final provision.

Non-conductive hand tools are permitted

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a “shooter” (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, when used with appropriate caution, is an “acceptable means” for locating underground utilities.

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ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director
Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA's interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at <http://www.osha.gov>.

APPENDIX B
FIELD DOCUMENTATION FORMS

Tetra Tech NUS, Inc.

PROJECT: _____

JOB #: _____

LOCATION: _____

DATE: _____

PROJECT MANAGER: _____

FOL: _____

DAILY ACTIVITIES CHECKLIST

Startup Checklist

Activity	Yes	No	N/A
Pertinent site activities/information entered into site logbook			
All onsite personnel listed in logbook			
Required medical information onsite for all workers (TtNUS and Subcontractors)			
Required MSDS's onsite			
Proper equipment calibrations performed (list equipment)			
1 _____			
2 _____			
3 _____			
4 _____			
Calibration logs filled out			
Tailgate H&S meeting held prior to beginning field activities			
Required work permits filled out/signed			
Required utility clearances obtained			
Required PPE onsite and in use			
Information required to be posted is in place (OSHA poster, hospital route, key phone numbers, etc.)			

Exit Checklist

Activity	Yes	No	N/A
Logbooks completely and comprehensively filled out			
Field forms complete and accounted for/properly filed			
Samples properly packaged/shipped			
COCs faxed to appropriate in-house personnel			
All equipment accounted for, on charge if needed, and properly secured			
All personnel accounted for			
Arrangements made for upcoming work (permits, clearances, equipment, etc.)			
Site properly secured			

Note - not all items listed apply to every job, and some additional requirements may apply on a job-specific basis.



TETRA TECH NUS, INC.

FIELD MODIFICATION RECORD

Site Name: _____ Location: _____

Project Number: _____ Task Assignment: _____

To: _____ Location: _____ Date: _____

Description: _____

Reason for Change: _____

Recommended Action: _____

Field Operations Leader (Signature): _____ Date: _____

Disposition/Action: _____

Project Manager (Signature): _____ Date: _____

Distribution: Program Manager: _____ Others as Required: _____

Project Manager: _____

Quality Assurance Officer: _____

Field Operations Leader: _____

Project File: _____



GROUNDWATER SAMPLE LOG SHEET

Project Site Name: _____
 Project No.: _____
 Domestic Well Data
 Monitoring Well Data
 Other Well Type: _____
 QA Sample Type: _____

Sample ID No.: _____
 Sample Location: _____
 Sampled By: _____
 C.O.C. No.: _____
 Type of Sample:
 Low Concentration
 High Concentration

SAMPLING DATA:

Date:	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Time:								
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	



Tetra Tech NUS, Inc.

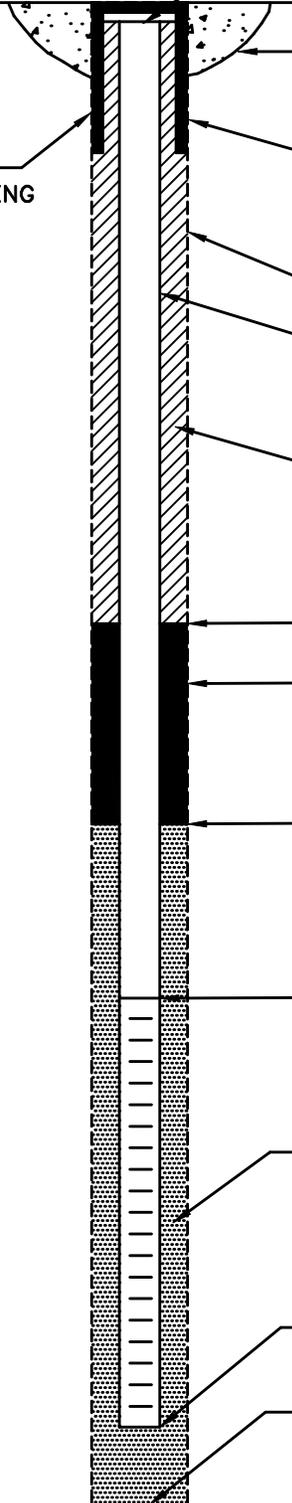
OVERBURDEN MONITORING WELL SHEET FLUSH - MOUNT

WELL NO.: _____

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
DATE BEGUN _____	DATE COMPLETED _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		
GROUND ELEVATION _____	DATUM _____	

ACAD:FORM_MWFM.dwg 07/20/99 INL

FLUSH MOUNT
SURFACE CASING
WITH LOCK



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

ELEVATION/DEPTH TOP OF SEAL: _____ / _____

TYPE OF SEAL: _____

ELEVATION/DEPTH TOP OF SAND: _____ / _____

ELEVATION/DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF SAND: _____ / _____

ELEVATION/DEPTH BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____



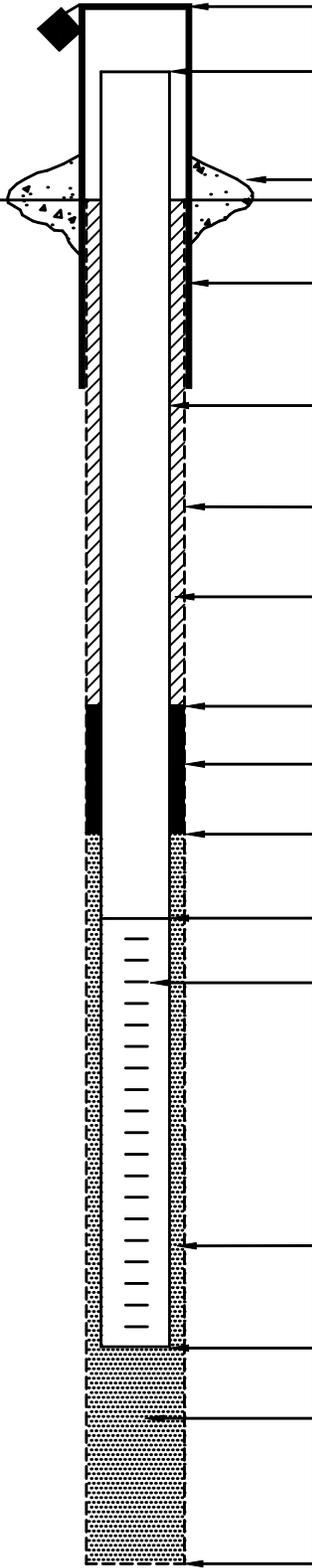
Tetra Tech NUS, Inc.

OVERBURDEN MONITORING WELL SHEET STICK-UP

WELL NO.: _____

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
DATE BEGUN _____	DATE COMPLETED _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		
GROUND ELEVATION _____	DATUM _____	

ACAD:FORM_MWSU.dwg 07/20/99 INL



ELEVATION/HEIGHT OF TOP OF SURFACE CASING: _____ / _____

ELEVATION/HEIGHT OF TOP OF RISER PIPE: _____ / _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

TYPE OF SURFACE CASING: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION/DEPTH TOP OF SEAL: _____ / _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION/DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION/DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION/DEPTH BOTTOM OF SAND PACK: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____

ELEVATION/DEPTH OF HOLE: _____ / _____



TETRA TECH NUS, INC.

PHOTOIONIZATION DETECTOR FIELD CALIBRATION LOG

Serial No.: _____

Model No.: _____

Decal No.: _____

Site Name/Location: _____

Tetra Tech NUS Charge No.: _____

CALIBRATION DATE	STANDARD GAS- ISOBUTYLENE	(AM) CALIBRATION READING Isobutylene Equiv. (ppm)	(PM) CALIBRATION CHECK Isobutylene Equiv. (ppm)	SIGNATURE	COMMENTS
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	
	Lot # _____ Conc. = _____ ppm	/		AM: PM:	



TETRA TECH NUS, INC.

Quarterly LTM: Round 1 2008

PURGE DATA SHEET - "LOW FLOW" GROUNDWATER

Site Name:
Sample ID:

Tetra Tech NUS Charge No. /CTO Page 1 of
QC: (If applicable)

Sample Method: Low Stress (flow) with Peristaltic Pump
Depth Sampled: ft bgs Screen Int. Depth ft bgs
Sample Date & Time: 4/ /2008 hours (Dup Time)
Sampler(s):
Data Recorded By: Signature:
Notes: Water Depth MP = top of riser (TOR); NAPL signal at start (Yes/No); if yes, report depths/describe thickness; Visual Evidence of Sheen (Yes/No); Olfactory Evidence of Odor (Yes/No); Weather:

H&S Survey Meter PPM Field Instrument Group A/B/C/D
Pre-tubing insertion WL ft btor; Post-tubing insertion WL ft btor

Field Analysis: Fe2+

Sampling Hierarchy and Lab Analyses:

- 1. VOC 2. EDB/DBCP 3. VPH 4. Pest/PCB 5a. Metals(unfiltered)
5b. Metals (filtered) 6. Cyanide 7. SVOC/PAH 8. Herbicides 9. COD
10. Alk. Nitrate, TDS, Chloride, Sulfate 11. EPH

(Also see separate sample logsheet for gw)

Table with 12 columns: Clock Time 24hr, Water Depth below MP ft, Pump Dial 1, Purge Rate ml/min, Cum. Volume Purged Gals., Temp °C, Spec. Cond. 2 uS/cm, pH (S.U.), ORP/Eh3 mv, DO mg/L, Turbidity NTU, Comments. The table contains 12 empty rows for data entry.

Acceptance Criteria: <0.3 ft (drawdown)

3% 3% +/- 1.0 S.U. +/- 10mV 10% 10%

TtNUS Form 0009

Saturated Screen Volume (gallons) (2" screen = 0.163 gals/ft of depth; 4" = 0.653 gals/ft; 6" = 1.469gals/ft)

- 1. Pump dial setting (for example: hertz, cycle/min, etc.)
2. Siemens per cm (same as umhos/cm) at 25 °C.
3. Oxidation reduction potential (stand in for Eh).



QA SAMPLE LOG SHEET

Project Site Name: _____ Sample ID Number: _____
 Project Number: _____ Sampled By: _____
 Sample Location: _____ C.O.C. Number: _____
 QA Sample Type:
 Trip Blank Rinsate Blank
 Source Water Blank Other Blank _____

SAMPLING DATA:	WATER SOURCE:
Date: _____ Time: _____ Method: _____	<input type="checkbox"/> Laboratory Prepared <input type="checkbox"/> Tap <input type="checkbox"/> Purchased <input type="checkbox"/> Fire Hydrant <input type="checkbox"/> Other _____

PURCHASED WATER INFORMATION (If Applicable as Source or Rinsate Water):	RINSATE INFORMATION (If Applicable):
Product Name: _____ Supplier: _____ Manufacturer: _____ Order Number: _____ Lot Number: _____ Expiration Date: _____	Media Type: _____ Equipment Used: _____ Equipment Type: <input type="checkbox"/> Dedicated <input type="checkbox"/> Reusable

SAMPLE COLLECTION INFORMATION:			
Analysis	Preservative	Container Requirements	Collected
Volatiles	Cool 4°C & HCl		YES / NO
Semivolatiles	Cool 4°C		YES / NO
Pesticide / PCB	Cool 4°C		YES / NO
Metals	Cool 4°C & HNO ₃		YES / NO
Cyanide	Cool 4°C & NaOH		YES / NO

OBSERVATIONS / NOTES:

Signature(s): _____



Project Site Name: _____ Sample ID Number: _____
 Project Number: _____ Sampled By: _____
 Sample Location: _____

DESCRIPTION OF SAMPLE LOCATION

Indoor

Location: _____
 Basement: yes / no
 Room size (ftxft): _____
 Floor material: concrete / wood / dirt / other
 Slab Thickness (ft): _____
 Visible Cracks: yes / no
 Subslab Material: dirt / gravel

Outdoor

Location: _____
 Depth to Water (ft): _____
 Soil type: _____
 Odor: _____
 Color: _____

PROBE INSTALLATION

Date: _____
 Method: _____
 Diameter: 3/8 inch
 Depth: _____
 Packing Material: _____
 Initial PID Reading: _____
 Post PID Reading: _____

LOCATION SKETCH

PURGE

Date: _____
 Time: _____
 Rate: _____
 Volume: _____

SAMPLE COLLECTION

Start Time: _____ End Time: _____
 Starting Pressure: _____ End Pressure: _____
 Rate: _____
 Volume: _____
 Canister Descriptio 6 L Summa

OBSERVATIONS / NOTES:

Signature(s):



WELL NUMBER: _____

PROJECT NAME: _____

DATE/TIME: _____

PROJECT MANAGER: _____

INSPECTED BY: _____

VENT WELL

MONITORING INSTRUMENT READING: _____

LEL/O2 READING: _____

WELL INSPECTION/GROUNDWATER LEVEL MEASUREMENT

WELL DEPTH (FEET FROM TOP OF PVC) _____

WATER LEVEL DEPTH (FEET FROM TOP OF PVC) _____

WELL STICK-UP _____

CASING STICK-UP (FEET) _____

WELL DIAMETER (INCHES) _____

WELL CONSTRUCTION (PVC, STEEL, ETC.) _____

LOCKED UPON ARRIVAL? YES NO

LOCKED REPLACED? YES NO

OBSTRUCTIONS? YES NO

WELL RELABELED? YES NO

SLUG TEST CONDUCTED? YES NO (If YES, refer to "Hydraulic Conductivity Testing Data Sheet")

GENERAL CONDITION/COMMENTS: _____



TETRA TECH NUS, INC.

YSI MULTIPARAMETER WATER QUALITY METER

Site Name: Naval Weapons Industrial Reserve Plant, Bedford, MA;

Job No: 112G00893 / Semi-Annual Event

Serial No. _____ Model No. _____ Decal Letter _____;

Instrument is calibrated in accordance with manufacturers instructions

DATE:	Post Calibration Readings	PM Check	Calibration STDs		Signature	Remarks
Cond.= 1 mS/cm			Lot No.	Exp.		
Cond. Check (DIUF)			Lot No.	Exp.		
pH=4.0			Lot No.	Exp.		
pH=7.0			Lot No.	Exp.		
pH=10.0			Lot No.	Exp.		
D.O. mg/l			% moisture in air			
REDOX mV			Lot No.	Exp.		
Temp °C						

DATE:						
Cond.= 1 mS/cm						
Cond. Check (DIUF)						
pH=4.0						
pH=7.0						
pH=10.0						
D.O. mg/l						
REDOX mV						
Temp °C						

APPENDIX C
ANALYTICAL SERVICES TECHNICAL SPECIFICATION

ATTACHMENT NO. 2

STATEMENT OF WORK/PRICE TABLES

TECHNICAL SPECIFICATION FOR LABORATORY SERVICES ON SHORE DERECKTOR SHIPYARD, SITE 19 NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT N62470-08-D-1001, CONTRACT TASK ORDER (CTO) NO. WE20

STUDY AREA SCREENING EVALUATION CHEMICAL ANALYSES

1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) under CLEAN Contract N62470-08-D-1001, is procuring laboratory analytical services to support a Study Area Screening Evaluation (SASE) at Naval Station Newport (NAVSTA), On-Shore Derecktor Shipyard, Site 19. Requested analyses include volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), gasoline range organics (GRO), diesel range organics (DRO), and target analyte list (TAL) metals.

The laboratory performing this analysis must provide a copy of its Department of Defense (DOD) Environmental Laboratory Accreditation Program (ELAP) accreditation letter; the scope of the ELAP accreditation must include all methods and all analytes requested.

The responding laboratory must submit Limits of Quantitation (LOQs), Limits of Detection (LODs), and Detection Limits (DLs) for all analyses and matrices requested by filling out the last three columns of the tables in Attachment A and including the completed attachment with the bid response. After award, the laboratory will be required to submit Standard Operating Procedures (SOPs) and relevant precision and accuracy limits for all preparation and analytical methods required under this scope of work. The laboratory will also be asked to complete Uniform Federal Policy (UFP) Sampling and Analysis Plan (SAP) Worksheets 19, 24, 25, and 28 for inclusion in the SAP. The SAP will be prepared according to the UFP for Quality Assurance Project Plans (March 2005) and will utilize the 37 UFP-SAP worksheets.

2.0 SAMPLE INFORMATION

The approximate number of samples to be submitted, the type of analyses to be conducted, and the analytical methods to be used are summarized in Table 1. This SASE includes analysis of groundwater and soil samples.

The sampling is scheduled for late January/early February, 2011. The exact date of sample collection will be communicated to the laboratory at least 2 weeks in advance.

The samples are expected to be of low or moderate contaminant concentration. The field crew will attempt to identify any potentially high concentration samples.

Field duplicate samples will be submitted to the laboratory with "blinded" identification. The field crew will designate samples (one per twenty samples of like matrices) for matrix spike/matrix spike duplicate (MS/MSD) analyses (organics) or matrix spike/laboratory duplicate analyses (metals). Additional volumes of these samples will be provided as necessary.

**TECHNICAL SPECIFICATION FOR LABORATORY SERVICES
CONTRACT N62470-08-D-1001, CTO WE20
ON SHORE DERECKTOR SHIPYARD, NAVSTA NEWPORT, NEWPORT, RI
STUDY AREA SCREENING EVALUATION, CHEMICAL ANALYSES
PAGE 2**

Soil Volatile Analyses

Soil samples for VOC and GRO analysis will be collected using a coring device (cut off syringe). The following aliquots will be collected:

- VOC analysis
 - Two 40-ml VOA vials pre-preserved with 1 g NaHSO₄ in 5 ml VOC-free reagent water w/ a magnetic stir bar.
 - One 40-ml VOA vial pre-preserved with 5 ml of methanol
- GRO analysis
 - One 40-ml VOA vial pre-preserved with 5 ml of methanol
 - One 2-oz wide-mouth jar for VOC/GRO percent moisture

The pre-preserved VOC and GRO soil sample containers must be weighed accurately to within 0.01 grams and identified with a unique ID number. Both the ID number and the applicable vial weight must be recorded on a weight tracking form for return shipment to the laboratory. When samples are received at the laboratory, the pre-preserved vials must be re-weighed and these values recorded in the weight tracking form. TtNUS must be contacted immediately if leaking vials are received at the laboratory.

The VOC low-concentration analysis (bisulfate-preserved vials) must be performed first for all of the soil samples in order to meet the required project action limits (PALs). If any target compound is above the calibration range, the laboratory should perform a dilution analysis using a methanol-preserved vial, and the medium level (methanol-preserved) trip blank associated with that sample must also be analyzed.

GRO/DRO Analyses

The GRO fraction must include all petroleum hydrocarbons ranging from **C₆ to C₁₀**. The diesel range organic analysis (DRO) must be extended to include the **C₈ to C₄₀** petroleum hydrocarbons. In addition to quantitating the GRO and DRO concentrations, the laboratory must identify the types of fuel contamination present in the samples. The gas chromatograms must depict the fingerprint patterns at greater than 25 percent of the full scale.

PCB Analyses

All positive identifications for PCBs by gas chromatography (GC) with electron capture detector (ECD) MUST be confirmed on a second column that possesses retention characteristics different from those exhibited by the first column. Identification using a single column with dual detectors does not meet second column confirmation requirements. Confirmed positive results less than the laboratory LOQ but greater than the DL must be reported by the laboratory; the laboratory must "J" flag these results. The laboratory should designate and use the same chromatographic stationary phase for Column 1 and likewise for Column 2 for all of the samples under this project. Results should be reported from Column 1. However, if the between-column RPD exceeds 40%, the analyst must select which result (i.e., from Column 1 or Column 2) to report based on technical conditions; and the laboratory must provide an explanation in the case narrative why the particular result was selected for each affected target analyte.

Metals Analyses

For the ICP and mercury metals analyses, perform a matrix spike and a laboratory duplicate analysis instead of matrix spike/matrix spike duplicate. If an ICP metals matrix spike recovery falls outside the control

**TECHNICAL SPECIFICATION FOR LABORATORY SERVICES
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STUDY AREA SCREENING EVALUATION, CHEMICAL ANALYSES
PAGE 3**

limits and the sample result does not exceed four times the spike added, a post-digestion spike analysis must be performed. In addition, a five-fold dilution analysis (ICP serial dilution) must be performed on the field-designated QC sample. Results for these QC analyses must be summarized in the corresponding CLP-equivalent forms (Attachment B).

3.0 ANALYSIS/REPORTING INFORMATION

One hard copy data package deliverable and two PDF CD copies must be submitted, in addition to the electronic data deliverables to be provided in the format described in Attachment C. The original chain-of-custody form received with the samples and signed by the laboratory sample custodian must be returned with the hard copy data package.

The analytical requirements and approximate number of samples to be submitted for analysis are detailed in Table 1. Analysis and reporting requirements addressed in the Department of Defense (DOD) Quality Systems Manual (April 2009) and the requested methods must be followed. Additionally, it is a requirement of TtNUS that the associated PDF and hard copy data packages for VOC, PAH, PCB, and metal analyses must meet Contract Laboratory Program (CLP) format, reporting, and PDF/hard copy data package deliverable requirements. Second-source initial calibration verification results must be reported on a summary form; and for the GC/MS analysis, the compounds associated with each internal standard must be identified. The PDF and hard copy data packages for the GRO and DRO analyses must be in a CLP-modified format and must include the appropriate summary forms and raw data for all samples and laboratory quality control samples. The summary forms should include the method-specific quality control limits (recoveries, relative percent differences, relative standard deviations, and/or percent differences, etc.). The TtNUS sample identification numbers **must be included** on the raw data and summary forms.

Additionally, each hard copy and PDF data package must contain a summary data package. This summary data package shall consist of only the summary forms (i.e., for CLP, Forms 1 through 15; for non-CLP it shall be the CLP-like equivalent of Forms 1 through 15).

Attachment A details the required target compound list and required PALs that must be met. The laboratory must submit its LOQs, LODs, and DLs for all analyses and matrices requested by filling out the last three columns of the tables in Attachment A and including the completed attachment with the bid response. If the PAL for a target compound is not technically achievable, or if no PAL is listed for a target compound in Attachment A, the laboratory should propose the lowest LOQ technically possible for the requested method.

Attachment B details the required summary forms for CLP-like data packages and requirements for organization/bookmarking of hard copy/PDF data packages.

Non-detected organic and metals results must be reported down to the laboratory's LODs. Positive results above the DL but below the laboratory's LOQ must be reported as estimated values qualified with a "J" for both organic analyses and metals analysis. Soil samples must be reported on a dry-weight basis.

The hard copy/PDF data package deliverable must contain a detailed case narrative for all analytical fractions. This case narrative must also include the Contract Task Order (CTO) number, the site name, and the TtNUS Project Manager's name. Data from all analytical runs (i.e., original, dilution, re-analysis) must be reported in the raw data and Form Is for organic analyses. For metals analyses, only the final sample results should be reported in the Form Is, and data from all analytical runs must be included in the raw data.

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As part of the laboratory case narrative, it is required that the Laboratory Quality Assurance Manager sign an attestation statement verifying that all electronic diskette deliverables exactly match the data summary forms (i.e. Form Is).

As stipulated in the CLEAN Basic Ordering Agreement (BOA), Sample Delivery Group (SDG) and fractionally-specific text (TXT) files containing all environmental sample and field quality control blank analysis results must be generated in accordance with the requirements outlined in Attachment C of this specification.

Maximum holding time allowances, as defined in the following table, are to be strictly observed. Calculation of holding time is in calendar days and is to begin from the time of sample collection. The holding times are as follows:

Analyses	Preservation	Holding Time
VOCs	Aqueous: HCl to pH < 2, cool to 4 °C	14 days to analysis
	Soil (low): 1 g NaHSO ₄ in 5 ml VOC-free reagent water, cool to 4 °C	
	Soil (medium): 5 ml methanol, cool to 4 °C	
GRO	Aqueous: HCl to pH < 2, cool to 4 °C	14 days to analysis
	Soil: 10 ml methanol, cool to 4 °C	
PAHs, DRO	Aqueous: Cool to 4 °C	7 days to extraction, 40 days to analysis
	Soil: Cool to 4 °C	14 days to extraction, 40 days to analysis
PCBs	Aqueous and Soil: Cool to 4 °C	None
TAL Metals	Aqueous: HNO ₃ to pH < 2, cool to 4 °C	6 months to analysis for ICP metals; 28 days to analysis for mercury
	Soil: Cool to 4 °C	

These holding times are based on 40 CFR 136, data validation criteria, and method specific requirements, and are measured from date of collection for samples preserved as requested in the analytical methods. The holding time criteria depicted apply to all analyses necessary to successfully determine the contaminant level contained in the sample. Hence, **the holding time criteria apply to any/all subsequent sample dilutions and re-analyses.**

The TtNUS Project Manager for this project is Mr. Thomas Campbell and he must be contacted in the event of any laboratory problems that could impact project deadlines (i.e., late deliverables, technical problems in the lab that could lead to late deliverables.) To ensure good communication, it is required that the laboratory's appointed project manager contact Mr. Campbell once a week for the entire project duration.

Contact information for Mr. Campbell is as follows:

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Tetra Tech NUS
55 Jonspin Road
Wilmington, MA 01887
Phone: 978-474-8404
Fax: 978-474-8499
Email: thomas.campbell@tetrattech.com

Analytical data turnaround times are to be measured from receipt of each sample shipment. All hard copy/PDF (2 CDs) analytical data packages and associated electronic (TXT) deliverables are due within the standard BOA turnaround term of 21 calendar days from receipt of the last sample in a Sample Delivery Group (SDG).

The SDGs must contain no more than 20 samples. The frequency with which SDGs contain fewer than 20 samples should be minimal. The hard copy data packages, PDF files (CDs), and electronic deliverables must be received at the same time or the deliverable will be considered incomplete and payment deductions may be imposed.

The hardcopy analytical data package, 1 PDF (CD) copy of the analytical data package, and the original chain-of-custody form (received with the samples and signed by the laboratory sample custodian) should be sent to Ms. Lucy Guzman. The contact information for Ms. Guzman is the same as noted above for Mr. Campbell except that her direct phone number is (978) 474-8416 and her email address is lucy.guzman@tetrattech.com.

The electronic (TXT) deliverables, 1 PDF (CD) copy of the analytical data package, and a copy of the chain-of-custody form, should be sent to Ms. Tobrena Skeen. The contact information for Ms. Skeen is as follows:

Tetra Tech NUS, Inc.
661 Andersen Drive, Foster Plaza 7
Pittsburgh, PA 15220-2745
Phone: 412-921-8582
Fax: 412-921-4040
e-mail: tobrena.skeen@tetrattech.com

4.0 PERIOD OF PERFORMANCE/BOTTLEWARE INFORMATION

All samples will be shipped to the laboratory via express carrier within 48 hours of collection. **The laboratory must be capable of receiving samples on Saturdays.** Please circle the Yes or No at the bottom of Table 1 which will indicate if the laboratory will provide courier service at no extra charge. The laboratory will be notified at least 2 weeks prior to sample collection.

Bottleware shipments will be coordinated by the field operation leader.

The laboratory is to provide all necessary sample containers **(plus approximately 10% extra for breakage)**. All sample containers must meet ICHM series 300 cleanliness criteria (or equivalent), and documentation of certified cleanliness must be provided. All of the appropriate sample bottleware must be pre-preserved. The bottleware must be shipped to the designated location in Coleman-like coolers. Each cooler must include a "temperature blank" vial. **The laboratory must also provide any extra coolers needed for return shipment of samples to the laboratory for analysis.** The laboratory is also requested

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to provide a packing slip indicating the analytical parameters for which each container type is designated, sample labels, and chain-of-custody forms.

For this project, TtNUS plans to analyze nine soil samples for VOCs and 20 for GRO; however, **the laboratory is requested to provide additional sets of pre-preserved sample containers for soil interval samples to be collected but not analyzed – 87 for VOC samples and 122 for GRO samples.** The laboratory should include the cost of these additional pre-preserved sample containers as a separate line item in the price sheet (Table 1).

The laboratory must provide Material Safety Data Sheets (MSDSs) for all preservatives sent with each bottleware shipment to the field. MSDSs must be representative of the chemicals provided as preservatives with regard to mixtures and/or purity of the chemicals. For example if a 35% sulfuric acid solution is the preservative, the MSDS provided should be for 35% sulfuric acid solution not 96% sulfuric acid.

5.0 ADDITIONAL COMMENTS/CONTACTS

Within the laboratory, the internal transfer of samples, extracts, and digestates must be accomplished and documented as controlled custody transfers. The laboratory must submit the documentation that supports an unbroken chain of custody for samples, digestates and extracts from time of receipt or production in the laboratory until disposal.

The laboratory is to provide a minimum of 60 days storage of sample extracts/digestates and 60 days storage of intact leftover sample aliquots, as stipulated in the BOA. **Additionally, the laboratory must store PDF data packages for 7 years.**

All analyses conducted under this subcontract assignment are to be performed at the solicited facility only. The laboratory is not permitted to lower-tier subcontract these analyses, or analyze these samples at a corporate facility other than the facility stipulated without prior notification and consent from the CLEAN Subcontracting Officer.

The unit cost for analysis is to include compensation for containers, preservatives, coolers, shipping costs, storage, disposal, and laboratory quality control analyses (such as matrix spike, matrix spike duplicate, laboratory duplicate, and laboratory control sample analyses.) These items are not to be billed as separate line items.

Technical, quality assurance, and data format concerns are to be directed to Ms. Lucy Guzman at 978-474-8416 or via e-mail lucy.guzman@tetratech.com. Ms. Guzman must be contacted and informed of any difficulties encountered during the conduct of the requested analyses.

Contract concerns, and response to this solicitation, are to be directed to:

Ms. Meg Price
CLEAN Subcontracting Officer
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, PA 19406-1433
Phone: 610-491-9688
Fax: 610-491-9645

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e-mail: meg.price@tetrattech.com

Triplicate copies of invoices associated with the analyses contracted herein are to be submitted to the attention of the Accounting Supervisor:

Tetra Tech NUS, Inc.
661 Andersen Drive, Foster Plaza 7
Pittsburgh, PA 15220
Phone: 412-921-8506
Fax: 412-921-4040

Please confirm the laboratory's ability to perform the methodologies requested at the analyte quantitation limits indicated. Also confirm available laboratory capacity, and complete/confirm the costing information indicated in Table 1. All costing information must reflect the terms and conditions established by the 2010 CLEAN BOA.

**TABLE 1
NUMBER OF SAMPLES/ANALYTICAL METHODS
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Matrix	Parameter⁽¹⁾	Method⁽²⁾	# Samples	Unit Price	Total Cost
Groundwater and Associated Field Blanks	VOCs	SW-846 5030/8260B	19	\$	\$
	PAHs	SW-846 3510C or 3520C/ 8270C SIM	6	\$	\$
	TAL Metals	SW-846 3010B/ 6010B/6020 ⁽³⁾ /7470A	12	\$	\$
Soil	VOCs	SW-846 5035/8260B	9	\$	\$
	GRO	SW-846 5035/ 8015B ⁽⁴⁾	20	\$	\$
	DRO	SW-846 3540C or 3550B/ 8015B ⁽⁴⁾	14	\$	\$
	PAHs	SW-846 3540C or 3550B/ 8270C SIM	16	\$	\$
	PCBs	SW-846 3540C or 3550B/ 8082	12	\$	\$
	TAL Metals	SW-846 3050B/ 6010B/6020 ⁽³⁾ /7471A	16	\$	\$
Aqueous Field Blanks Associated with Soil Samples	VOCs	SW-846 5030/8260B	2	\$	\$
	GRO	SW-846 5030/8015B ⁽⁴⁾	2	\$	\$
	DRO	SW-846 3510C or 3520C/ 8015B ⁽⁴⁾	2	\$	\$
	PAHs	SW-846 3510C or 3520C/ 8270C SIM	2	\$	\$
	PCBs	SW-846 3510C or 3520C/ 8082	2	\$	\$
	TAL Metals	SW-846 3010B/ 6010B/6020 ⁽⁵⁾ /7470A	2	\$	\$
Additional sets of pre-preserved VOC containers for 87 soil samples ⁽⁶⁾				\$	\$
Additional sets of pre-preserved GRO containers for 122 soil samples ⁽⁶⁾				\$	\$

(1) See list of required target analytes in Attachment A. (2) Laboratory may use a more recent version of the SW-846 methods listed; if so, the laboratory must identify on this page and on Attachment A the method version to be used. (3) Laboratory must identify on Attachment A which metals will be analyzed by method 6020 in order to meet PALs. (4) GRO range C6-C10; DRO range C8-C40. (5) Field blanks associated with soil samples should be analyzed for metals by the same method (6010B or 6020) as the method to be used for soils. (6) See Section 2.0 for aliquots to be collected.

TOTAL COST \$

The laboratory must point out if they are not DOD ELAP accredited for all of the methods and analytes requested. Clearly state the methods and or compounds that you are NOT accredited for (if any).

Can the laboratory provide sample pick-up on site? YES or NO (circle one)
If yes is there a charge and what is that charge? _____

Name of Laboratory _____

Signature _____

ATTACHMENT A

REQUIRED TARGET ANALYTE LISTS AND PROJECT ACTION LIMITS
(See tables for groundwater and soil in accompanying Excel files)

ATTACHMENT B
DATA PACKAGE DELIVERABLES REQUIREMENTS

DATA PACKAGE DELIVERABLE REQUIREMENTS

The laboratory is to provide a hard copy plus two compact disks (CDs) each containing a PDF file in the following format:

1. Table of Contents
2. Case Narrative
3. Chain-of-Custody
4. Data Summary Package (contains summary of all CLP or CLP-like Forms 1 through 15 per analytical fraction)
5. Analytical Fractions (e.g., VOA, SVOC, Metals, etc.)
 - a. Results and QC Summary (summary of all CLP or CLP like Forms 1 through 15 for a particular analytical fraction)
 - b. Raw Sample Data (includes all sample dilutions, sample re-analyses, QC samples, etc.)
 - c. Calibration Data (includes all initial and continuing calibrations and initial calibration verification)
 - d. Miscellaneous (includes extraction/preparation forms, percent solids determination, IDLs, MDLs, etc.)

Each of the above sections should be bookmarked in the PDF for easy access.

Summary Form Requirements for PDF data package deliverable for non-CLP Methods:

In addition to the following forms, second-source initial calibration verification summary forms are required, if applicable per the method or the DOD QSM. Also, the compounds associated with internal standards must be identified.

The following summary forms are required as part of the data package deliverable for SW-846 6020/6010B/7000A series for metals:

Results Report - must present all information presented on CLP FORM 1 (ILM05.4).

Initial and Continuing Calibration Summary - must present all information presented on CLP FORM 2A (ILM05.4).

Low-Level Calibration Standard Summary – if applicable, must present all information presented on CLP FORM 2B (ILM05.4).

Blanks - must present all information presented on CLP FORM 3 (ILM05.4).

ICP Interference Check Sample Summary - must present all information presented on CLP FORM 4 (ILM05.4).

Matrix Spike Summary - must present all information presented on CLP FORM 5A (ILM05.4).

Post Digestion Spike - must present all information presented on CLP FORM 5B (ILM05.4).

Lab Duplicate Results - must present all information presented on CLP FORM 6 (ILM05.4).

LCS Summary - must present all information presented on CLP FORM 7 (ILM05.4).

MSA Summary (Method of Standard Addition) – if applicable, must present all information presented on CLP FORM 8 (ILM04.1).

ICP Serial Dilution Summary - must present all information presented on CLP FORM 8 (ILM05.4).

Detection Limits - must present all information presented on CLP FORM 9 (ILM05.4).

Linear Range – must present all information presented on CLP FORM 11 (ILM05.4).

Internal Standard Association (ICP-MS) – must present all information presented on CLP FORM 11 (ISM01.2). Alternatively, the laboratory may provide the information in the Narrative.

Prep Log - must present all information presented on CLP FORM 12 (ILM05.4).

Analysis Run Log - must present all information presented on CLP FORM 13 (ILM05.4).

ICP-MS Tune – must present all information presented on CLP FORM 14 (ISM01.2). Laboratory must also document the number of tune analysis integrations on this form or in the Narrative.

ICP/MS Internal Standard Relative Intensity Summary - must present all information presented on CLP FORM 15 (ILM05.4).

Also must include: Instrument Calibration Records, Chain-of-Custody Forms, and Case Narrative. The Narrative, forms, or raw data must indicate the number of replicate integrations for ICP-MS sample analysis.

Summary Forms for GC/MS analysis of Volatile and Semivolatile Organic Compounds should be presented in a CLP-Like format. The following Summary Forms must be included:

Result Summary	One Sample per summary page. Presentation of analytical results for both method blanks and environmental samples, date of collection, preparation, and analysis. Environmental samples should be identified with the field identification numbers on the COCs.
Surrogate Recovery Form	Present all information contained on CLP Form II.
Summary of Matrix Spike/Matrix Spike Duplicate Recovery	Present all information contained on CLP Form III.
Instrument Performance Check Summary Form - Mass Spec Tuning Form	Present all information Contained on CLP Form V.
Initial Calibration Summary	Present all information contained CLP Form VI.
Continuing Calibration Summary	Present All Information contained on CLP Form VII.
Internal Standard Area and Retention Time Summary	Present all information contained CLP Form VIII.

Summary Forms for GC analysis of pesticides and PCBs should be presented in a CLP-Like format. The following Summary Forms must be included:

Result Summary	One Sample per summary page. Presentation of analytical results for both method blanks and environmental samples, date of collection, preparation, and analysis. Environmental samples should be identified with the field identification numbers on the COCs.
Surrogate Recovery Form	Present all information contained on CLP Form II for both Analytical Columns.
Summary of Matrix Spike/Matrix Spike Duplicate Recovery	Present all information contained on CLP Form III.
Summary of Pesticide Initial Calibration of Single Component Analytes	Present all information contained on CLP Form VI-PEST-2.
Summary of Pesticide Calibration Verification	Present all information contained on CLP Form VII-PEST-1 and Form VII-PEST-2.
Pesticide Analytical Sequence	Present all information contained on CLP Form VIII-PEST.
Pesticide Identification Summary For Single Component Analytes and for Multiple Component Analytes	Present all information contained on CLP Form X PEST 1 and 2.

ATTACHMENT C
ELECTRONIC DATA DELIVERABLE REQUIREMENTS

ELECTRONIC DATA FORMAT REQUIREMENTS

1.0 INTRODUCTION

The laboratory is to submit text-based tab delimited EDD files for each SDG using Tetra Tech's laboratory data checker explained below. The files must be in the format specified in this Attachment. Additional information such as laboratory name, project name, fractions included, project number, site name/number, laboratory contact person and any specific comments related to the EDD should be included in the comments section of the EDD Submittal page.

The RESULT for nondetects should be populated with the project-specific sample quantitation reporting limits (i.e., either the sample quantitation limit or method detection limit, as specified in Section 3.0 of this scope of work. Any corrections made to the hardcopy data must also be made to the electronic file. Appropriate qualifiers as identified by the analytical protocol must also be designated; laboratory QC non-compliance codes are not to be depicted.

Tetra Tech's electronic EDD format follows the ADAPT structure and requires the A1 and A3 files. The A2 file is only required if the project is using ADAPT; and, for non-ADAPT EDD submittals the A2 file may be omitted. The EDD consists of separate, tab-delimited ASCII text files. Each file corresponds to a database table. The tables are identified as the Analytical Results Table (A1) and Sample Analysis Table (A3). A separate set of text files must be created and submitted for each sample delivery group (SDG). The files must be identified to correspond to the (A1) table and the (A3) table. The file naming convention is: the Sample Delivery Group (SDG) followed by the table identifier (A1 or A3), followed by the ".txt" extension. The file names must not contain spaces or special characters. For example, the EDD file names for a laboratory-reporting batch identified as SDG001 would be as follows:

SDG001A1.txt
SDG001A3.txt

On certain projects Tetra Tech will utilize the ADAPT Electronic Data Validation software, which will require the laboratory to use the ADAPT electronic data deliverable checker software prior to submitting the files through Tetra Tech's laboratory data checker (this will be clearly specified in the Tetra Tech laboratory statement of work). The ADAPT checker software can be downloaded from Laboratory Data Consultants' web site: <http://www.lab-data.com>. For projects which Tetra Tech is using the ADAPT software, Tetra Tech will provide the laboratory with the project library. The laboratory is not permitted to modify the project library. ADAPT projects will require the laboratory to export all three checked files (A1, A2, and A3) from the ADAPT software and submit them through Tetra Tech's laboratory data checker. **ADAPT error logs generated must be included with the electronic PDF data validation package and cannot be submitted through the laboratory data checker.**

The values reported in the EDD text files must agree exactly with the final values reported on the PDF data package sample result summaries. The details of file naming conventions, data structure and data checker use are discussed below.

Analytical Results Table (A1 File)

The Analytical Results table contains analytical results and related information for target analytes in field samples and associated laboratory quality control samples (excluding calibrations and tunes). Field samples and laboratory method blanks must report a result record for each analyte reported within a method. Laboratory control samples (LCS and LCSD) and matrix spike samples (MS and MSD) must report a result record for every analyte specified as a spiked analyte in the laboratory statement of work. Table A1 in this document lists the field names and data type descriptions for the Analytical Results Table (A1).

Lab Instrument Table (A2 File)

A2 file is only required if the project is using ADAPT. In all other EDD submittals, the A2 file may be omitted. Laboratories should refer to the ADAPT User Guide for populating the A2 Table.

Sample Analysis Table (A3 File)

The Sample Analysis table contains information specific to field environmental samples and laboratory quality control analyses (excluding calibrations and tunes). A sample record must exist for each sample/method/matrix/analysis type combination. Table A3 in this document lists the field names and data type descriptions for the Sample Analysis Table (A3).

All electronic data deliverables are due within the same time established for the associated hardcopy data packages.

In addition, the laboratory QC officer must read and sign a copy of the Quality Assurance Review Form displayed on the next page of this Attachment. Electronic deliverables are not considered to be complete without the accompanying Quality Assurance Review Form.

I _____, as the designated Quality Assurance Officer, hereby attest that all electronic deliverables have been thoroughly reviewed and are in agreement with the associated hardcopy data. The enclosed electronic files have been reviewed for accuracy (including significant figures), completeness and format. The laboratory will be responsible for any labor time necessary to correct enclosed electronic deliverables that have been found to be in error. I can be reached at _____ if there are any questions or problems with the enclosed electronic deliverables.

Signature: _____ Title: _____ Date: _____

2.0 EDD Field Properties

Tables A1 and A3 in this document specify the EDD field properties. Laboratories should refer to the ADAPT User Guide for populating the A2 Table. These include the field name, sequence order, field description, data type/length and reporting requirement for each field. Fields in the EDD **must** be sequenced according to the order that they appear below in Tables A1 and A3. For example, in the Analytical Results table (A1), the field “ClientSampleID” will always be the first piece of information to start every new line of data (or database record), followed by the field “LabAnalysisRefMethodID”, “AnalysisType”, etc.

When creating an EDD as a text file, use the ASCII character set in a file of lines terminated by a carriage return and line feed. No extra characters are allowed at the end of a line, after the carriage return and line feed. Enclose each data value with double quotes (text qualifier) and separate each field value with a **tab** character (tab delimiter). Data fields with no information (null) may be represented by two consecutive tabs. For example, in the Sample Analysis table, since the “Collected”, “ShippingBatchID”, and “Temperature” fields do not apply to laboratory generated QA/QC samples, the record for a Laboratory Control Sample by Method 8270C would be entered as follows. Note that the first two fields (“ProjectNumber” and “ProjectName”) are omitted in this example.

...“LCSW100598” “AQ” “LCSW100598” “LCS” “8270C”,...etc.

If a field is populated with less than the maximum allowed number of characters, do not pad the values with leading or trailing spaces. In the above example, although the “MatrixID” field can accommodate up to 10 characters, only 2 characters were entered in this field. **Do not include the delimiter (tab character) within any of the field values.** Example EDD files may be downloaded from the LEDD Checker application.

An example database shall be sent for review prior to the first electronic deliverable in the required .txt format. The example file will be examined for completeness and comments will be sent to the laboratory. Any questions regarding the electronic deliverable should be directed to LabSupport@tetrattech.com

Table A1
Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ClientSampleID	Client or contractor’s identifier for a field sample If a sample is analyzed as a laboratory duplicate, matrix spike, or matrix spike duplicate, append suffixes DUP, MS and MSD respectively to the Client Sample ID	Text	25	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>with no intervening spaces or hyphens (i.e. MW01DUP, MW01MS, and MW01MSD). For Method Blanks, LCS, and LCSD enter the unique LaboratorySampleID into this field.</p> <p>Do not append suffixes to the ClientSampleID for dilutions, reanalyses, or re-extracts (the AnalysisType field is used for this distinction). For example, MW01<u>DL</u> and MW01<u>RE</u> are not allowed.</p> <p>Parent sample records must exist for each MS and MSD. If an MS/MSD is shared between two EDDs, records for the MS/MSD and its parent sample must exist in the Analytical Results table for both EDDs.</p>			
LabAnalysisRefMethodID	Laboratory reference method ID. The method ID may be an EPA Method number or a Lab Identifier for a method such as a SOP Number, however; method ID is specified by the project. The method ID must be entered into the standard list.	Text	25	X
AnalysisType	Defines the analysis type (i.e., Dilution, Reanalysis, etc.). This field provides distinction for sample result records when multiple analyses are submitted for the same sample, method, and matrix; for example dilutions, re-analyses, and re-extracts.	Text	10	X
LabSampleID	Laboratory tracking number for field samples and lab generated QC samples such as method blank, LCS, and LCSD. There are no restrictions for the LabSampleID except for field length and that the LabSampleID must be distinct for a given field sample or lab QC sample and method.	Text	25	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	Suffixes may be applied to the LabSampleID to designate dilutions, reanalysis, etc.			
LabID	Identification of the laboratory performing the analyses.	Text	7	X
ClientAnalyteID	<p>CAS Number or unique client identifier for an analyte or isotope.</p> <p>If a CAS Number is not available, use a unique identifier provided by the client or contractor. The ClientAnalyteID for a particular target analyte or isotope should be specified by the project and must exist in the standard value tables for Analytes.</p> <p>For the LCS, LCSD, MS, and MSD, it is only necessary to report the compounds designated as spikes in the library (and surrogates for organic methods.)</p> <p>For TICs from GC/MS analyses, enter the retention time in decimal minutes as the Client Analyte ID.</p>	Text	12	X
AnalyteName	Chemical name for the analyte or isotope. The project specifies how an analyte or isotope is named. The analyte name must be associated to a ClientAnalyteID in the standard values table for Analytes (excluding compounds designated as TIC's).	Text	60	X
Result	<p>Result value for the analyte or isotope.</p> <p>Entries must be numeric. For non-</p>	Numeric ⁽¹⁾	20(6)	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>detects of target analytes or isotopes and spikes, do not enter "ND" or "0". Do not leave this field blank. If an analyte or spike was not detected, enter the associated value specified in Section 3.0 of this scope of work (e.g., LOD, SQL, PQL, etc.), corrected for dilution and percent moisture as applicable. Do not enter "0". A "0" result may be acceptable for surrogate or internal standard percent recoveries; however, it should not be reported for any target compound.</p>			
ResultUnits	<p>The units defining how the values in the Result, DetectionLimit, and ReportingLimit fields are expressed. For radiochemistry this also includes how the value in the Error field is expressed.</p>	Text	10	X
LabQualifiers	<p>A string of single letter result qualifiers assigned by the lab based on client-defined rules and values.</p> <p><u>The "U" Lab Qualifier must be entered for all non-detects.</u> Other pertinent lab qualifiers may be entered with the "U" qualifier. Order is insignificant. Lab qualifiers other than those listed in the standard values table may be used. If so, these must be added to the standard value table in the application.</p>	Text	7	Q
DetectionLimit	<p>For radiochemistry methods, the minimum detectable activity for the isotope being measured.</p> <p>For all other methods: The minimum</p>	Numeric ⁽¹⁾	10(6)	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>detection limit value for the analyte being measured.</p> <p>For surrogates, internal standards, etc. where detection limits are not applicable use the value -99.</p>			
DetectionLimitType	<p>Specifies the type of detection limit (i.e., MDA, MDL, IDL, etc.).</p> <p>If -99 is specified in the DetectionLimit field us the value NA.</p>	Text	10	X
RetentionTime or Error	<p><u>For radiochemistry methods only</u>, enter the 2 Sigma Counting Errors. The units for error are entered in the ResultUnits field.</p> <p><u>For GC/MS methods only</u>, enter the time expressed in decimal minutes between injection and detection for <u>GC/MS TICs only</u></p> <p><u>For target analytes in all other methods</u>, leave this field blank. Note: GC retention times are not evaluated at this time.</p>	Text	5	T
AnalyteType	<p>Defines the type of result, such as tracer, surrogate, spike, or target compound.</p>	Text	7	X
PercentRecovery	<p>For radiochemistry methods: The tracer yield, if applicable.</p> <p>For all other analytical methods: The percent recovery value of a spiked compound or surrogate.</p> <p>If the spike or surrogate was not recovered because of dilution, enter "DIL". If a spike or surrogate was not recovered because of matrix interference, enter "INT". If a spike or</p>	Numeric ⁽¹⁾	5(3)	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	surrogate was not recovered because it was not added to the sample, enter "NS".			
RelativePercentDifference	The relative percent difference (RPD) of two QC results, such as MS/MSD, LCS/LCSD, and Laboratory Duplicates. Report RPD in Laboratory Duplicate, LCSD, and MSD records only.	Numeric ⁽¹⁾	5(3)	X
ReportingLimit	Reporting limit value for the measured analyte or isotope Factor in the dilution factor and percent moisture correction, if applicable. The Reporting Limit for each analyte and matrix in a given method is specified in the project library or QAPP. For surrogates, internal standards, etc. where reporting limits are not applicable use the value -99.	Numeric ⁽¹⁾	10(6)	X
ReportingLimitType	Specifies the type of reporting limit (i.e., CRQL, PQL, SQL, RDL, etc). The Reporting Limit Type for each method and matrix is specified in the project library or QAPP. If -99 is specified in the ReportingLimit field us the value NA.	Text	10	X
ReportableResult	This field indicates whether or not the laboratory chooses an individual analyte or isotope result as reportable. Enter "YES" if the result is reportable. Enter "NO" if the result is not reportable. If only one analysis is submitted for a particular sample and method, enter "YES"	Text	3	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>for all target compounds (where Analyte Type = TRG). For GC/MS methods enter yes for tentatively identified compounds (where Analyte Type = TIC).</p> <p>If two or more analyses are submitted for a particular sample and method (i.e. initial analysis, reanalysis and/or dilutions), enter “YES” from only <u>one</u> of the analyses for each target compound. For example: a sample was run a second time at dilution because benzene exceeded the calibration range in the initial, undiluted analysis. All target analytes are reported in each analysis. For the initial analysis, (Analysis Type = RES), enter “NO” for benzene and enter “YES” for all other compounds. For the diluted analysis (Analysis Type = DL), enter “YES” for benzene and enter “NO” for all other compounds.</p> <p>For TICs (Analyte Type = TIC), if more than one analysis is submitted for a particular sample and method, choose only one of the analyses where Reportable Result = YES for <u>all</u> TICs. For example, a sample was run a second time because one or more target compounds exceeded the calibration range in the undiluted analysis. Choose a particular analysis and enter “YES” for all TICs. In the other analysis enter “NO” for all TICs.</p> <p>Note that it is not necessary to report the full target analyte list for the initial result, dilution, re-analysis, or re-extraction. However, each target analyte must be reported YES once and once only in the case of multiple analyses for a given sample, method, and</p>			

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	matrix. In the case of organics, all surrogates must be reported for all analyses submitted for a given sample, method, and, matrix.			
SpkConcnAdded	<p>The spike added. This value must be reported in the same units as the result. Where (SA) in the following equation: $\% \text{ Recovery} = (\text{SSA} - \text{SC}) / \text{SA} \times 100\%$ where :</p> <p>SSA is the spiked sample concentration (amount) after spiking. SC is the sample concentration (amount) before spiking. SA is the the expected increase in sample concentration (amount) as a result of spiking. This value must incorporate all correction factors such as dilution factor and moisture content that are applied to the spiked sample when computing the spiked sample concentration or amount. Enter -99 where no spike was added.</p>	Numeric ⁽¹⁾	10(6)	X
SpkParentSampleID	<p>The sampleID of a sample (often called the original sample) that receives a spike aliquot to form a spiked sample such as a matrix spike. This is not the same as the ID of the spiked sample (such as a matrix spike) after spiking.</p> <p>The result for SpkParentSampleID and the result (i.e., SpkConcnAdded) for the spiked sample are used to compute percent recovery of the analyte.</p>	Text	25	X
SamplePrepInitial	The initial sample preparation volume in liters (L) for aqueous samples or grams (g) for solid samples.	Numeric ⁽¹⁾	20(6)	

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
SamplePrepFinal	The final sample preparation volume in liters (L) for aqueous samples or grams (g) for solid samples.	Numeric ⁽¹⁾	20(6)	
LimitOfDetection	The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a 99% confidence level. In other words, if a sample has a true concentration at the LOD, there is a minimum probability of 99% of reporting a "detection" (a measured value \geq DL) and a 1% chance of reporting a non-detect (a false negative).	Numeric ⁽¹⁾	10(6)	N
Comment	Add any comments or additional information specific to the analyte test result data record.	Text	200	

X Required field.

Q Only required if laboratory has qualified the result.

T Only required for tentatively identified compounds by GC/MS.

(1) Field Length indicates decimal precision in parenthesis. For example, 5(2) = a total width of 5 numbers including a maximum of 2 decimal places.

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ProjectNumber	Project number assigned by the client.	Text	30	X
ProjectName	Project name assigned by the client.	Text	90	X
ClientSampleID	<p>Client or contractor's identifier for a field sample</p> <p>If a sample is analyzed as a laboratory duplicate, matrix spike, or matrix spike duplicate, append suffixes DUP, MS and MSD respectively to the Client Sample ID with no intervening spaces or hyphens (i.e. MW01DUP, MW01MS, and MW01MSD). For Laboratory QC samples (i.e. Method Blanks, LCS, and LCSD, etc.) enter the unique LaboratorySampleID into this field</p> <p>Do not append suffixes to the ClientSampleID for dilutions, reanalyses, or re-extracts (the Analysis_Type field is used for this distinction). For example, MW01<u>DL</u> and MW01<u>RE</u> are not allowed</p> <p>Parent sample records must exist for each MS and MSD. If an MS/MSD is shared between two EDDs, records for the MS/MSD and its parent sample must exist in the Sample Analysis table for both EDDs.</p>	Text	25	X
Collected	<p>Date and Time of sample collection. Refer to the date/time format at the end of this table.</p> <p>Leave this field blank for Method Blank, LCS, and LCSD. For Collected values that are not applicable use the value of 00/00/0000 00:00.</p>	Date/Time	16*	X
MatrixID	Sample matrix (i.e., AQ, SO, etc.)	Text	10	X
LabSampleID	Laboratory tracking number for field samples	Text	25	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>and lab generated QC samples such as method blank, LCS, and LCSD.</p> <p>There are no restrictions for the LabSampleID except field length and that the LabSampleID must be unique for a given field sample or lab QC sample and method.</p>			
QCType	<p>This record identifies the type of quality control sample QC (i.e., Duplicate, LCS, Method Blank, MS, or MSD). <u>For regular environmental samples, populate this field with "NM".</u></p>	Text	10	X
ShippingBatchID	<p>Unique identifier assigned to a cooler or shipping container used to transport client or field samples. Links all samples to a cooler or shipping container. No value is required for method blanks, LCS, and LCSD.</p>	Text	25	X
Temperature	<p>Temperature (in centigrade degrees) of the sample as received.</p> <p>The storage refrigerator or room temperature should be reported (in centigrade degrees) for laboratory QC samples (i.e. method blanks, laboratory control standards).</p> <p>Use -99 if temperature is not available.</p> <p><u>This field is not required for radiochemistry methods.</u></p>	Numeric ⁽¹⁾	10(6)	X
LabAnalysisRefMethodID	<p>Laboratory reference method ID. The method ID may be an EPA Method number or laboratory identifier for a method such as a SOP number, however; values used for Laboratory Method IDs are specified by the</p>	Text	25	X

Table A3**Field Description for the Sample Analysis (Table A3)**

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	project and must in the in standard value list for method IDs.			
PreparationType	Preparation Method Number (i.e., 3010A, 3510C, 3550C, 5030B, etc.) For analytical procedures that do not have a specific preparation method number, use "Gen Prep".	Text	25	X
AnalysisType	Defines the type of analysis such as initial analysis, dilution, re-analysis, etc. This field provides distinction for sample records when multiple analyses are submitted for the same sample, method, and matrix, for example: dilutions, re-analyses, and re-extracts.	Text	10	X
Prepared	Refer to the date/time format at the end of this table. If no sample preparation is involved enter the analysis date and time in this field. Refer to the date/time format at the end of this table.	Date/ Time	16*	X
Analyzed	Date and time of sample analysis. Refer to the date and time format at the end of this table. For Analyzed values that are not applicable use the value of 00/00/0000 00:00.	Date/ Time	16*	X
LabID	Identification of the laboratory performing the analysis.	Text	7	X
QCLevel	The level of laboratory QC associated with the analysis reported in the EDD. If only the Analytical Results Table (A1) and the Sample Analysis Table (A3) information are submitted for the sample, enter "COA". If the Laboratory Instrument Table (A2) information is also submitted for the sample, enter "COCAL"	Text	6	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ResultBasis	Indicates whether results associated with this sample records are reported as wet or percent moisture corrected. Enter "WET" if results are not corrected for percent moisture. Enter "DRY" if percent moisture correction is applied to results. For aqueous samples, enter "WET". For other matrices where basis is not applicable enter "NA"	Text	3	X
TotalOrDissolved	This field indicates if the results related to this sample record are reported as a total or dissolved fraction. If not applicable please report "NA"	Text	3	X
Dilution	Dilution of the sample aliquot. Enter "1" for method blanks, LCS, and LCSD, or if the field samples was analyzed without dilution.	Numeric ⁽¹⁾	10(6)	X
HandlingType	Indicates the type of leaching procedure, if applicable (i.e., SPLP, TCLP, WET). Enter "NA" if the sample analysis was <u>not</u> performed on a leachate.	Text	10	X
HandlingBatch	Unique laboratory identifier for a batch of samples prepared together in a leaching procedure (i.e., SPLP, TCLP, or WET preparation). The HandlingBatch links samples with leaching blanks. Enter "NA" if the sample analysis was <u>not</u> performed on a leachate.	Text	12	X
LeachateDate	Date and time of leaching procedure (i.e., date for SPLP, TCLP, or WET preparation). Refer to the date and time format at the end of this table.	Date /Time	16*	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	. For Analyzed values that are not applicable use the value of 00/00/0000 00:00			
Percent_Moisture	For soil and sediment samples, enter the percent of sample composed of water. For aqueous samples enter "100". For other matrices where Percent_Moisture is not applicable use a value of -99	Numeric ⁽¹⁾	10(6)	X
MethodBatch	<p>Unique laboratory identifier for a batch of samples of similar matrices analyzed by one method and treated as a group for matrix spike, matrix spike duplicate, or laboratory duplicate association</p> <p>The method batch links the matrix spike and/or matrix spike duplicate or laboratory duplicates to associated samples. Note the MethodBatch association may coincide with the PreparationBatch association. The MethodBatch is specifically used to link the MS/MSD and/or DUP to associated samples.</p>	Text	12	X
PreparationBatch	<p>Unique laboratory identifier for a batch of samples prepared together for analysis by one method and treated as a group for method blank, LCS and LCSD association.</p> <p>The PreparationBatch links method blanks and laboratory control samples (blank spikes) to associated samples. Note, the PreparationBatch association may coincide with the MethodBatch association but the PreparationBatch specifically links the Method Blank and LCS to associated samples.</p>	Text	12	X
RunBatch	<u>For all other methods</u> the RunBatch is the unique identifier for a batch of analyses performed on one instrument under the control	Text	12	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>of one initial calibration and initial calibration verification. The RunBatch links both the initial calibration and initial calibration verification to subsequently analyzed and associated continuing calibrations, field samples, and QC analyses. For GC/MS methods, the RunBatch also links a BFB or DFTPP tune. A distinct RunBatch must used with every new initial calibration within a method</p> <p>The value entered in this field links a particular sample/method/analysis type record to a set of associated initial calibration and initial calibration verification records from Table A2.</p> <p>If Table A2 is not submitted enter a value of 'NA" in this field.</p>			
AnalysisBatch	<p><u>For radiochemistry methods</u> leave this field blank.</p> <p><u>For all other methods</u> the AnalysisBatch is the unique identifier for a batch of analyses performed on one instrument and under the control of a continuing calibration or continuing calibration verification. The AnalysisBatch links the continuing calibration or calibration verification to subsequently analyzed and associated field sample and QC analyses. For GC/MS methods, the AnalysisBatch also links the BFB or DFTPP tune. A distinct AnalysisBatch must be used with every new continuing calibration or continuing calibration verification within a method</p> <p>The value entered in this field links a particular sample/method/analysis type record to a set of</p>	Text	12	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	associated continuing calibration records in the Laboratory Instrument table.			
LabReportingBatch	Unique laboratory identifier for the EDD. This is equivalent to the sample delivery group, lab work number, login ID, etc. The LabReportingBatch links all records in the EDD reported as one group. The value entered in this field must be the same in all records.	Text	12	X
LabReceipt	Date and time the sample was received in the lab. A time value of 00:00 may be entered. Refer to the date/time format at the end of this table.	Date/Time	16*	X
LabReported	Date and time hard copy reported delivered by the lab. A time value of 00:00 may be entered. Refer to the date/time format at the end of this table.	Date/Time	16*	X
Comment	Add any comments or additional information specific to the sample analysis data record.	Text	200	

C Only required for regular samples, duplicates and MS/MSDs.

X Required field.

(1) Field Length indicates decimal precision in parenthesis. For example, 5(2) = a total width of 5 numbers including a maximum of 2 decimal places.

* Format Date and Time as MM/DD/YYYY hh:mm; where MM = two digit month, DD = two digit day, and YYYY = four digit year, hh = hour in 24 hour format, and mm = minutes.

3.0 Laboratory Data Checker

The Laboratory Data Checker is a web-based application that will review Laboratory Electronic Data Deliverables (LEDDs) for adherence to Tetra Tech's EDD format requirements. EDDs will be reviewed for elements such as missing data and/or columns of data, and compliance of the data within each column to the required data types/lengths.

Once an EDD passes through the checker with no errors, it must be submitted to Tetra Tech through the LEDD Checker application.

Access to the LEDD Checker application will be provided by an initial registration/approval process. An Information Systems Group (ISG) Administrator will approve requests for access. To access the site or begin the registration process, visit the ISG web site at <http://isg.ttnus.com> and select the “Laboratory Checker” link on the left of the home page. Registered users may access the checker immediately by logging in to the system using their credentials. New users must select the “Register” button and provide all of the requested information.

After completing all fields on the registration form, select the “Submit” button to complete the request process. Upon verification by an ISG Administrator, an email notification will be sent verifying the user ID, password and account status. Forgotten passwords may be retrieved by using the “Forgot password?” link on the login page. Note that the email address that was provided for registration or password retrieval is the user ID and must be a valid e-mail address.

The general process for submitting EDD files through the LEDD Checker involves a 3-stage process that includes an upload stage, an error checking stage and a submittal stage.

Log into the LEDD Checker by typing your login credentials and select the “Login” button. The LEDD Checker home page provides a general overview of the checker functionality and EDD file format requirements. At the bottom of the home page, example EDDs are provided that may be viewed or downloaded. To download the files, right click on the link and select “Save target as” from the menu. Each LEDD Checker page includes a navigation bar with links to return to the home page or continue the checking and submittal process. Users should **NOT** use the back or forward buttons on the browser, instead use the links provided in the application to navigate through the site.

Detailed information regarding EDD preparation, formatting requirements and text file naming conventions are provided in the Electronic Data Format Requirements Section of the Laboratory SOW.

Begin the upload stage by selecting the “Upload/Check Files” link on the home page. Follow the steps on the upload page starting with the selection of the laboratory name that corresponds to your organization. If your organization is not listed, contact LabSupport@tetrattech.com, and provide a full description of your organization name, contact information and include “Laboratory Contractor ID Request” in the subject line. An ISG Administrator will respond to the request via e-mail.

Load the appropriate A1, A2, or A3 target EDD files by clicking the “Browse” button next to each data table input box. A file browser dialog will appear allowing files to be selected from a local or network drive. After the EDD files are loaded, click the “Upload” button to complete the upload stage. Note that each table may be uploaded and checked separately; however, a minimum of the A1 and A3 files are required in order to submit the EDDs.

If the file upload was successful, the checking page will immediately load. Begin the checking stage by selecting the “Check Files” button. The LEDD Checker will begin validating the EDD files for compliance. Depending on file size and network activity the validation process may take several minutes. The progress should be displayed in the information bar at the bottom of the browser window. **Do not** select the “Check Files” button again or otherwise use the browser during this process. Other applications may be used; however, note that the LEDD Checker may not sit idle for more than 30 minutes. If the time is exceeded a new session must be started in a new browser window.

Any errors will be processed and returned on the error page. The following general errors may be returned.

- Column count / table structure errors – due to column header names being included, improper delimiter, extra tabs, extra or missing columns of data, spaces or other characters at the end of a row.
- Row and column value specific errors – may occur for one or more reasons including: data truncation, invalid date / time format, invalid decimal precision or field width exceedance, or if a value is not in a list of valid values or expected range.

If column count / table structure errors are encountered, the LEDD Checker will return an error and stop the checking process.

The EDDs will not be processed any further until the column errors are resolved. Text fields are validated for truncation. Date / Time fields are validated for truncation and format compliance. Numeric decimal fields are validated for truncation, character type compliance and decimal precision. All required fields are validated for null values or empty text strings (i.e. spaces). The LEDD Checker will return a list of all errors in and include a reference to the row number on which the error occurred. Note that consecutive EDD files may be loaded and checked, and submitted while logged in. However, no data may be submitted until all EDD files have passed through the LEDD Checker without errors. The list of errors may be printed by selecting the “Print this Page” button from the checker error page.

If the EDD files pass with no errors, the submittal page will immediately load. To complete the submittal stage, include the following information in the comment and additional information area of the form: laboratory name, laboratory contact person, project name, project number, site name/number, fractions included and any specific comments related to the EDD. Select the “Submit Files” button to continue the submittal process.

The submittal stage is not considered complete until a unique ticket key reference is returned in the browser window. The ticket key reference must be printed for record of submission and future reference. In addition, a copy of the ticket key reference must be included in the PDF data package.

Engineer's Estimate - 10/11/10

CTO WE20 - On Shore Derecktor Shipyard, NAVSTA Newport

STUDY AREA SCREENING EVALUATION, CHEMICAL ANALYSES for GW & Soil

Matrix	Parameter ⁽¹⁾	Method	# Samples	Unit Price = 75th %ile except as noted	Total Cost
Groundwater and Associated Field Blanks	VOCs	SW-846 5030/8260B	19	86.05	1634.95
	PAHs	SW-846 3510C or 3520C/ 8270C SIM	6	152.38	914.28
	TAL Metals	SW-846 3010B/ 6010B/6020 ⁽²⁾ /7470A	12	229 ⁽⁶⁾	2748
Soil	VOCs	SW-846 5035/8260B	9	111.76	1005.84
	GRO	SW-846 5035/ 8015B ⁽³⁾	20	60	1200
	DRO	SW-846 3540C or 3550B/ 8015B ⁽³⁾	14	70	980
	PAHs	SW-846 3540C or 3550B/ 8270C SIM	16	159.5	2552
	PCBs	SW-846 3540C or 3550B/ 8082	12	80	960
	TAL Metals	SW-846 3050B/ 6010B/6020 ⁽²⁾ /7471A	16	227.5 ⁽⁷⁾	3640
	Aqueous Field Blanks Associated with Soil Samples	VOCs	SW-846 5030/8260B	2	86.05
	GRO	SW-846 5030/8015B ⁽³⁾	2	56.68	113.36
	DRO	SW-846 3510C or 3520C/ 8015B ⁽³⁾	2	65	130
	PAHs	SW-846 3510C or 3520C/ 8270C SIM	2	152.38	304.76
	PCBs	SW-846 3510C or 3520C/ 8082	2	80	160
	TAL Metals	SW-846 3010B/ 6010B/6020 ⁽⁴⁾ /7470A	2	229 ⁽⁶⁾	458
Additional sets of pre-preserved VOC containers for 87 soil samples ⁽⁵⁾			87	10 ⁽⁸⁾	870
Additional sets of pre-preserved GRO containers for 122 soil samples ⁽⁵⁾			122	10 ⁽⁸⁾	1220

TOTAL

19063.3

(1) See list of required target analytes in Attachment A. (2) Laboratory must identify in Attachment A or in bid which metals will be analyzed by method 6020 in order to meet PALs. (3) GRO range C6-C10; DRO range C8-C40. (4) Field blanks associated with soil samples should be analyzed for metals by the same method (6010B or 6020) as the method to be used for soils. (5) See Section 2.0 for aliquots to be collected.

(6) Cost of 6010/7470 is \$121.25. Estimate 5 metals will require 6020 @ \$26 per metal: 121.25 + (5 x 26) = \$251.25.

However, cost of 6020/7470 less mercury is 137.5 - 30 = 107.5

$$\$107.5 + 121.25 = \$229$$

(7) Cost of 6010/7471 is \$120. Estimate 6 metals will require 6020 @ \$26 per metal: $120 + (6 \times 26) = \$276$.

However, cost of 6020/7471 less mercury is $137.5 - 30 = 107.5$.

$$\$107.5 + 120 = \$227.5.$$

(8) Past bids have ranged \$5 - \$15.

**TABLE A-1
GROUNDWATER REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND**

Chemical	CAS Number	Method	MCL ⁽¹⁾ (ug/L)	RIDEM GA Aquifer ⁽²⁾ (ug/L)	Project Action Level ⁽³⁾ (ug/L)	LOQ Goal ⁽⁴⁾ (ug/L)	Laboratory Limits		
							LOQ (ug/L)	LOD (ug/L)	DL (ug/L)
Volatile Organic Compounds									
1,1,1-Trichloroethane	71-55-6	SW-846 8260B	200	200	200	66.7			
1,1,2,2-Tetrachloroethane	79-34-5	SW-846 8260B	--	--	--	--			
1,1,2-Trichloroethane	79-00-5	SW-846 8260B	5	5	5	1.7			
1,1-Dichloroethane	75-34-3	SW-846 8260B	--	--	--	--			
1,1-Dichloroethene	75-35-4	SW-846 8260B	7	7	7	2.3			
1,2,4-Trichlorobenzene	120-82-1	SW-846 8260B	70	70	70	23.3			
1,2-Dibromo-3-Chloropropane (DBCP)	96-12-8	SW-846 8260B	0.2	0.2	0.2	0.1			
1,2-Dibromoethane (EDB)	106-93-4	SW-846 8260B	0.05	0.05	0.05	0.02			
1,2-Dichlorobenzene	95-50-1	SW-846 8260B	600	600	600	200			
1,2-Dichloroethane	107-06-2	SW-846 8260B	5	5	5	1.7			
1,2-Dichloropropane	78-87-5	SW-846 8260B	5	5	5	1.7			
1,3-Dichlorobenzene	541-73-1	SW-846 8260B	--	--	--	--			
1,4-Dichlorobenzene	106-46-7	SW-846 8260B	75	75	75	25			
2-Butanone	78-93-3	SW-846 8260B	--	--	--	--			
2-Hexanone	591-78-6	SW-846 8260B	--	--	--	--			
4-Methyl-2-pentanone	108-10-1	SW-846 8260B	--	--	--	--			
Acetone	67-64-1	SW-846 8260B	--	--	--	--			
Benzene	71-43-2	SW-846 8260B	5	5	5	1.7			
Bromodichloromethane	75-27-4	SW-846 8260B	80	--	80	26.7			
Bromoform	75-25-2	SW-846 8260B	80	--	80	26.7			
Bromomethane	74-83-9	SW-846 8260B	--	--	--	--			
Carbon disulfide	75-15-0	SW-846 8260B	--	--	--	--			
Carbon tetrachloride	56-23-5	SW-846 8260B	5	5	5	1.7			
Chlorobenzene	108-90-7	SW-846 8260B	100	100	100	33.3			
Chloroethane	75-00-3	SW-846 8260B	--	--	--	--			
Chloroform	67-66-3	SW-846 8260B	80	--	80	26.7			
Chloromethane	74-87-3	SW-846 8260B	--	--	--	--			
cis-1,2-Dichloroethene	156-59-2	SW-846 8260B	70	70	70	23.3			
cis-1,3-Dichloropropene	10061-01-5	SW-846 8260B	--	--	--	--			
Cyclohexane	110-82-7	SW-846 8260B	--	--	--	--			
Dibromochloromethane	124-48-1	SW-846 8260B	80		80	26.7			
Dichlorodifluoromethane	75-71-8	SW-846 8260B	--	--	--	--			
Ethylbenzene	100-41-4	SW-846 8260B	700	700	700	233.3			
Isopropylbenzene	98-82-8	SW-846 8260B	--	--	--	--			

**TABLE A-1
GROUNDWATER REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND**

Chemical	CAS Number	Method	MCL ⁽¹⁾ (ug/L)	RIDEM GA Aquifer ⁽²⁾ (ug/L)	Project Action Level ⁽³⁾ (ug/L)	LOQ Goal ⁽⁴⁾ (ug/L)	Laboratory Limits		
							LOQ (ug/L)	LOD (ug/L)	DL (ug/L)
Methyl acetate	79-20-9	SW-846 8260B	--	--	--	--			
Methylcyclohexane	108-87-2	SW-846 8260B	--	--	--	--			
Methylene chloride	75-09-2	SW-846 8260B	5	5	5	1.7			
Methyl-tert-butyl ether	1634-04-4	SW-846 8260B	--	40	40	13.3			
Styrene	100-42-5	SW-846 8260B	100	100	100	33.3			
Tetrachloroethene	127-18-4	SW-846 8260B	5	5	5	1.7			
Toluene	108-88-3	SW-846 8260B	1000	1000	1000	333.3			
trans-1,2-Dichloroethene	156-60-5	SW-846 8260B	100	100	100	33.3			
trans-1,3-Dichloropropene	10061-02-6	SW-846 8260B	--	--	--	--			
Trichloroethene	79-01-6	SW-846 8260B	5	5	5	1.7			
Trichlorofluoromethane	75-69-4	SW-846 8260B	--	--	--	--			
Vinyl chloride	75-01-4	SW-846 8260B	2	2	2	0.7			
Xylenes (total)	1330-20-7	SW-846 8260B	10000	10000	10000	3333			
Polycyclic Aromatic Hydrocarbons									
2-Methylnaphthalene	91-57-6	SW846 8270C SIM	--	--	--	--			
Acenaphthene	83-32-9	SW846 8270C SIM	--	--	--	--			
Acenaphthylene	208-96-8	SW846 8270C SIM	--	--	--	--			
Anthracene	120-12-7	SW846 8270C SIM	--	--	--	--			
Benzo(a)anthracene	56-55-3	SW846 8270C SIM	--	--	--	--			
Benzo(a)pyrene	50-32-8	SW846 8270C SIM	0.2	0.2	0.2	0.1			
Benzo(b)fluoranthene	205-99-2	SW846 8270C SIM	--	--	--	--			
Benzo(g,h,i)perylene	191-24-2	SW846 8270C SIM	--	--	--	--			
Benzo(k)fluoranthene	207-08-9	SW846 8270C SIM	--	--	--	--			
Chrysene	218-01-9	SW846 8270C SIM	--	--	--	--			
Dibenzo(a,h)anthracene	53-70-3	SW846 8270C SIM	--	--	--	--			
Fluoranthene	206-44-0	SW846 8270C SIM	--	--	--	--			
Fluorene	86-73-7	SW846 8270C SIM	--	--	--	--			
Indeno(1,2,3-cd)pyrene	193-39-5	SW846 8270C SIM	--	--	--	--			
Naphthalene	91-20-3	SW846 8270C SIM		100	100	33.3			
Phenanthrene	85-01-8	SW846 8270C SIM	--	--	--	--			
Pyrene	129-00-0	SW846 8270C SIM	--	--	--	--			
Metals									
Aluminum	7429-90-5	SW846 6010B	--	--	--	--			
Antimony	7440-36-0	SW846 6010B or 6020 ⁽⁵⁾	6	6	6	2			
Arsenic	7440-38-2	SW846 6010B or 6020 ⁽⁵⁾	10	10	10	3.3			
Barium	7440-39-3	SW846 6010B or 6020 ⁽⁵⁾	2000	2000	2000	666.7			

**TABLE A-1
GROUNDWATER REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND**

Chemical	CAS Number	Method	MCL ⁽¹⁾ (ug/L)	RIDEM GA Aquifer ⁽²⁾ (ug/L)	Project Action Level ⁽³⁾ (ug/L)	LOQ Goal ⁽⁴⁾ (ug/L)	Laboratory Limits		
							LOQ (ug/L)	LOD (ug/L)	DL (ug/L)
Beryllium	7440-41-7	SW846 6010B or 6020 ⁽⁵⁾	4	4	4	1.3			
Cadmium	7440-43-9	SW846 6010B or 6020 ⁽⁵⁾	5	5	5	1.7			
Calcium	7440-70-2	SW846 6010B	--	--	--	--			
Chromium	7440-47-3	SW846 6010B or 6020 ⁽⁵⁾	100	100	100	33.3			
Cobalt	7440-48-4	SW846 6010B	--	--	--	--			
Copper	7440-50-8	SW846 6010B or 6020 ⁽⁵⁾	1300	1300	1300	433.3			
Iron	7439-89-6	SW846 6010B	--	--	--	--			
Lead	7439-92-1	SW846 6010B or 6020 ⁽⁵⁾	15	15	15	5			
Magnesium	7439-95-4	SW846 6010B	--	--	--	--			
Manganese	7439-96-5	SW846 6010B	--	--	--	--			
Mercury	7439-97-6	SW846 7470	--	2	2	0.7			
Nickel	7440-02-0	SW846 6010B or 6020 ⁽⁵⁾	--	100	100	33.3			
Potassium	7440-09-7	SW846 6010B	--	--	--	--			
Selenium	7782-49-2	SW846 6010B or 6020 ⁽⁵⁾	50	50	50	16.7			
Silver	7440-22-4	SW846 6010B	--	--	--	--			
Sodium	7440-23-5	SW846 6010B	--	--	--	--			
Thallium	7440-28-0	SW846 6010B or 6020 ⁽⁵⁾	2	2	2	0.7			
Vanadium	7440-62-2	SW846 6010B	--	--	--	--			
Zinc	7440-66-6	SW846 6010B	--	--	--	--			

Notes:

1. Source: U.S. EPA (May, 2009)
2. RIDEM Groundwater Quality Standards for GA aquifers. Source: RIDEM March, 2005)
3. The project action level is the lower of the MCL or the RIDEM Groundwater Quality Standards for GA aquifers.
4. Laboratory to enter its LOQs, LODs, and DLs for the methods requested.
5. **Laboratory to identify metals for which method 6020 will be used in order to meet the PAL. If the laboratory typically analyzes groundwater samples at dilution when using method 6020, the LOQs, LODs, and DLs must be presented adjusted for the dilution factor, and the dilution factor identified.**

Abbreviations:

- ug/L = micrograms per liter
- DRO = Diesel-range organics
- GRO = Gasoline-range organics
- MCL = U.S. EPA Maximum Contaminant Levels for drinking water
- PAL = Project Action Limit
- RIDEM = Rhode Island Department of Environmental Management
- = Not Available

**TABLE A-1
GROUNDWATER REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND**

Chemical	CAS Number	Method	MCL ⁽¹⁾ (ug/L)	RIDEM GA Aquifer ⁽²⁾ (ug/L)	Project Action Level ⁽³⁾ (ug/L)	LOQ Goal ⁽⁴⁾ (ug/L)	Laboratory Limits		
							LOQ (ug/L)	LOD (ug/L)	DL (ug/L)

Method References:

SW846 -Test Methods for Evaluating Solid Wastes. EPA Office of Solid Waste. Third Edition, including all promulgated revisions.

TABLE A-2
SOIL REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Analyte	CAS Number	Method	Project Action Limit (PAL) ⁽¹⁾ (mg/Kg)	PAL Reference	LOQ Goal (mg/Kg)	Laboratory Limits ⁽²⁾		
						LOQ (mg/Kg)	LOD (mg/Kg)	DL (mg/Kg)
Volatile Organic Compounds								
1,1,1-Trichloroethane	71-55-6	SW846 8260B	540	RIDEM DEC Res	180			
1,1,2,2-Tetrachloroethane	79-34-5	SW846 8260B	0.56	RSL	0.2			
1,1,2-Trichloroethane	79-00-5	SW846 8260B	1.1	RSL	0.37			
1,1-Dichloroethane	75-34-3	SW846 8260B	3.3	RSL	1.1			
1,1-Dichloroethene	75-35-4	SW846 8260B	0.2	RIDEM DEC Res	0.067			
1,2,4-Trichlorobenzene	120-82-1	SW846 8260B	4.9	RSL	1.63			
1,2-Dibromo-3-chloropropane	96-12-8	SW846 8260B	0.0054	RSL	0.002			
1,2-Dibromoethane (EDB)	106-93-4	SW846 8260B	0.034	RSL	0.01			
1,2-Dichlorobenzene	95-50-1	SW846 8260B	190	RSL	0.01			
1,2-Dichloroethane	107-06-2	SW846 8260B	0.9	RIDEM DEC Res	0.3			
1,2-Dichloropropane	78-87-5	SW846 8260B	0.89	RSL	0.3			
1,3-Dichlorobenzene	541-73-1	SW846 8260B	430	RIDEM DEC Res	143			
1,4-Dichlorobenzene	106-46-7	SW846 8260B	2.4	RSL	0.8			
2-Butanone	78-93-3	SW846 8260B	2800	RSL	933.3			
2-Hexanone	591-78-6	SW846 8260B	21	RSL	7			
4-Methyl-2-pentanone (MIBK)	108-10-1	SW846 8260B	530	RSL	177			
Acetone	67-64-1	SW846 8260B	6100	RSL	2033			
Benzene	71-43-2	SW846 8260B	1.1	RSL	0.4			
Bromodichloromethane	75-27-4	SW846 8260B	0.27	RSL	0.1			
Bromoform	75-25-2	SW846 8260B	61	RSL	20.3			
Bromomethane	74-83-9	SW846 8260B	0.73	RSL	0.2			
Carbon disulfide	75-15-0	SW846 8260B	82	RSL	27.3			
Carbon tetrachloride	56-23-5	SW846 8260B	0.61	RSL	0.2			
Chlorobenzene	108-90-7	SW846 8260B	29	RSL	9.7			
Chloroethane	75-00-3	SW846 8260B	1500	RSL	500			
Chloroform	67-66-3	SW846 8260B	0.29	RSL	0.097			
Chloromethane	74-87-3	SW846 8260B	12	RSL	4			
cis-1,2-Dichloroethene	156-59-2	SW846 8260B	78	RSL	26			
cis-1,3-Dichloropropene	10061-01-5	SW846 8260B	--	--	--			
Cyclohexane	110-82-7	SW846 8260B	700	RSL	233.3			
Dibromochloromethane	124-48-1	SW846 8260B	0.68	RSL	0.2			
Dichlorodifluoromethane	75-71-8	SW846 8260B	18	RSL	6			
Ethylbenzene	100-41-4	SW846 8260B	5.4	RSL	1.8			
Isopropylbenzene	98-82-8	SW846 8260B	27	RIDEM DEC Res	9			
Methyl acetate	79-20-9	SW846 8260B	7800	RSL	2600			
Methylcyclohexane	108-87-2	SW846 8260B	--	--	--			
Methylene chloride	75-09-2	SW846 8260B	11	RSL	3.67			

TABLE A-2
SOIL REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Analyte	CAS Number	Method	Project Action Limit (PAL) ⁽¹⁾ (mg/Kg)	PAL Reference	LOQ Goal (mg/Kg)	Laboratory Limits ⁽²⁾		
						LOQ (mg/Kg)	LOD (mg/Kg)	DL (mg/Kg)
Methyl-tert-butyl ether	1634-04-4	SW846 8260B	43	RSL	14.3			
Styrene	100-42-5	SW846 8260B	13	RIDEM DEC Res	4.33			
Tetrachloroethene	127-18-4	SW846 8260B	0.55	RSL	0.2			
Toluene	108-88-3	SW846 8260B	190	RIDEM DEC Res	63.3			
trans-1,2-Dichloroethene	156-60-5	SW846 8260B	15	RSL	5			
trans-1,3-Dichloropropene	10061-02-6	SW846 8260B	--	--	--			
Trichloroethene	79-01-6	SW846 8260B	2.8	RSL	0.93			
Trichlorofluoromethane	75-69-4	SW846 8260B	79	RSL	26.3			
Vinyl chloride	75-01-4	SW846 8260B	0.02	RIDEM DEC Res	0.007			
Xylenes (total)	1330-20-7	SW846 8260B	63	RSL	21			
Polycyclic Aromatic Hydrocarbons								
2-Methylnaphthalene	91-57-6	SW846 8270C SIM	31	RSL	10.3			
Acenaphthene	83-32-9	SW846 8270C SIM	340	RSL	113.3			
Acenaphthylene	208-96-8	SW846 8270C SIM	23	RIDEM DEC Res	7.67			
Anthracene	120-12-7	SW846 8270C SIM	1700	RSL	566.7			
Benzo(a)anthracene	56-55-3	SW846 8270C SIM	0.15	RSL	0.05			
Benzo(a)pyrene	50-32-8	SW846 8270C SIM	0.015	RSL	0.01			
Benzo(b)fluoranthene	205-99-2	SW846 8270C SIM	0.15	RSL	0.1			
Benzo(g,h,i)perylene	191-24-2	SW846 8270C SIM	0.8	RIDEM DEC Res	0.27			
Benzo(k)fluoranthene	207-08-9	SW846 8270C SIM	0.9	RIDEM DEC Res	0.33			
Chrysene	218-01-9	SW846 8270C SIM	0.4	RIDEM DEC Res	0.067			
Dibenzo(a,h)anthracene	53-70-3	SW846 8270C SIM	0.015	RSL	0.005			
Fluoranthene	206-44-0	SW846 8270C SIM	20	RIDEM DEC Res	6.67			
Fluorene	86-73-7	SW846 8270C SIM	28	RIDEM DEC Res	9.34			
Indeno(1,2,3-cd)pyrene	193-39-5	SW846 8270C SIM	0.15	RSL	0.05			
Naphthalene	91-20-3	SW846 8270C SIM	3.6	RSL	1.2			
Phenanthrene	85-01-8	SW846 8270C SIM	40	RIDEM DEC Res	13.3			
Pyrene	129-00-0	SW846 8270C SIM	13	RIDEM DEC Res	4.3			
Polychlorinated Biphenyls								
Aroclor-1016	12674-11-2	SW846 8082	0.39	RSL	0.1			
Aroclor-1221	11104-28-2	SW846 8082	0.14	RSL	0.05			
Aroclor-1232	11141-16-5	SW846 8082	0.14	RSL	0.05			
Aroclor-1242	53469-21-9	SW846 8082	0.22	RSL	0.1			
Aroclor-1248	12672-29-6	SW846 8082	0.22	RSL	0.1			
Aroclor-1254	11097-69-1	SW846 8082	0.22	RSL	0.1			
Aroclor-1260	11096-82-5	SW846 8082	0.22	RSL	0.1			
Petroleum Hydrocarbons								
GRO (C6-C10)		8015B	500	RIDEM TPH	166.7			

**TABLE A-2
SOIL REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND**

Analyte	CAS Number	Method	Project Action Limit (PAL) ⁽¹⁾ (mg/Kg)	PAL Reference	LOQ Goal (mg/Kg)	Laboratory Limits ⁽²⁾		
						LOQ (mg/Kg)	LOD (mg/Kg)	DL (mg/Kg)
DRO (C8-C40)		8015B	500	RIDEM TPH	166.7			
Metals								
Aluminum	7429-90-5	SW846 6010B or 6020 ⁽³⁾	7700	RSL	2567			
Antimony	7440-36-0	SW846 6010B or 6020 ⁽³⁾	3.1	RSL	1			
Arsenic	7440-38-2	SW846 6010B or 6020 ⁽³⁾	0.39	RSL	0.13			
Barium	7440-39-3	SW846 6010B or 6020 ⁽³⁾	1500	RSL	500			
Beryllium	7440-41-7	SW846 6010B or 6020 ⁽³⁾	0.4	RIDEM DEC Res	0.13			
Cadmium	7440-43-9	SW846 6010B or 6020 ⁽³⁾	7	RSL	2.33			
Calcium	7440-70-2	SW846 6010B	--	--	--			
Chromium	7440-47-3	SW846 6010B or 6020 ⁽³⁾	0.29	RSL	0.1			
Cobalt	7440-48-4	SW846 6010B or 6020 ⁽³⁾	2.3	RSL	0.8			
Copper	7440-50-8	SW846 6010B or 6020 ⁽³⁾	310	RSL	103.3			
Iron	7439-89-6	SW846 6010B or 6020 ⁽³⁾	5500	RSL	1833.3			
Lead	7439-92-1	SW846 6010B or 6020 ⁽³⁾	40	RSL	13.3			
Magnesium	7439-95-4	SW846 6010B	--	--	--			
Manganese	7439-96-5	SW846 6010B or 6020 ⁽³⁾	180	RSL	60			
Mercury	7439-97-6	SW846 7471	5.6	RSL	1.87			
Nickel	7440-02-0	SW846 6010B or 6020 ⁽³⁾	150	RSL	50			
Potassium	7440-09-7	SW846 6010B	--	--	--			
Selenium	7782-49-2	SW846 6010B or 6020 ⁽³⁾	39	RSL	13			
Silver	7440-22-4	SW846 6010B or 6020 ⁽³⁾	39	RSL	13			
Sodium	7440-23-5	SW846 6010B	--	--	--			
Thallium	7440-28-0	SW846 6010B or 6020 ⁽³⁾	5.5	RIDEM DEC Res	1.83			
Vanadium	7440-62-2	SW846 6010B or 6020 ⁽³⁾	0.55	RSL	0.18			
Zinc	7440-66-6	SW846 6010B or 6020 ⁽³⁾	2300	RSL	766.67			

Notes:

1. The project action limit (PAL) for all analytes except GRO and DRO is the lower of U.S. EPA Regional Screening Level (RSL) for Residential Soil (EPA, 2010), or the RIDEM Residential Direct Exposure Criteria (DEC) (RIDEM, 2004). For GRO and DRO, the PAL is the RIDEM Residential TPH DEC (RIDEM, 2004).
2. Laboratory to enter its LOQs, LODs, and DLs for the methods requested.
3. **Laboratory to identify metals for which method 6020 will be used in order to meet the PAL. If the laboratory typically analyzes soil samples at dilution when using method 6020, the LOQs, LODs, and DLs must be presented adjusted for the dilution factor, and the dilution factor identified.**

Abbreviations:

mg/Kg = milligrams per kilogram (dry weight)

DEC = Direct Exposure Criteria

DRO = Diesel-range organics

EPA = Environmental Protection Agency

GRO = Gasoline-range organics

**TABLE A-2
SOIL REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND**

Analyte	CAS Number	Method	Project Action Limit (PAL) ⁽¹⁾ (mg/Kg)	PAL Reference	LOQ Goal (mg/Kg)	Laboratory Limits ⁽²⁾		
						LOQ (mg/Kg)	LOD (mg/Kg)	DL (mg/Kg)

MCL = U.S. EPA Maximum Contaminant Levels for drinking water

PAL = Project Action Limit

Res = Residential

RIDEM = Rhode Island Department of Environmental Management

TPH = Total Petroleum Hydrocarbons

-- = Not Available

Method References:

SW846 - Test Methods for Evaluating Solid Wastes. EPA Office of Solid Waste. Third Edition, including all promulgated revisions.

ATTACHMENT NO. 2

STATEMENT OF WORK/PRICE TABLES

TECHNICAL SPECIFICATION FOR LABORATORY SERVICES ON-SHORE DERECKTOR SHIPYARD NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT N62470-08-D-1001, CONTRACT TASK ORDER (CTO) NO. WE20

STUDY AREA SCREENING EVALUATION CHEMICAL SOIL GAS ANALYSIS

1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) under CLEAN Contract **N62470-08-D-1001** is procuring laboratory analytical services to support a study area screening evaluation at Naval Station Newport (NAVSTA), On-Shore Derecktor Shipyard. The requested analysis is volatile organic compounds (VOCs) in soil gas samples.

The laboratory performing this analysis must provide a copy of its Department of Defense (DOD) Environmental Laboratory Accreditation Program (ELAP) accreditation letter; the scope of the ELAP accreditation must include the method and all analytes requested.

The responding laboratory must submit method detection limits (MDLs), Limits of Detection (LODs), and Limits of Quantitation (LOQs) for all target analytes requested by filling out the last three columns of the tables in Attachment A and including the completed attachment with the bid response. After award, the laboratory will be asked to complete Uniform Federal Policy (UFP) Sampling and Analysis Plan (SAP) Worksheets 19, 24, 25, and 28 for inclusion in the work plan. The laboratory may be required to submit Standard Operating Procedures (SOPs) and relevant precision and accuracy limits for the analytical method required under this statement of work.

2.0 SAMPLE INFORMATION

The sampling is scheduled for late January/early February, 2011. The exact date of sample collection will be communicated to the laboratory at least 2 weeks in advance.

The approximate number of samples to be submitted, the type of analyses to be conducted, and the analytical methods to be used are summarized in Table 1 of this statement of work (SOW). Grab soil gas samples will be collected.

Field duplicate samples will be submitted with "blinded" identification to the laboratory. The field crew will designate samples (one per twenty samples) for laboratory duplicate analysis.

The samples are expected to be of low or moderate volatile organic contaminant concentration. The field crew will attempt to identify any potentially high concentration samples.

3.0 ANALYSIS/REPORTING INFORMATION

One hard copy data package deliverable and two PDF CD copies must be submitted, in addition to the electronic data deliverables to be provided in the format described in Attachment C. The analytical requirements and approximate number of samples to be submitted for analysis are detailed in Table 1.

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**TECHNICAL SPECIFICATION FOR LABORATORY SERVICES
CONTRACT N62470-08-D-1001, CTO WE20
ON-SHORE DERECKTOR SHIPYARD, NAVSTA NEWPORT, NEWPORT, RI
STUDY AREA SCREENING EVALUATION, CHEMICAL SOIL GAS ANALYSIS
PAGE 2**

Analysis and reporting requirements addressed in the DOD Quality Systems Manual (April 2009) and the requested method must be followed. Additionally, it is a requirement of TtNUS that the data package and associated PDF file for the VOC air analysis must meet Contract Laboratory Program (CLP) Statement of Work SAV01 format, reporting, and PDF data package deliverable requirements. See <http://www.epa.gov/superfund/programs/clp/sav1.htm>.

Additionally, the data package must contain a summary data package. This summary data package shall consist of only the summary forms (i.e., CLP Forms 1 through 7). Attachment B details the required summary forms for CLP-like data packages and requirements for organization/bookmarking of the hard copy and PDF data packages.

Attachment A details the required target VOC list and Project Action Limits (PALs) that must be met. The laboratory must submit its DLs, LODs, and LOQs for soil gas for all target analytes for the requested method by filling out the last three columns of the table in Attachment A and including the completed attachment with the bid response. If the PAL for a target compound is not technically achievable, or if no PAL is listed for a target compound in Attachment A, the laboratory should propose the lowest LOQ technically possible for the requested method.

Non-detected VOC results must be reported down to the laboratory LODs. Positive results above the DL but below the laboratory's LOQ must be reported as estimated values qualified with a "J".

The hard copy/PDF data package deliverable must contain a detailed case narrative for the VOC analysis. This case narrative must also include the Contract Task Order (CTO) number, the site name, and the TtNUS Project Manager's name. Data from all analytical runs (i.e., original, dilution, re-analysis) must be reported.

As part of the laboratory case narrative, it is required that the Laboratory Quality Assurance Manager sign an attestation statement verifying that all electronic diskette deliverables exactly match the data summary forms (i.e. Form Is).

Maximum holding time allowances, as defined in the following table, are to be strictly observed. Calculation of holding time is in calendar days and is to begin from the time of collection. The holding time is as follows:

Analysis	Holding Time
VOC	Summa Canister: 30 days from sample collection

This holding time is based on data validation criteria and method specific requirements, and is measured from date of collection to analysis. The holding time criterion depicted applies to all analyses necessary to successfully determine the contaminant level contained in the sample. Hence, the holding time criterion applies to any/all subsequent sample dilutions and re-analyses.

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The TtNUS Project Manager for this project is Mr. Thomas Campbell, and he must be contacted in the event of any laboratory problems that could impact project deadlines (i.e., late deliverables, technical problems in the lab that could lead to late deliverables).

Contact information for Mr. Campbell is as follows:

Tetra Tech NUS, Inc.
55 Jonspin Road
Wilmington, MA 01887
Phone: 978-474-8404
Fax: 978-474-8499
e-mail: thomas.campbell@tetrattech.com

Analytical data turnaround times are to be measured from receipt of each sample shipment. The hard copy/PDF (2 CDs) analytical data packages and associated electronic (TXT) deliverables are due within 21 calendar days from receipt of the last sample in a Sample Delivery Group (SDG).

The SDG must contain all the soil gas samples for this project. The hard copy/PDF data package and electronic deliverables must be received at the same time or the deliverable will be considered incomplete and payment deductions may be imposed.

The hardcopy analytical data package, 1 PDF (CD) copy of the analytical data package, and the original chain-of-custody form (received with the samples and signed by the laboratory sample custodian) should be sent to Ms. Lucy Guzman. The contact information for Ms. Guzman is the same as noted above for Mr. Race except that her direct phone number is (978) 474-8416 and her email address is lucy.guzman@tetrattech.com.

The electronic (TXT) deliverables, 1 PDF (CD) copy of the analytical data package, and a copy of the chain-of-custody form, should be sent to Ms. Tobrena Skeen. The contact information for Ms. Skeen is as follows:

Tetra Tech NUS, Inc.
661 Andersen Drive, Foster Plaza 7
Pittsburgh, PA 15220-2745
Phone: 412-921-8582
Fax: 412-921-4040
e-mail: tobrena.skeen@tetrattech.com

4.0 PERIOD OF PERFORMANCE/BOTTLEWARE INFORMATION

Summa canisters should be delivered to TtNUS (attention T. Campbell). Summa canister shipments will be coordinated by the field operation leader.

The laboratory must supply 1 L Summa canisters (100%-certified clean), T-splitters, gauges, fittings/ferrules, and other necessary equipment associated with the Summa canisters for collection of grab samples. The Summa canisters must have a valve that can fit on ¼ inch OD tubing. The laboratory is also requested to provide sample labels, and chain-of-custody forms.

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5.0 ADDITIONAL COMMENTS/CONTACTS

The internal transfers of samples within the laboratory must be accomplished and documented as controlled custody transfers. The laboratory must submit documentation that supports an unbroken chain of custody for samples from time of sample receipt at the laboratory until disposal.

The laboratory is to provide a minimum of 10 business days storage of leftover samples in Summa canisters. **Additionally, the laboratory must store PDF data packages for 5 years.**

All analyses conducted under this subcontract assignment are to be performed at the solicited facility only. The laboratory is not permitted to lower-tier subcontract these analyses, or analyze these samples at a corporate facility other than the facility stipulated without prior notification and consent from the CLEAN Subcontracting Officer.

The unit cost for analysis is to include compensation for canister rentals and associated equipment, shipping costs, storage, disposal, and laboratory quality control analyses (such as method blank, laboratory duplicate, and laboratory control sample analyses.) These items are not to be billed as separate line items.

Technical, quality assurance and data format concerns are to be directed to Ms. Lucy Guzman at (978) 474-8416 or via e-mail at: lucy.guzman@tetrattech.com. Ms. Guzman must be contacted and informed of any difficulties encountered during the conduct of the requested analyses.

Contract concerns, and response to this solicitation, are to be directed to:

Ms. Meg Price
CLEAN Subcontracting Officer
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, PA 19406
Phone: 610-491-9688
Fax: 610-491-9646
e-mail: meg.price@tetrattech.com

Triplicate copies of invoices associated with the analyses contracted herein are to be submitted to the attention of the Accounting Supervisor:

Tetra Tech NUS, Inc.
661 Andersen Drive, Foster Plaza 7
Pittsburgh, PA 15220
Phone: 412-921-8506
Fax: 412-921-4040

Please confirm the laboratory's ability to perform the methodologies requested at the analyte detection limits indicated. Also confirm available laboratory capacity, and complete/confirm the costing information

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indicated in Table 1. **All costing information must reflect the terms and conditions established by the 2010 CLEAN Basic Ordering Agreement (BOA).**

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TABLE 1
 NUMBER OF SAMPLES/ANALYTICAL METHODS
 CTO WE20, ON-SHORE DERECKTOR SHIPYARD
 NAVSTA NEWPORT, NEWPORT, RI
 STUDY AREA SCREENING EVALUATION, CHEMICAL SOIL GAS ANALYSIS

Matrix	Parameter ⁽¹⁾	Method	# Samples	Unit Price	Total Cost
Soil Gas	VOCs (lab to provide Summa canisters, T-splitters, and other associated equipment ⁽²⁾)	EPA Method TO-15 ⁽³⁾	5	\$	\$
20 extra fittings/ferrules				\$	\$

TOTAL COST \$

(1) The required target analytes are listed in Attachment A.

(2) **The laboratory must supply 1 L Summa canisters (100%-certified clean), T-splitters, gauges, fittings/ferrules, particulate filters, and brass caps. The unit price must include the cost of canister rental, all equipment (except for extra fittings/ferrules requested above), shipping, and any other associated fees. The Summa canisters must have a valve that can fit on ¼-inch OD tubing. Grab samples will be collected.**

(3) Laboratory may propose SIM or method modifications to achieve LOQs or LODs below the Project Action Limits listed in Attachment A.

The laboratory must point out if they are not DOD ELAP accredited for all the target analytes requested. Clearly state the analytes that you are NOT accredited for (if any).

Name of Laboratory _____

Signature _____

ATTACHMENT A
Required Target Analyte List and Project Action Limits
(See Accompanying Excel File)

ATTACHMENT B
Summary Form Requirements for PDF Deliverable and PDF Data Package Deliverables

PDF DATA PACKAGE DELIVERABLE REQUIREMENTS

The laboratory is to provide 2 compact disks (CDs) containing a PDF file in the following format:

1. Table of Contents
2. Case Narrative
3. Chain-of-Custody
4. Data Summary Package (contains summary of all CLP or CLP like Forms 1 through 8 per analytical fraction)
5. Analytical Fractions (VOA, SVOC, General Chemistry, etc.)
 - a. QC Summary (summary of all CLP or CLP like Forms 1 through 8 for a particular analytical fraction)
 - b. Raw Sample Data (includes all sample dilutions, sample re-analyses, QC samples, etc.)
 - c. Calibration Data (includes all initial and continuing calibrations and initial calibration verifications)
 - d. Miscellaneous (includes extraction forms, IDLs, MDLs, etc.)

Each of the above sections should be bookmarked in the PDF for easy access.

In addition to the following forms, second-source initial calibration verification summary forms are required, if applicable per the method or the DOD QSM. Also, the compounds associated with internal standards must be identified.

Summary Forms for method TO-15 should be presented in a CLP-Like format based on CLP SOW SAV01. The following Summary Forms must be included:

Result Summary	Present all information contained in CLP Form I. One Sample per summary page. Presentation of analytical results for both method blanks and environmental samples, date of collection, preparation, and analysis. Environmental samples should be identified with the field identification numbers on the COCs.
LCS recovery and Precision Form	Present all information contained on CLP Form II.
Method Blank Summary	Present all information contained on CLP Form III.
Instrument Performance Check Bromofluorobenzene Form	Present all information Contained on CLP Form IV .
Initial Calibration Summary	Present all information contained CLP Form V .
Continuing Calibration Summary	Present All Information contained on CLP Form VI .
Internal Standard Area and Retention Time Summary	Present all information contained CLP Form VII .

ATTACHMENT C
ELECTRONIC DATA DELIVERABLE REQUIREMENTS

ELECTRONIC DATA FORMAT REQUIREMENTS

1.0 INTRODUCTION

The laboratory is to submit text-based tab delimited EDD files for each SDG using Tetra Tech's laboratory data checker explained below. The files must be in the format specified in this Attachment. Additional information such as laboratory name, project name, fractions included, project number, site name/number, laboratory contact person and any specific comments related to the EDD should be included in the comments section of the EDD Submittal page.

The RESULT for nondetects should be populated with the project-specific sample quantitation reporting limits (i.e., either the sample quantitation limit or method detection limit, as specified in Section 3.0 of this scope of work. Any corrections made to the hardcopy data must also be made to the electronic file. Appropriate qualifiers as identified by the analytical protocol must also be designated; laboratory QC non-compliance codes are not to be depicted.

Tetra Tech's electronic EDD format follows the ADAPT structure and requires the A1 and A3 files. The A2 file is only required if the project is using ADAPT; and, for non-ADAPT EDD submittals the A2 file may be omitted. The EDD consists of separate, tab-delimited ASCII text files. Each file corresponds to a database table. The tables are identified as the Analytical Results Table (A1) and Sample Analysis Table (A3). A separate set of text files must be created and submitted for each sample delivery group (SDG). The files must be identified to correspond to the (A1) table and the (A3) table. The file naming convention is: the Sample Delivery Group (SDG) followed by the table identifier (A1 or A3), followed by the ".txt" extension. The file names must not contain spaces or special characters. For example, the EDD file names for a laboratory-reporting batch identified as SDG001 would be as follows:

SDG001A1.txt
SDG001A3.txt

On certain projects Tetra Tech will utilize the ADAPT Electronic Data Validation software, which will require the laboratory to use the ADAPT electronic data deliverable checker software prior to submitting the files through Tetra Tech's laboratory data checker (this will be clearly specified in the Tetra Tech laboratory statement of work). The ADAPT checker software can be downloaded from Laboratory Data Consultants' web site: <http://www.lab-data.com>. For projects which Tetra Tech is using the ADAPT software, Tetra Tech will provide the laboratory with the project library. The laboratory is not permitted to modify the project library. ADAPT projects will require the laboratory to export all three checked files (A1, A2, and A3) from the ADAPT software and submit them through Tetra Tech's laboratory data checker. **ADAPT error logs generated must be included with the electronic PDF data validation package and cannot be submitted through the laboratory data checker.**

The values reported in the EDD text files must agree exactly with the final values reported on the PDF data package sample result summaries. The details of file naming conventions, data structure and data checker use are discussed below.

Analytical Results Table (A1 File)

The Analytical Results table contains analytical results and related information for target analytes in field samples and associated laboratory quality control samples (excluding calibrations and tunes). Field samples and laboratory method blanks must report a result record for each analyte reported within a method. Laboratory control samples (LCS and LCSD) and matrix spike samples (MS and MSD) must report a result record for every analyte specified as a spiked analyte in the laboratory statement of work. Table A1 in this document lists the field names and data type descriptions for the Analytical Results Table (A1).

Lab Instrument Table (A2 File)

A2 file is only required if the project is using ADAPT. In all other EDD submittals, the A2 file may be omitted. Laboratories should refer to the ADAPT User Guide for populating the A2 Table.

Sample Analysis Table (A3 File)

The Sample Analysis table contains information specific to field environmental samples and laboratory quality control analyses (excluding calibrations and tunes). A sample record must exist for each sample/method/matrix/analysis type combination. Table A3 in this document lists the field names and data type descriptions for the Sample Analysis Table (A3).

All electronic data deliverables are due within the same time established for the associated hardcopy data packages.

In addition, the laboratory QC officer must read and sign a copy of the Quality Assurance Review Form displayed on the next page of this Attachment. Electronic deliverables are not considered to be complete without the accompanying Quality Assurance Review Form.

I _____, as the designated Quality Assurance Officer, hereby attest that all electronic deliverables have been thoroughly reviewed and are in agreement with the associated hardcopy data. The enclosed electronic files have been reviewed for accuracy (including significant figures), completeness and format. The laboratory will be responsible for any labor time necessary to correct enclosed electronic deliverables that have been found to be in error. I can be reached at _____ if there are any questions or problems with the enclosed electronic deliverables.

Signature: _____ Title: _____ Date: _____

2.0 EDD Field Properties

Tables A1 and A3 in this document specify the EDD field properties. Laboratories should refer to the ADAPT User Guide for populating the A2 Table. These include the field name, sequence order, field description, data type/length and reporting requirement for each field. Fields in the EDD **must** be sequenced according to the order that they appear below in Tables A1 and A3. For example, in the Analytical Results table (A1), the field “ClientSampleID” will always be the first piece of information to start every new line of data (or database record), followed by the field “LabAnalysisRefMethodID”, “AnalysisType”, etc.

When creating an EDD as a text file, use the ASCII character set in a file of lines terminated by a carriage return and line feed. No extra characters are allowed at the end of a line, after the carriage return and line feed. Enclose each data value with double quotes (text qualifier) and separate each field value with a tab character (tab delimiter). Data fields with no information (null) may be represented by two consecutive tabs. For example, in the Sample Analysis table, since the “Collected”, “ShippingBatchID”, and “Temperature” fields do not apply to laboratory generated QA/QC samples, the record for a Laboratory Control Sample by Method 8270C would be entered as follows. Note that the first two fields (“ProjectNumber” and “ProjectName”) are omitted in this example.

...“LCSW100598” ”AQ” ”LCSW100598” ”LCS” ”8270C”,...etc.

If a field is populated with less than the maximum allowed number of characters, do not pad the values with leading or trailing spaces. In the above example, although the “MatrixID” field can accommodate up to 10 characters, only 2 characters were entered in this field. **Do not include the delimiter (tab character) within any of the field values.** Example EDD files may be downloaded from the LEDD Checker application.

An example database shall be sent for review prior to the first electronic deliverable in the required .txt format. The example file will be examined for completeness and comments will be sent to the laboratory. Any questions regarding the electronic deliverable should be directed to LabSupport@tetrattech.com

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ClientSampleID	Client or contractor’s identifier for a field sample If a sample is analyzed as a laboratory duplicate, matrix spike, or matrix spike duplicate, append suffixes DUP, MS and	Text	25	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>MSD respectively to the Client Sample ID with no intervening spaces or hyphens (i.e. MW01DUP, MW01MS, and MW01MSD). For Method Blanks, LCS, and LCSD enter the unique LaboratorySampleID into this field.</p> <p>Do not append suffixes to the ClientSampleID for dilutions, reanalyses, or re-extracts (the AnalysisType field is used for this distinction). For example, MW01<u>DL</u> and MW01<u>RE</u> are not allowed.</p> <p>Parent sample records must exist for each MS and MSD. If an MS/MSD is shared between two EDDs, records for the MS/MSD and its parent sample must exist in the Analytical Results table for both EDDs.</p>			
LabAnalysisRefMethodID	Laboratory reference method ID. The method ID may be an EPA Method number or a Lab Identifier for a method such as a SOP Number, however; method ID is specified by the project. The method ID must be entered into the standard list.	Text	25	X
AnalysisType	Defines the analysis type (i.e., Dilution, Reanalysis, etc.). This field provides distinction for sample result records when multiple analyses are submitted for the same sample, method, and matrix; for example dilutions, re-analyses, and re-extracts.	Text	10	X
LabSampleID	Laboratory tracking number for field samples and lab generated QC samples such as method blank, LCS, and LCSD. There are no restrictions for the LabSampleID except for field length and that the LabSampleID must be distinct for a given field sample or	Text	25	X

Table A1**Field Descriptions for the Analytical Results Table (Table A1)**

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	lab QC sample and method. Suffixes may be applied to the LabSampleID to designate dilutions, reanalysis, etc.			
LabID	Identification of the laboratory performing the analyses.	Text	7	X
ClientAnalyteID	CAS Number or unique client identifier for an analyte or isotope. If a CAS Number is not available, use a unique identifier provided by the client or contractor. The ClientAnalyteID for a particular target analyte or isotope should be specified by the project and must exist in the standard value tables for Analytes. For the LCS, LCSD, MS, and MSD, it is only necessary to report the compounds designated as spikes in the library (and surrogates for organic methods.) For TICs from GC/MS analyses, enter the retention time in decimal minutes as the Client Analyte ID.	Text	12	X
AnalyteName	Chemical name for the analyte or isotope. The project specifies how an analyte or isotope is named. The analyte name must be associated to a ClientAnalyteID in the standard values table for Analytes (excluding compounds designated as TIC's).	Text	60	X
Result	Result value for the analyte or isotope.	Numeric ⁽¹⁾	20(6)	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	Entries must be numeric. For non-detects of target analytes or isotopes and spikes, do not enter "ND" or "0". Do not leave this field blank. If an analyte or spike was not detected, enter the associated value specified in Section 3.0 of this scope of work (e.g., LOD, SQL, PQL, etc.), corrected for dilution and percent moisture as applicable. Do not enter "0". A "0" result may be acceptable for surrogate or internal standard percent recoveries; however, it should not be reported for any target compound.			
ResultUnits	The units defining how the values in the Result, DetectionLimit, and ReportingLimit fields are expressed. For radiochemistry this also includes how the value in the Error field is expressed.	Text	10	X
LabQualifiers	A string of single letter result qualifiers assigned by the lab based on client-defined rules and values. <u>The "U" Lab Qualifier must be entered for all non-detects.</u> Other pertinent lab qualifiers may be entered with the "U" qualifier. Order is insignificant. Lab qualifiers other than those listed in the standard values table may be used. If so, these must be added to the standard value table in the application.	Text	7	Q
DetectionLimit	For radiochemistry methods, the minimum detectable activity for the isotope being measured. For all other methods: The minimum detection limit value for the analyte being measured.	Numeric ⁽¹⁾	10(6)	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	For surrogates, internal standards, etc. where detection limits are not applicable use the value -99.			
DetectionLimitType	Specifies the type of detection limit (i.e., MDA, MDL, IDL, etc.). If -99 is specified in the DetectionLimit field us the value NA.	Text	10	X
RetentionTime or Error	<u>For radiochemistry methods only</u> , enter the 2 Sigma Counting Errors. The units for error are entered in the ResultUnits field. <u>For GC/MS methods only</u> , enter the time expressed in decimal minutes between injection and detection for <u>GC/MS TICs only</u> <u>For target analytes in all other methods</u> , leave this field blank. Note: GC retention times are not evaluated at this time.	Text	5	T
AnalyteType	Defines the type of result, such as tracer, surrogate, spike, or target compound.	Text	7	X
PercentRecovery	For radiochemistry methods: The tracer yield, if applicable. For all other analytical methods: The percent recovery value of a spiked compound or surrogate. If the spike or surrogate was not recovered because of dilution, enter "DIL". If a spike or surrogate was not recovered because of matrix interference, enter "INT". If a spike or surrogate was not recovered because it was not added to the sample, enter "NS".	Numeric ⁽¹⁾	5(3)	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
RelativePercentDifference	The relative percent difference (RPD) of two QC results, such as MS/MSD, LCS/LCSD, and Laboratory Duplicates. Report RPD in Laboratory Duplicate, LCSD, and MSD records only.	Numeric ⁽¹⁾	5(3)	X
ReportingLimit	Reporting limit value for the measured analyte or isotope Factor in the dilution factor and percent moisture correction, if applicable. The Reporting Limit for each analyte and matrix in a given method is specified in the project library or QAPP. For surrogates, internal standards, etc. where reporting limits are not applicable use the value -99.	Numeric ⁽¹⁾	10(6)	X
ReportingLimitType	Specifies the type of reporting limit (i.e., CRQL, PQL, SQL, RDL, etc). The Reporting Limit Type for each method and matrix is specified in the project library or QAPP. If -99 is specified in the ReportingLimit field use the value NA.	Text	10	X
ReportableResult	This field indicates whether or not the laboratory chooses an individual analyte or isotope result as reportable. Enter "YES" if the result is reportable. Enter "NO" if the result is not reportable. If only one analysis is submitted for a particular sample and method, enter "YES" for all target compounds (where Analyte Type = TRG). For GC/MS methods enter yes for tentatively identified compounds	Text	3	X

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>(where Analyte Type = TIC).</p> <p>If two or more analyses are submitted for a particular sample and method (i.e. initial analysis, reanalysis and/or dilutions), enter "YES" from only <u>one</u> of the analyses for each target compound. For example: a sample was run a second time at dilution because benzene exceeded the calibration range in the initial, undiluted analysis. All target analytes are reported in each analysis. For the initial analysis, (Analysis Type = RES), enter "NO" for benzene and enter "YES" for all other compounds. For the diluted analysis (Analysis Type = DL), enter "YES" for benzene and enter "NO" for all other compounds.</p> <p>For TICs (Analyte Type = TIC), if more than one analysis is submitted for a particular sample and method, choose only one of the analyses where Reportable Result = YES for <u>all</u> TICs. For example, a sample was run a second time because one or more target compounds exceeded the calibration range in the undiluted analysis. Choose a particular analysis and enter "YES" for all TICs. In the other analysis enter "NO" for all TICs.</p> <p>Note that it is not necessary to report the full target analyte list for the initial result, dilution, re-analysis, or re-extraction. However, each target analyte must be reported YES once and once only in the case of multiple analyses for a given sample, method, and matrix. In the case of organics, all surrogates must be reported for all analyses submitted for a given sample, method, and,</p>			

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	matrix.			
SpkConcnAdded	<p>The spike added. This value must be reported in the same units as the result. Where (SA) in the following equation: $\% \text{ Recovery} = (\text{SSA} - \text{SC}) / \text{SA} \times 100\%$ where : SSA is the spiked sample concentration (amount) after spiking. SC is the sample concentration (amount) before spiking. SA is the the expected increase in sample concentration (amount) as a result of spiking. This value must incorporate all correction factors such as dilution factor and moisture content that are applied to the spiked sample when computing the spiked sample concentration or amount. Enter -99 where no spike was added.</p>	Numeric ⁽¹⁾	10(6)	X
SpkParentSampleID	<p>The sampleID of a sample (often called the original sample) that receives a spike aliquot to form a spiked sample such as a matrix spike. This is not the same as the ID of the spiked sample (such as a matrix spike) after spiking.</p> <p>The result for SpkParentSampleID and the result (i.e., SpkConcnAdded) for the spiked sample are used to compute percent recovery of the analyte.</p>	Text	25	X
SamplePrepInitial	The initial sample preparation volume in liters (L) for aqueous samples or grams (g) for solid samples.	Numeric ⁽¹⁾	20(6)	
SamplePrepFinal	The final sample preparation volume in liters (L) for aqueous samples or grams (g) for solid samples.	Numeric ⁽¹⁾	20(6)	

Table A1

Field Descriptions for the Analytical Results Table (Table A1)

Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
LimitOfDetection	The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a 99% confidence level. In other words, if a sample has a true concentration at the LOD, there is a minimum probability of 99% of reporting a "detection" (a measured value \geq DL) and a 1% chance of reporting a non-detect (a false negative).	Numeric ⁽¹⁾	10(6)	N
Comment	Add any comments or additional information specific to the analyte test result data record.	Text	200	

X Required field.

Q Only required if laboratory has qualified the result.

T Only required for tentatively identified compounds by GC/MS.

(1) Field Length indicates decimal precision in parenthesis. For example, 5(2) = a total width of 5 numbers including a maximum of 2 decimal places.

Table A3**Field Description for the Sample Analysis (Table A3)**

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ProjectNumber	Project number assigned by the client.	Text	30	X
ProjectName	Project name assigned by the client.	Text	90	X
ClientSampleID	<p>Client or contractor's identifier for a field sample</p> <p>If a sample is analyzed as a laboratory duplicate, matrix spike, or matrix spike duplicate, append suffixes DUP, MS and MSD respectively to the Client Sample ID with no intervening spaces or hyphens (i.e. MW01DUP, MW01MS, and MW01MSD). For Laboratory QC samples (i.e. Method Blanks, LCS, and LCSD, etc.) enter the unique LaboratorySampleID into this field</p> <p>Do not append suffixes to the ClientSampleID for dilutions, reanalyses, or re-extracts (the Analysis_Type field is used for this distinction). For example, MW01<u>DL</u> and MW01<u>RE</u> are not allowed</p> <p>Parent sample records must exist for each MS and MSD. If an MS/MSD is shared between two EDDs, records for the MS/MSD and its parent sample must exist in the Sample Analysis table for both EDDs.</p>	Text	25	X
Collected	<p>Date and Time of sample collection. Refer to the date/time format at the end of this table.</p> <p>Leave this field blank for Method Blank, LCS, and LCSD. For Collected values that are not applicable use the value of 00/00/0000 00:00.</p>	Date/Time	16*	X
MatrixID	Sample matrix (i.e., AQ, SO, etc.)	Text	10	X
LabSampleID	Laboratory tracking number for field samples	Text	25	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>and lab generated QC samples such as method blank, LCS, and LCSD.</p> <p>There are no restrictions for the LabSampleID except field length and that the LabSampleID must be unique for a given field sample or lab QC sample and method.</p>			
QCType	This record identifies the type of quality control sample QC (i.e., Duplicate, LCS, Method Blank, MS, or MSD). <u>For regular environmental samples, populate this field with "NM".</u>	Text	10	X
ShippingBatchID	Unique identifier assigned to a cooler or shipping container used to transport client or field samples. Links all samples to a cooler or shipping container. No value is required for method blanks, LCS, and LCSD.	Text	25	X
Temperature	<p>Temperature (in centigrade degrees) of the sample as received.</p> <p>The storage refrigerator or room temperature should be reported (in centigrade degrees) for laboratory QC samples (i.e. method blanks, laboratory control standards).</p> <p>Use -99 if temperature is not available.</p> <p><u>This field is not required for radiochemistry methods.</u></p>	Numeric ⁽¹⁾	10(6)	X
LabAnalysisRefMethodID	Laboratory reference method ID. The method ID may be an EPA Method number or laboratory identifier for a method such as a SOP number, however; values used for Laboratory Method IDs are specified by the	Text	25	X

Table A3**Field Description for the Sample Analysis (Table A3)**

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	project and must in the in standard value list for method IDs.			
PreparationType	Preparation Method Number (i.e., 3010A, 3510C, 3550C, 5030B, etc.) For analytical procedures that do not have a specific preparation method number, use "Gen Prep".	Text	25	X
AnalysisType	Defines the type of analysis such as initial analysis, dilution, re-analysis, etc. This field provides distinction for sample records when multiple analyses are submitted for the same sample, method, and matrix, for example: dilutions, re-analyses, and re-extracts.	Text	10	X
Prepared	Refer to the date/time format at the end of this table. If no sample preparation is involved enter the analysis date and time in this field. Refer to the date/time format at the end of this table.	Date/ Time	16*	X
Analyzed	Date and time of sample analysis. Refer to the date and time format at the end of this table. For Analyzed values that are not applicable use the value of 00/00/0000 00:00.	Date/ Time	16*	X
LabID	Identification of the laboratory performing the analysis.	Text	7	X
QCLevel	The level of laboratory QC associated with the analysis reported in the EDD. If only the Analytical Results Table (A1) and the Sample Analysis Table (A3) information are submitted for the sample, enter "COA". If the Laboratory Instrument Table (A2) information is also submitted for the sample, enter "COCAL"	Text	6	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ResultBasis	Indicates whether results associated with this sample records are reported as wet or percent moisture corrected. Enter "WET" if results are not corrected for percent moisture. Enter "DRY" if percent moisture correction is applied to results. For aqueous samples, enter "WET". For other matrices where basis is not applicable enter "NA"	Text	3	X
TotalOrDissolved	This field indicates if the results related to this sample record are reported as a total or dissolved fraction. If not applicable please report "NA"	Text	3	X
Dilution	Dilution of the sample aliquot. Enter "1" for method blanks, LCS, and LCSD, or if the field samples was analyzed without dilution.	Numeric ⁽¹⁾	10(6)	X
HandlingType	Indicates the type of leaching procedure, if applicable (i.e., SPLP, TCLP, WET). Enter "NA" if the sample analysis was <u>not</u> performed on a leachate.	Text	10	X
HandlingBatch	Unique laboratory identifier for a batch of samples prepared together in a leaching procedure (i.e., SPLP, TCLP, or WET preparation). The HandlingBatch links samples with leaching blanks. Enter "NA" if the sample analysis was <u>not</u> performed on a leachate.	Text	12	X
LeachateDate	Date and time of leaching procedure (i.e., date for SPLP, TCLP, or WET preparation). Refer to the date and time format at the end of this table.	Date /Time	16*	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	. For Analyzed values that are not applicable use the value of 00/00/0000 00:00			
Percent_Moisture	For soil and sediment samples, enter the percent of sample composed of water. For aqueous samples enter "100". For other matrices where Percent_Moisture is not applicable use a value of -99	Numeric ⁽¹⁾	10(6)	X
MethodBatch	<p>Unique laboratory identifier for a batch of samples of similar matrices analyzed by one method and treated as a group for matrix spike, matrix spike duplicate, or laboratory duplicate association</p> <p>The method batch links the matrix spike and/or matrix spike duplicate or laboratory duplicates to associated samples. Note the MethodBatch association may coincide with the PreparationBatch association. The MethodBatch is specifically used to link the MS/MSD and/or DUP to associated samples.</p>	Text	12	X
PreparationBatch	<p>Unique laboratory identifier for a batch of samples prepared together for analysis by one method and treated as a group for method blank, LCS and LCSD association.</p> <p>The PreparationBatch links method blanks and laboratory control samples (blank spikes) to associated samples. Note, the PreparationBatch association may coincide with the MethodBatch association but the PreparationBatch specifically links the Method Blank and LCS to associated samples.</p>	Text	12	X
RunBatch	<u>For all other methods</u> the RunBatch is the unique identifier for a batch of analyses performed on one instrument under the control	Text	12	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	<p>of one initial calibration and initial calibration verification. The RunBatch links both the initial calibration and initial calibration verification to subsequently analyzed and associated continuing calibrations, field samples, and QC analyses. For GC/MS methods, the RunBatch also links a BFB or DFTPP tune. A distinct RunBatch must used with every new initial calibration within a method</p> <p>The value entered in this field links a particular sample/method/analysis type record to a set of associated initial calibration and initial calibration verification records from Table A2.</p> <p>If Table A2 is not submitted enter a value of 'NA" in this field.</p>			
AnalysisBatch	<p><u>For radiochemistry methods</u> leave this field blank.</p> <p><u>For all other methods</u> the AnalysisBatch is the unique identifier for a batch of analyses performed on one instrument and under the control of a continuing calibration or continuing calibration verification. The AnalysisBatch links the continuing calibration or calibration verification to subsequently analyzed and associated field sample and QC analyses. For GC/MS methods, the AnalysisBatch also links the BFB or DFTPP tune. A distinct AnalysisBatch must be used with every new continuing calibration or continuing calibration verification within a method</p> <p>The value entered in this field links a particular sample/method/analysis type record to a set of</p>	Text	12	X

Table A3

Field Description for the Sample Analysis (Table A3)

This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	associated continuing calibration records in the Laboratory Instrument table.			
LabReportingBatch	Unique laboratory identifier for the EDD. This is equivalent to the sample delivery group, lab work number, login ID, etc. The LabReportingBatch links all records in the EDD reported as one group. The value entered in this field must be the same in all records.	Text	12	X
LabReceipt	Date and time the sample was received in the lab. A time value of 00:00 may be entered. Refer to the date/time format at the end of this table.	Date/Time	16*	X
LabReported	Date and time hard copy reported delivered by the lab. A time value of 00:00 may be entered. Refer to the date/time format at the end of this table.	Date/Time	16*	X
Comment	Add any comments or additional information specific to the sample analysis data record.	Text	200	

C Only required for regular samples, duplicates and MS/MSDs.

X Required field.

(1) Field Length indicates decimal precision in parenthesis. For example, 5(2) = a total width of 5 numbers including a maximum of 2 decimal places.

* Format Date and Time as MM/DD/YYYY hh:mm; where MM = two digit month, DD = two digit day, and YYYY = four digit year, hh = hour in 24 hour format, and mm = minutes.

3.0 Laboratory Data Checker

The Laboratory Data Checker is a web-based application that will review Laboratory Electronic Data Deliverables (LEDDs) for adherence to Tetra Tech's EDD format requirements. EDDs will be reviewed for elements such as missing data and/or columns of

data, and compliance of the data within each column to the required data types/lengths. Once an EDD passes through the checker with no errors, it must be submitted to Tetra Tech through the LEDD Checker application.

Access to the LEDD Checker application will be provided by an initial registration/approval process. An Information Systems Group (ISG) Administrator will approve requests for access. To access the site or begin the registration process, visit the ISG web site at <http://isg.ttnus.com> and select the “Laboratory Checker” link on the left of the home page. Registered users may access the checker immediately by logging in to the system using their credentials. New users must select the “Register” button and provide all of the requested information.

After completing all fields on the registration form, select the “Submit” button to complete the request process. Upon verification by an ISG Administrator, an email notification will be sent verifying the user ID, password and account status. Forgotten passwords may be retrieved by using the “Forgot password?” link on the login page. Note that the email address that was provided for registration or password retrieval is the user ID and must be a valid e-mail address.

The general process for submitting EDD files through the LEDD Checker involves a 3-stage process that includes an upload stage, an error checking stage and a submittal stage.

Log into the LEDD Checker by typing your login credentials and select the “Login” button. The LEDD Checker home page provides a general overview of the checker functionality and EDD file format requirements. At the bottom of the home page, example EDDs are provided that may be viewed or downloaded. To download the files, right click on the link and select “Save target as” from the menu. Each LEDD Checker page includes a navigation bar with links to return to the home page or continue the checking and submittal process. Users should **NOT** use the back or forward buttons on the browser, instead use the links provided in the application to navigate through the site.

Detailed information regarding EDD preparation, formatting requirements and text file naming conventions are provided in the Electronic Data Format Requirements Section of the Laboratory SOW.

Begin the upload stage by selecting the “Upload/Check Files” link on the home page. Follow the steps on the upload page starting with the selection of the laboratory name that corresponds to your organization. If your organization is not listed, contact LabSupport@tetrattech.com, and provide a full description of your organization name, contact information and include “Laboratory Contractor ID Request” in the subject line. An ISG Administrator will respond to the request via e-mail.

Load the appropriate A1, A2, or A3 target EDD files by clicking the “Browse” button next to each data table input box. A file browser dialog will appear allowing files to be selected from a local or network drive. After the EDD files are loaded, click the “Upload” button to complete

the upload stage. Note that each table may be uploaded and checked separately; however, a minimum of the A1 and A3 files are required in order to submit the EDDs.

If the file upload was successful, the checking page will immediately load. Begin the checking stage by selecting the “Check Files” button. The LEDD Checker will begin validating the EDD files for compliance. Depending on file size and network activity the validation process may take several minutes. The progress should be displayed in the information bar at the bottom of the browser window. **Do not** select the “Check Files” button again or otherwise use the browser during this process. Other applications may be used; however, note that the LEDD Checker may not sit idle for more than 30 minutes. If the time is exceeded a new session must be started in a new browser window.

Any errors will be processed and returned on the error page. The following general errors may be returned.

- Column count / table structure errors – due to column header names being included, improper delimiter, extra tabs, extra or missing columns of data, spaces or other characters at the end of a row.
- Row and column value specific errors – may occur for one or more reasons including: data truncation, invalid date / time format, invalid decimal precision or field width exceedance, or if a value is not in a list of valid values or expected range.

If column count / table structure errors are encountered, the LEDD Checker will return an error and stop the checking process.

The EDDs will not be processed any further until the column errors are resolved. Text fields are validated for truncation. Date / Time fields are validated for truncation and format compliance. Numeric decimal fields are validated for truncation, character type compliance and decimal precision. All required fields are validated for null values or empty text strings (i.e. spaces). The LEDD Checker will return a list of all errors in and include a reference to the row number on which the error occurred. Note that consecutive EDD files may be loaded and checked, and submitted while logged in. However, no data may be submitted until all EDD files have passed through the LEDD Checker without errors. The list of errors may be printed by selecting the “Print this Page” button from the checker error page.

If the EDD files pass with no errors, the submittal page will immediately load. To complete the submittal stage, include the following information in the comment and additional information area of the form: laboratory name, laboratory contact person, project name, project number, site name/number, fractions included and any specific comments related to the EDD. Select the “Submit Files” button to continue the submittal process.

The submittal stage is not considered complete until a unique ticket key reference is returned in the browser window. The ticket key reference must be printed for record of submission and future reference. In addition, a copy of the ticket key reference must be included in the PDF data package.

Engineer's Estimate - 10/11/10

**CTO WE20 - On Shore Derecktor Shipyard, NAVSTA Newport
STUDY AREA SCREENING EVALUATION, CHEMICAL ANALYSES for Soil Gas**

Matrix	Parameter ⁽¹⁾	Method	# Samples	Unit Price = 75th %ile	Safety Margin ⁽⁵⁾	Total Cost
Soil Gas	VOCs (lab to provide Summa canisters, T- splitters, and other associated equipment ⁽²⁾)	EPA Method TO-15 SIM ⁽³⁾	5	250.39	1.2	1502.34
20 extra fittings/ferrules			20	5 ⁽⁴⁾	1	100

TOTAL

1602.34

(1) The required target analytes are listed in Attachment A. (2) Grab samples will be collected. The laboratory must supply 1 L Summa canisters (100%-certified clean), T-splitters, gauges, fittings/ferrules, particulate filters, and brass caps. The unit price must include the cost of canister rental, all equipment (except for extra fittings/ferrules requested above), shipping, any other associated fees, and all deliverables. The Summa canisters must have a valve that can fit on ¼-inch OD tubing.

(3) Method is listed in specification Table 1 as TO-15, but footnote said that laboratory may propose SIM or method modifications to achieve LOQs or LODs below the Project Action Limits listed in Attachment A. Therefore the unit price assumes SIM.

(4) Unit cost is \$2 for box of 100, but lab may charge more for only 20.

(5) Margin is added for associated equipment costs that may not be accounted for in unit price.

TABLE A
SOIL GAS REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical	CAS Number	Method ⁽¹⁾	Project Action Limit ⁽²⁾ (µg/m ³)	LOQ Goal (µg/m ³)	Laboratory Limits		
					LOQ (µg/m ³)	LOD (µg/m ³)	DL (µg/m ³)
Volatile Organic Compounds							
1,1,1-Trichloroethane	71-55-6	TO-15	5200	1733.3			
1,1,2,2-Tetrachloroethane	79-34-5	TO-15	0.042	0.014			
1,1,2-Trichloroethane	79-00-5	TO-15	0.15	0.05			
1,1-Dichloroethane	75-34-3	TO-15	1.5	0.5			
1,1-Dichloroethene	75-35-4	TO-15	210	70			
1,2,4-Trichlorobenzene	120-82-1	TO-15	2.1	0.7			
1,2,4-Trimethylbenzene	95-63-6	TO-15	7.3	2.43			
1,2-Dibromoethane (EDB)	106-93-4	TO-15	0.0041	0.0014			
1,2-Dichlorobenzene	95-50-1	TO-15	2100	700			
1,2-Dichloroethane*	107-06-2	TO-15	0.094	0.031			
1,2-Dichloropropane	78-87-5	TO-15	0.24	0.08			
1,3,5-Trimethylbenzene	108-67-8	TO-15	--	--			
1,3-Butadiene	106-99-0	TO-15	0.081	0.027			
1,3-Dichlorobenzene	541-73-1	TO-15	--	--			
1,4-Dichlorobenzene	106-46-7	TO-15	0.22	0.073			
2-Butanone (Methyl Ethyl Ketone)	78-93-3	TO-15	5200	1733.3			
2-Hexanone	591-78-6	TO-15	31	10.3			
4-Ethyl Toluene	622-96-8	TO-15	--	--			
4-Methyl-2-pentanone (Methyl Isobutyl)	108-10-1	TO-15	3100	1033.3			
Acrylonitrile	107-13-1	TO-15	0.036	0.012			
Allyl Chloride (3-chloropropene)	107-05-1	TO-15	0.41	0.14			
Benzene	71-43-2	TO-15	0.31	0.1			
Benzyl chloride	100-44-7	TO-15	0.05	0.017			
Bromodichloromethane	75-27-4	TO-15	0.066	0.022			
Bromoform	75-25-2	TO-15	2.2	0.73			
Bromomethane (Methyl Bromide)	74-83-9	TO-15	5.2	1.7			
Carbon Tetrachloride	56-23-5	TO-15	0.41	0.14			
Chlorobenzene	108-90-7	TO-15	52	17.3			
Chloroethane	75-00-3	TO-15	--	--			
Chloroform	67-66-3	TO-15	0.11	0.037			
Chloromethane (Methyl Chloride)	74-87-3	TO-15	94	31.3			
cis-1,2-Dichloroethene*	156-59-2	TO-15	--	--			
cis-1,3-Dichloropropene	10061-01-5	TO-15	0.61	0.2			
Cyclohexane	110-82-7	TO-15	6300	2100			

TABLE A
SOIL GAS REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical	CAS Number	Method ⁽¹⁾	Project Action Limit ⁽²⁾ (µg/m3)	LOQ Goal (µg/m3)	Laboratory Limits		
					LOQ (µg/m3)	LOD (µg/m3)	DL (µg/m3)
Dibromochloromethane	124-48-1	TO-15	0.09	0.03			
Dichlorodifluoromethane (F12)	75-71-8	TO-15	210	70			
Dichlorotetrafluoroethane	76-14-2	TO-15	--	--			
Ethylbenzene	100-41-4	TO-15	0.97	0.32			
Heptane	142-82-5	TO-15	--	--			
Hexachlorobutadiene	87-68-3	TO-15	--	--			
Hexane	110-54-3	TO-15	730	243.3			
m,p-Xylene	179601-23-1	TO-15	730	243.3			
Methylene Chloride	75-09-2	TO-15	5.2	1.7			
Methyl-tert-butyl ether	1634-04-4	TO-15	9.4	3.1			
o-Xylene	95-47-6	TO-15	730	243.3			
Styrene	100-42-5	TO-15	1000	333.3			
Tetrachloroethene	127-18-4	TO-15	0.41	0.14			
Tetrahydrofuran	109-99-9	TO-15	--	--			
Toluene	108-88-3	TO-15	5200	1733.3			
trans-1,2-Dichloroethene	156-60-5	TO-15	63	21			
trans-1,3-Dichloropropene	10061-02-6	TO-15	--	--			
Trichloroethene*	79-01-6	TO-15	1.2	0.4			
Trichlorofluoromethane	75-69-4	TO-15	730	243.3			
Trichlorotrifluoroethane	76-13-1	TO-15	--	--			
Vinyl Bromide	593-60-2	TO-15	0.076	0.025			
Vinyl Chloride	75-01-4	TO-15	0.16	0.05			

* Compound is a site contaminant.

-- = Not available

(1) Laboratory may propose analysis in SIM mode to achieve LOQs or LODs below the Project Action Limit.

(2) EPA Regions 3, 6, and 9 Regional Screening Levels for Chemical Contaminants at Superfund Sites, Residential Air values, May 2010, (EPA 2010)

TABLE A
SOIL GAS REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical	CAS Number	Method ⁽¹⁾	Project Action Limit ⁽²⁾ (µg/m3)	LOQ Goal (µg/m3)	Laboratory Limits		
					LOQ (µg/m3)	LOD (µg/m3)	DL (µg/m3)
Volatile Organic Compounds							
1,1,1-Trichloroethane	71-55-6	TO-15	2.20E+05	7.30E+04			
1,1,2,2-Tetrachloroethane	79-34-5	TO-15	4.2	1.4			
1,1,2-Trichloroethane	79-00-5	TO-15	15	5			
1,1-Dichloroethane	75-34-3	TO-15	5.00E+05	1.70E+05			
1,1-Dichloroethene	75-35-4	TO-15	2.00E+04	6.67E+03			
1,2,4-Trichlorobenzene	120-82-1	TO-15	2.00E+04	6.60E+03			
1,2,4-Trimethylbenzene	95-63-6	TO-15	600	200			
1,2-Dibromoethane (EDB)	106-93-4	TO-15	1.1	0.37			
1,2-Dichlorobenzene	95-50-1	TO-15	2.00E+04	6.60E+03			
1,2-Dichloroethane*	107-06-2	TO-15	9.4	3.1			
1,2-Dichloropropane	78-87-5	TO-15	400	133			
1,3,5-Trimethylbenzene	108-67-8	TO-15	600	200			
1,3-Butadiene	106-99-0	TO-15	0.87	0.29			
1,3-Dichlorobenzene	541-73-1	TO-15	1.10E+04	3666			
1,4-Dichlorobenzene	106-46-7	TO-15	8.00E+04	2.70E+04			
2-Butanone (Methyl Ethyl Ketone)	78-93-3	TO-15	1.00E+05	3.30E+04			
2-Hexanone	591-78-6	TO-15	--	--			
4-Ethyl Toluene	622-96-8	TO-15	--	--			
4-Methyl-2-pentanone (Methyl Isobutyl	108-10-1	TO-15	8000	2666			
Acrylonitrile	107-13-1	TO-15	3.6	1.2			
Allyl Chloride (3-chloropropene)	107-05-1	TO-15	--	--			
Benzene	71-43-2	TO-15	31	10.3			
Benzyl chloride	100-44-7	TO-15	5	1.7			
Bromodichloromethane	75-27-4	TO-15	14	4.7			
Bromoform	75-25-2	TO-15	220	73.3			
Bromomethane (Methyl Bromide)	74-83-9	TO-15	500	166.7			
Carbon Tetrachloride	56-23-5	TO-15	16	5.3			
Chlorobenzene	108-90-7	TO-15	6000	2000			
Chloroethane	75-00-3	TO-15	1.00E+06	3.30E+05			
Chloroform	67-66-3	TO-15	11	3.7			
Chloromethane (Methyl Chloride)	74-87-3	TO-15	240	80			
cis-1,2-Dichloroethene*	156-59-2	TO-15	3500	1166			
cis-1,3-Dichloropropene	10061-01-5	TO-15	61	20.3			
Cyclohexane	110-82-7	TO-15	--	--			
Dibromochloromethane	124-48-1	TO-15	--	--			
Dichlorodifluoromethane (F12)	75-71-8	TO-15	2.00E+04	6.60E+03			

TABLE A
SOIL GAS REQUIRED TARGET ANALYTES AND PROJECT ACTION LIMITS
ON SHORE DERECKTOR SHIPYARD
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical	CAS Number	Method ⁽¹⁾	Project Action Limit ⁽²⁾ (µg/m3)	LOQ Goal (µg/m3)	Laboratory Limits		
					LOQ (µg/m3)	LOD (µg/m3)	DL (µg/m3)
Dichlorotetrafluoroethane	76-14-2	TO-15	--	--			
Ethylbenzene	100-41-4	TO-15	220	73.3			
Heptane	142-82-5	TO-15	--	--			
Hexachlorobutadiene	87-68-3	TO-15	11	3.7			
Hexane	110-54-3	TO-15	2.00E+04	6.60E+03			
m,p-Xylene	179601-23-1	TO-15	7.00E+05	2.30E+05			
Methylene Chloride	75-09-2	TO-15	520	173			
Methyl-tert-butyl ether	1634-04-4	TO-15	3000	1000			
o-Xylene	95-47-6	TO-15	7.00E+05	2.30E+05			
Styrene	100-42-5	TO-15	1.00E+05	3.30E+04			
Tetrachloroethene	127-18-4	TO-15	81	27			
Tetrahydrofuran	109-99-9	TO-15	--	--			
Toluene	108-88-3	TO-15	4.00E+04	1.30E+04			
trans-1,2-Dichloroethene	156-60-5	TO-15	7000	2333			
trans-1,3-Dichloropropene	10061-02-6	TO-15	61	20.3			
Trichloroethene*	79-01-6	TO-15	2.2	0.73			
Trichlorofluoromethane	75-69-4	TO-15	7.00E+04	2.30E+04			
Trichlorotrifluoroethane	76-13-1	TO-15	--	--			
Vinyl Bromide	593-60-2	TO-15	--	--			
Vinyl Chloride	75-01-4	TO-15	28	9.3			

* Compound is a site contaminant.

-- = Not available

(1) Laboratory may propose analysis in SIM mode to achieve LOQs or LODs below the Project Action Limit.

(2) EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway for Groundwater and Soils, Target Deep Soil Gas Concentration, November 2002, (EPA 2002)

APPENDIX D

**SELECTED ANALYTICAL LABORATORY STANDARD OPERATING PROCEDURES B
FIELD DOCUMENTATION FORMS**

EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE

INORGANICS: SOP100 REVISION #: 22 EFFECTIVE DATE: 20101117

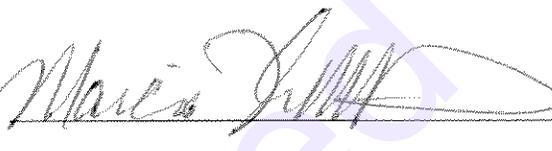
METALS DIGESTION/PREPARATION

References:

Methods 3005A/USEPA CLPILM0 4.1 Aqueous, 3010A, 3030C, 3050B
USEPA CLPILM0 4.1 (Soil/Sediment), 200.7, Standard Methods 3030C 21st
See Addendum for USEPA CLPILM 05.2 (Aqueous & Soil/Sediment)

APPROVALS:

Lab Director:  Date: 11/19/10

Data Quality Manager:  Date: 11/19/10

Section Supervisor:  Date: 11/19/10

Changes Summary

Revision 22, 11/17/10

- The SOP is an update from Revision 21 dated 9/1/10
- Revised to add the need for matrix spike duplicates to be digested and analyzed for TCLP extracts.
- Requirement to hold samples 24 hours after in-house preservation was added to section III.

Revision 21, 9/1/10

- The SOP is an update from Revision 20 dated 04/27/10
- The SOP has been found to be up-to-date with Standard Methods 21st edition.
- Reference to adjusting filtrate volume for method 3030C has been removed.
- References to bound logbooks have been replaced with LIMS references.

Revision 20, 4/27/10

- The SOP is an update from Revision 19 dated 04/20/09.
- References to oil sample preparation have been removed.
- Extraction volumes for TCLP have been updated.

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METALS DIGESTION/PREPARATION

References:

**Methods 3005A/USEPA CLPILM0 4.1 Aqueous, 3010A, 3030C, 3050B
USEPA CLPILM0 4.1 (Soil/Sediment), 200.7, Standard Methods 3030C
See Addendum for USEPA CLPILM 05.2 (Aqueous & Soil/Sediment)**

I. SCOPE AND APPLICATION

A. AQUEOUS

1. Method 3005A and USEPA CLP ILM0 4.1, "Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by ICP Spectroscopy".
 - a. This method is used to prepare surface water, ground water, drinking water and wastewater samples for analysis by inductively coupled argon plasma spectroscopy (ICP).
2. Method 200.7, "Determination of Metals and Trace Metals in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry".
 - a. This method is used to prepare surface water, ground water, drinking water and wastewater samples for analysis by inductively coupled argon plasma spectroscopy (ICP).
3. Method 3010A, "Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy".
 - a. This method is used to prepare aqueous samples, EP and mobility-procedure extracts, and wastes that contain suspended solids for analysis by ICP. The procedure is used to determine total metals.
4. Method 3030C (Standard methods), "Preliminary Treatment for Acid-Extractable Metals".
 - a. This method is used to prepare ground water samples from North Carolina for analysis by ICP.

B. SOLIDS

1. Method 3050B, "Acid Digestion of Sediments, Sludges and Soils".
 - a. This method is used to prepare sediments, sludges and soil samples for analysis by ICP. Since certain matrices may result in poor recovery, the method of standard additions may be used when analyzed.
 - b. It should be noted that some metals could be biased high with the soil digestion when dilution is necessary. Take necessary measures to ensure that dilutions are made as accurately as possible.
2. USEPA CLP ILM0 4.1, "Acid Digestion of Soil/Sediment".
 - a. This method is used to prepare sediments and soil samples for analysis by ICP. Since certain matrices may result in poor recovery, the method of standard additions may be used when analyzed.

D. NOTES:

1. "Total Metals" includes all metals, inorganically and organically bound and both dissolved and particulate.
2. "Dissolved metals" includes all metals present in a sample after filtration through a 0.45 micron filter followed by digestion.

II. SUMMARY OF METHODS

A. A representative sample of water or soil is put into an acid medium and exposed to heat for a certain amount of time. This allows for reduction of interferences by organic matter and converts metals bound to particulates to form the free metal that can be determined by ICP-Atomic Emission Spectrometry.

NOTE: When a reporting limit is required for a project lower than is customary, a four times concentration or alternate soil digestion ratio must be used in order to reach that lower level. Care must be taken to matrix match this concentrated aliquot. A blank and laboratory control sample (at a reduced concentration) are required with this concentration. A matrix spike (not at reduced concentration) and duplicate or matrix spike and matrix spike duplicate is needed per 20 samples or per batch.

III. SAMPLE HANDLING AND PRESERVATION

A. AQUEOUS

1. Samples are taken in high density polyethylene, one liter bottles. Samples should be preserved with concentrated HNO₃ to a pH <2 immediately upon sampling. If dissolved metals are to be analyzed the sample should be filtered before the HNO₃ is added. The samples should be maintained at 4°C until analysis. The holding time for metals samples is 180 days or approximately 6 months. Note – samples received unpreserved and preserved in-house must be held 24 hours prior to preparation.

B. SOLIDS

1. Samples are taken in high density polyethylene (CLP only) or glass bottles. The samples should be maintained at 4°C until analysis. The holding time for metals samples is 180 days or approximately 6 months.

IV. INTERFERENCES

A. AQUEOUS

1. Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks.

B. SOLIDS

1. Sludge samples can contain diverse matrix types, each of which may present its own analytical challenge. Spiked samples and any relevant standard reference material should be processed to aid in determining whether this method is applicable to a given waste.

V. SAFETY

A. Normal accepted laboratory safety practices should be followed while performing this analysis.

B. Be certain the exhaust hood is functioning before you begin the digestion procedure.

C. Hot acids can be extremely corrosive. Avoid inhalation or contact with skin.

VI. EQUIPMENT/APPARATUS

A. Fume hood, Labconco or equivalent.

B. Hot plate, Thermolyne cimarec-3 or equivalent source for use at 95°C. The temperature of the hot plate must be monitored via the use of a temperature blank.

- C. Thermometer capable of reading 80 to 120 degrees C – ERTCO cat# 611-3-SC or equivalent.
 - D. Vacuum pump for filtering dissolved metals- Gast or equivalent.
 - E. Analytical balance capable of weighing to 0.01 gram. Mettler model BB300 or equivalent.
 - F. Beckman CS-6R centrifuge.
 - G. Various class A volumetric glassware and ribbed watchglasses, Pyrex or equivalent.
 - H. Whatman No. 41 filter paper or equivalent.
 - I. Whatman No. 42 filter paper or equivalent.
 - J. Whatman 0.45 micron filter paper or equivalent.
 - K. 250 mL beaker or other appropriate vessel such as polypropylene block digester tubes, watch glasses and caps.
 - L. Stirring device, e.g. magnetic stirrer, glass rod or equivalent.
 - M. Manual Sample Mill
 - N. Wiley Sample Mill
 - O. Clippers for cutting vegetation
- NOTE:** All glassware should be acid washed.

VII. REAGENTS AND STANDARD PREPARATION

A. REAGENTS

1. Metals grade Nitric acid (HNO₃). Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.
2. Metals grade Hydrochloric acid (HCl). Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.
3. 30% hydrogen peroxide reagent, ACS Grade. Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.
4. Metals grade Sulfuric acid (H₂SO₄). Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.
5. Reagent water (Deionized water).
6. Potassium Permanganate - Ultra pure grade. Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.
7. Ammonium hydroxide, concentrated, reagent grade. Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.
8. Ammonium phosphate, reagent grade- Reagent should be analyzed to determine level of impurities. If method blank is <MDL, then the reagent can be used.

B. STANDARDS

1. Traceability

- a. A LIMS record shall be maintained on all reference materials. The record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique number in the LIMS as well as on the container's label.
- b. All working standards made from reference materials shall be labeled with a unique ID number with complete information on preparation date, concentration of each compound, solvent, preparer's name, expiration date and the information is recorded in LIMS. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded in LIMS. Measurements made during standards preparation (e.g., from weighing operations, volume diluted to, etc.) shall also be recorded. There should be no container with

sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.

c. The analyst must initial and date each entry made in LIMS.

2. PREPARATION

A. Laboratory control sample

1. Aqueous

- a. This solution is prepared as follows: 50 mL concentrated HCl, 20 mL concentrated HNO₃, 1 mL of CLP-CAL-1, Solution A, 1 mL of CLP-CAL-1 Solution B, 0.25 mL of CLP-CAL-2, and 0.25 mL of CLP-CAL-3 diluted to 1 L in a volumetric flask. Use 50 mL (100 mL for strict CLPILM0 4.1) for digestion. This solution is given a unique identifier and recorded in sample LIMS.
- b. For four times concentrated samples: The solution is prepared as follows: 50 mL concentrated HCl, 20 mL concentrated HNO₃, 1mL CLPP-SPK-4 (Inorganic Ventures) (This solution contains 10 mg/L Selenium, 100 mg/L Antimony, 50 mg/L Cadmium and Thallium, 40 mg/L Arsenic and 20 mg/L Lead) to 1 L in a volumetric flask. This solution is given a unique identifier. Use 12.5 mLs to 50 mLs and prepare two aliquots. Heat at 90 to 95°C to reduce the volume in each vessel to ten mLs and then combine each 10 mL aliquot into one vessel and take to a final volume of 25 mLs. Take care to matrix match acids so that the final 25 mL portion will contain 2% HNO₃ and 5% HCl. Use 0.125 mLs HNO₃ and 0.3125 mLs HCl to each 50 mL vessel.

2. Solids:

- a. 1.0 ±0.02 (or 2.0 ±0.02) gram aliquot of teflon chips is weighed and spiked using the same spiking solution used for matrix spikes. This sample is given a unique identifier according to the Lot# for the teflon chips used and when digested is given the descriptor. i.e. BS1 and then BS2 etc. plus the unique identifier number assigned. Alternatively a solid matrix standard reference material is obtained from the manufacturer. This sample is given a unique identifier and the weight is recorded in a bound logbook and transferred to LIMS.

B. Spiking solution

1. Sample is spiked using 0.1 mL of CLP-CAL-1, Solution A, 0.1 mL of CLP-CAL-1 Solution B, 0.025 mL of CLP-CAL-2 and 0.025 mL of CLP-CAL-3 for a final volume of 100 mL. If only 50 mL is used, decrease amount used appropriately. These solutions are given unique identifiers. Record the amount spiked and the unique identifier of the standard.
2. CLP sample is spiked using 0.1 mL CLPP-SPK-1 and 0.1 mL CLPP-SPK-4 for a final volume of 100 mL. If only 50 mL is used, decrease amount used appropriately. These solutions are given unique identifiers.
3. For samples that require four times concentration, the sample is spiked using 0.0125 mLs of CLPP-SPK-4 to each of two vessels with 50 mLs of sample in each. The volume of each of the vessels is lowered to less than 10 mLs and combined and the final volume of this concentrated sample is 25mLs.

VIII. CALIBRATION

- A. The temperature of the samples must be maintained at 95°C and monitored via a temperature blank. Record in temperature logbook for later transfer into LIMS.

IX. PROCEDURE

- A. Glassware preparation for digestion or when the hot-block can not be used:
 1. Wash glassware with hot soapy water and rinse thoroughly. (Beakers must be washed as soon as possible after being used, dirty beakers must not be allowed to sit overnight.)
 2. Rinse glassware with reagent water that contains 5% HNO₃ and 5% HCl followed by a rinse with reagent water.
 3. Prior to use, all glassware must be confirmed clean via a glassware check. Otherwise, repeat step "2" until the glassware check passes.
- B. Aqueous sample filtration (for dissolved metals):
 1. Thoroughly clean a flask and funnel with hot soapy water. Next, rinse the flask and funnel with 1:5 HNO₃ followed by a thorough D.I. water rinsing. This step is very important because the filters contain some metals (namely Zn) which could contaminate the samples.
 2. Rinse a 0.45 micron filter with 1:5 HNO₃ thoroughly, followed by D.I. water.
 3. Filter the unpreserved sample. If dissolved Hg analysis is requested for the sample, filter at least 200 mL.
 4. Discard the first 50 to 100 mL.
 5. A preparation blank must be taken through the filtration step and analyzed with the sample.
 6. Preserve the sample with HNO₃ to pH<2.
 7. Soluble samples that are clean and clear do not have to be digested. Use 100 mL sample, add 5 mL of concentrated HCl and 2 mL of concentrated HNO₃. **Samples must be digested unless approval for analysis without digestion is received from the project manager.**
- C. Aqueous sample preparation
 1. Method 3005A and USEPA CLP ILM0 4.1, "**Acid digestion procedure for total recoverable or dissolved metals for analysis by ICP**".
 - a. Shake sample thoroughly and pour 50 mL of the well-mixed sample into a digestion vessel. For samples which require concentration pour 50 mLs of the well-mixed sample into two digestion vessels.
 - b. Add 0.50 mL (1 mL of (1+1) when strict CLP ILM0 4.1 is required) concentrated HNO₃ to the sample. For samples which require concentration, add 0.125 mL (0.25 mL of (1+1) when strict CLP ILM0 4.1 is required) concentrated HNO₃ to the sample.
 - c. Add 2.5 mL (5 mL of 1+1) when strict CLP ILM0 4.1 is required) concentrated HCl to the sample. For samples which require concentration, add 0.3125 mL (0.625 mL of (1+1) when strict CLP ILM0 4.1 is required) concentrated HCl to the sample.
 - d. Cover the sample with a ribbed watch glass or equivalent source.
 - e. Transfer the digestion vessel to a pre-heated hot plate or hot block at 90 to 95°C. A temperature blank will assure correct temperature. The temperature must be

- recorded in the temperature logbook. Take the volume down to between 5 to 10 mL, (12 to 25 mLs when strict CLP ILM0 4.1 is required) **making certain that the sample does not boil. This is extremely important. Boiling may lead to vaporization of certain analytes.** Remove the sample from the hot plate and cool
- f. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.
 - g. Bring sample to its predigestion volume (or when samples require concentration, to a volume four times lower then what was started with) with DI water in the digestion vessel. The final volume must be recorded in the LIMS.
 - h. The sample is now ready for analysis.
 - i. The LIMS must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards plus identification #'s for standards used for spiking and the volume spiked into the sample.
2. Method 200.7, "**Acid digestion procedure for total recoverable metals**".
- a. Shake sample thoroughly and pour 50 mL of the well-mixed sample into the digestion vessel. If sample contains undissolved solids >1% refer to Section 11.3 of Method 200.7 for subsequent procedures.
 - b. Add 1.0 mL concentrated HNO₃ to the sample.
 - c. Add 2.50 mL concentrated HCl to the sample.
 - d. Cover the sample with a ribbed watch glass or equivalent source.
 - e. Transfer the digestion vessel to a pre-heated hot plate or equivalent source at 85°C. Take the volume down to between 10 to 15 mL, **making certain that the sample does not boil. This is extremely important. Boiling may lead to vaporization of certain analytes.**
 - f. Leave sample on hot plate and gently reflux for 30 minutes. Remove from hot plate and cool.
 - g. Bring sample to its predigestion volume with DI water in the digestion vessel.
 - h. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.
 - i. The sample is now ready for analysis.
 - j. The LIMS must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards.
3. Method 3010A, "**Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by ICP Spectroscopy**".
- a. Shake sample thoroughly and pour 50 mL (5ml diluted to 50mL for TCLP, full 50ml volume for SPLP) of the well-mixed sample into the digestion vessel.
 - b. Add 1.5 mL concentrated HNO₃ to the sample.
 - c. Cover the sample with a ribbed watch glass.
 - d. Transfer the digestion vessel to a pre-heated hot plate or hot block at 90 to 95°C. A temperature blank must be used, with the temperature being recorded in the temperature logbook. Take the volume down to a low volume (~5 mL), **making certain that the sample does not boil. This is extremely important. Boiling may lead to vaporization of certain analytes. Also make certain that no portion of**

the bottom of the digestion vessel is allowed to go dry. This may lead to low recoveries. Remove the sample from the hot plate and cool.

- e. Add another 1.5 mL portion of concentrated HNO₃ to the sample.
 - f. Cover the sample with a ribbed watch glass.
 - g. Transfer the vessel to the hotblock or equivalent source. Increase the temperature so a gentle reflux occurs. Continue heating, adding additional acid as necessary, until the digestion is complete (generally indicated when the digestate is light in color or does not change in appearance with continued refluxing).
 - h. Uncover the vessel and evaporate to a low volume (~3 mL) **making certain that no portion of the bottom of the digestion vessel is allowed to go dry.** Remove and cool.
 - i. Add 2.5 ml of 1:1 HCl (10 mL/100 mL of final solution).
 - j. Cover the digestion vessel and reflux for an additional 15 minutes.
 - k. Bring sample to its predigestion volume in digestion vessel.
 - l. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.
Note: When preparing DoD project samples, if any sample in a digestion batch requires filtration, all samples (including QC samples) must be treated in the same manner.
 - m. The sample is now ready for analysis.
 - n. The LIMS must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards.
- 4 Method 3030C (Standard Methods), "**Preliminary treatment for Acid-Extractable Metals**"
- a. Shake sample thoroughly and pour 50 mL of the well-mixed sample into a 50 mL digestion vessel.
 - b. Add 2.5 mL 1:1 HCl to the sample.
 - c. Heat 15 minutes in a hot bath.
 - d. Filter through a membrane filter.
 - e. Transfer to ICP analyst.

D. Solid sample preparation

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- *The material in the sample pan (inorganic-plastic/organic-aluminum) should be divided into quarters and each quarter should be mixed individually.*
- *Two quarters should then be mixed to form halves.*
- *The two halves should be mixed to form a homogenous matrix.*

This procedure should be repeated several times until the sample is adequately mixed.

NOTE: Samples that are clay type materials should be handled in a different manner. Due to these type sample matrices having an affinity to stick to most anything that touches it, another approach must be followed. Obtain a representative sub-sample aliquot from the center or middle section of the sample container.

Grinding of Vegetation Samples

Remove sample from shipping container and brush off dirt particles. Chop sample into about half inch pieces with clippers or other cutting tool. Place the sample in an aluminum pan and air-dry in an exhaust hood to the appropriate dryness for grinding. It should be dry enough where it won't stick to the inside of the mill. Grind the dried sample to fineness in either the manual sample mill or the Wiley mill or both if needed. Place the ground sample in a container and label immediately.

1. USEPA CLP ILM0 4.1, "**Acid digestion of Soil/Sediment**"
 - a. Mix the sample thoroughly to achieve homogeneity. For each digestion procedure, weigh (to the nearest 0.01 g) a 1.0 to 1.5 g portion of sample and transfer to a digestion vessel.
 - b. Add 10 mL of 1:1 nitric acid (HNO_3), mix the slurry, and cover with a watch glass or equivalent source. Heat the sample to 92 to 95°C and reflux for 10 minutes without boiling. Allow the sample to cool, add 5.0 mL of concentrated HNO_3 , replace with watch glass or equivalent source, as appropriate, and reflux for 30 minutes. Do not allow the volume to be reduced to less than 5 mL while maintaining a covering of solution over the bottom of the heating vessel.
 - c. After the second reflux step has been completed and the sample has cooled, add 2 mL of Type II water and 3.0 mL of 30% hydrogen peroxide (H_2O_2). Return the heating vessel to the hot plate or equivalent heating source for warming to start the peroxide reaction. Care must be taken to ensure that losses do not occur due to excessively vigorous effervescence. Heat until effervescence subsides, and cool the heating vessel.
 - d. Continue to add 30% H_2O_2 in 1 mL aliquots with warming until the effervescence is minimal or until the general sample appearance is unchanged. (NOTE: Do not add more than a total of 10 mL 30% H_2O_2 .)
 - e. If the sample is being prepared for ICP analysis of Al, As, Sb, Ba, Be, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, and Zn, add 5 mL of 1:1 HCl and 10 mL of Type II water, return the covered heating vessel to the hot plate or equivalent heating source, and heat for an additional 10 minutes. After cooling, filter through Whatman No. 42 filter paper (or equivalent) and dilute to 50 mL with Type II water. NOTE: In place of filtering, the sample (after dilution and mixing) may be centrifuged or allowed to settle by gravity overnight to remove insoluble material. Dilute the digestate to 144 mL with DI water, add 5 mLs concentrated HCl and 1 mL of concentrated HNO_3 , mix well and place into the appropriate container. The diluted sample has an approximate acid concentration of 2.5% (v/v) HCl and 5% (v/v) HNO_3 . The sample is now ready for analysis.
 - f. The LIMS must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards and ID of matrix spikes and the amounts used for spiking.
2. Method 3050B, "**Acid digestion of Sediments, Sludges and Soils**"

- a. Mix the sample thoroughly for 5 minutes using a plastic spatula or Teflon coated spatula in a glass or plastic weigh boat to achieve homogeneity.
- b. Weigh approximately (to the nearest 0.01 g) a 1 to 1.5 g portion of the sample directly into a digestion vessel. For samples with low percent solids a larger sample size may be used as long as digestion is completed. Record the exact mass in the LIMS.

NOTE: To achieve the lowest reporting limit possible, use a 2.0 g portion of sample with an ending volume of 100 mLs.

- c. Add 5 mL D.I. water and 5 mL concentrated $\text{HNO}_3(1:1)$, mix the slurry and cover with a watch glass. Place the sample in a preheated hot block and reflux at 95°C for 10 to 15 minutes being certain that the sample does not boil. Record temperature in temperature logbook
- d. Allow the sample to cool. Add 5 mL concentrated HNO_3 , replace the watch glass and heat/reflux again for 30 minutes. If brown fumes are generated, indicating oxidation of the sample by HNO_3 , repeat this step (addition of 5 mL of concentrated HNO_3) over and over until no brown fumes are given off by the sample indicating the complete reaction with HNO_3 . Using a watch glass or equivalent allow the solution to evaporate to approximately 5 mL without boiling at $95^\circ\text{C} \pm 5^\circ\text{C}$ for approximately two hours. Maintain a covering of solution over the bottom of the vessel at all times. Do not allow the volume to be reduced to less than 5 mL while maintaining a covering of solution over the bottom of the beaker. If the volume does get low, add 2.5 mL of D.I. water to bring volume back up.
- e. Take the sample off the hot block and allow it to cool. Next, add 2 mL of D.I. water and 3 mL of 30% Hydrogen Peroxide. (The sample will bubble upon the addition of H_2O_2 if it is still warm.) Cover the vessel with a watch glass and return the sample to the hot block or equivalent source and heat until the bubbling subsides. Care must be taken to ensure that losses do not occur due to excessively vigorous effervescence. Heat until effervescence subsides and cool the beaker. Add two more 3 mL portions of H_2O_2 to the sample in the same manner as before. (NOTE: Do not add more than a total of 10 mL 30% H_2O_2 .)
- f. Cover the sample with a ribbed watch glass and continue heating the acid-peroxide digestate at $95^\circ\text{C} \pm 5^\circ\text{C}$ without boiling for approximately two hours until the volume has been reduced to approximately 2.5 mL. Maintain covering of solution over the bottom of the vessel at all times.
- g. Add 2.5 mL of DI water and 2.5 mL of concentrated HCl and 10 mL of DI water, cover the sample with a ribbed watch glass and continue refluxing for an additional 10 minutes without boiling
- h. When necessary, filter or centrifuge the sample to remove insoluble material that could clog the nebulizer. The filtering apparatus must be thoroughly cleaned with dilute nitric acid prior to filtration.
- i. Bring sample up to 50 mL with D.I. water in the vessel. Add 150 ml of DI water to a 250 ml sample bottle. Invert the 50 ml sample digestion vessel several times to mix the sample and pour sample into the 150 ml of the sample bottle. Pour some sample back into the 50 ml sample digestion vessel to rinse and pour back into the 250 ml sample bottle and cap and mix.

NOTE1: When preparing DoD project samples, if any sample in a digestion batch requires filtration, all samples (including QC samples) must be treated in the same manner.

NOTE2: To achieve the lowest reporting limit possible use 2.0 grams of sample with an ending volume of 100 mLs.

- j. The sample is now ready for analysis.
- k. The LIMS must contain the date, analyst, sample number, client, sample mass/volume, final volume of digestate, lot # of acids used and the preparation and ID of standards.

X. CALCULATIONS

- A. The analyst must be supplied with both beginning sample masses/volumes and final digestate volumes. This information must be recorded in the digestion log.

XI. QUALITY CONTROL

- A. Digestion
 - 1. Temperature blank
 - a. The temperature of the hot plate/hot block must be monitored for temperature during the digestion process.
 - b. The thermometer must be tagged with annual calibration information. Record the thermometer reading, correction factor and the corrected temperature in the digestion log.
 - 2. Blanks
 - a. Digest a blank with every batch of samples digested (20 sample maximum). The blank is prepared by adding all the same reagents added to the samples to a clean dry beaker and taking it through the same process as the samples.
 - b. Also, there must be a blank for every different method of digestion that is set up that day, every 20 samples.
 - c. There must also be a blank for every different matrix of samples that is to be digested, every 20 samples.
 - d. Sample is given a unique identifier in the digestion log.
 - 3. Laboratory Control Samples
 - a. For water samples, one LCS is digested with every batch of samples digested (20 sample maximum).
 - b. For water samples, a LCS is digested every day for each type of digestion, every 20 samples.
 - c. For soil/sediment samples, a soil matrix standard reference material (SRM) must be digested per batch (20 samples maximum) or alternatively a spiked teflon chip sample.
 - d. Sample is given a unique identifier in the digestion log.
 - 4. Duplicates
 - a. A duplicate is prepared every 20 samples. This usually takes the form of a matrix spike duplicate.
NOTE: Certain projects require a sample duplicate and a matrix spike duplicate with each set of twenty samples.
 - 5. Blank Spike
 - a. This is required for certain projects.

B. Sample Matrix

NOTE: Field blanks/duplicates, trip blanks, or equipment blanks are not to be used for sample matrix QC samples.

1. Matrix spike

- a. Digest a spike and spike duplicate every 20 samples where sample volume is adequate to do so. Choose a sample (if possible) that has a lot of metals requested to be analyzed.

NOTE: For some projects, a sample duplicate and sample spike may be required instead of a spike and spike duplicate. Your supervisor should make you aware of these projects.

- b. The following metals do not get digested spikes when using CLP spike.

Calcium

Magnesium

Sodium

Potassium

- c. For TCLP samples, a spike **and a spike duplicate** must be digested for every matrix. You should inspect the sample (original sample prior to extraction) or check the log book to determine matrix type. (Also the matrix spike aliquots must be added to the extracts after filtration but before preservation.)

- d. **The CLH project requires that a high and a low spike be prepared and analyzed. Spikes should be prepared at 40 mg/Kg and 400 mg/Kg for soil samples and 200 ug/L and 2000 ug/L for aqueous samples.**

XII. CORRECTIVE ACTIONS

A. Sample boils during digestion.

1. Redigest another sample aliquot.

B. Sample goes dry or portion of beaker bottom is exposed due to excess evaporation during digestion.

1. Redigest another sample aliquot.
2. Glass beaker dry for an extended period of time? Discard beaker.

XIII. SPECIAL NOTES

A. **Never** take for granted how a sample should be digested. If the sample looks strange or unusual, or if you are not sure what metals the sample gets, what detection limits are required, whether the sample is total or dissolved, or even what method of digestion should be used, always ask your supervisor or the person who is to analyze the sample. How metals need to be digested changes too often to take it for granted.

B. **Antimony (Sb) soils** should be analyzed within 48 hours of digestion whenever possible. When a soil requesting Antimony analysis is received, you must coordinate with the person who will be analyzing it to be sure that they can analyze it on the same day that it is digested.

C. Labels for the digested sample must be written in a neat and legible manner. The labels must include such information as sample number, client name, the date digested, and the volume or mass digested.

D. There are several precautions that must be taken to minimize the possibility of contamination.

1. All metals glassware must be kept separate from all other laboratory glassware.

2. Metals glassware must be washed as soon as possible after being used. **Dirty metals beakers must not be left overnight.**
 3. Acid to be used for metals digestions must be kept separate from all other laboratory acid.
- E. Samples must be digested in a timely manner to ensure ICP analysis remains on schedule for data generation. Samples received on or before Wednesday of week X must be prepared for ICP digestion by the end of week X. Your supervisor must be consulted if this schedule can not be met at a particular time.
- F. Please consult Waste Disposal SOP-QS14, for information concerning disposal of waste generated from this area. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

Addendum for USEPA CLPILM 05.2 AQUEOUS & SOIL/SEDIMENT

The following is a list of changes for sample preparation when the 5.2 statement of work is required:

1. Soluble samples are required to be digested unless the chain of custody specifically states that digestion is not required. An MDL study must be done on the unprepared MDL solution in order to provide MDL levels for samples that are not digested. When digestion is not required an LCSW and post digestion spike are not required.
2. Digestates must be stored until 365 days after delivery of a complete, reconciled data package.
3. Preparation codes are used on form 13's. They are found in the 5.2 statement of work page B-39 3.4.12.2.4.

DEFINITIONS – Refer to SOP-QS08 for common environmental laboratory definitions.

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

METALS: SOP 103 REVISION #: 19 EFFECTIVE DATE: 20101117

**MERCURY ANALYSIS IN WATER
BY MANUAL COLD VAPOR TECHNIQUE
METHODS USEPA SW846 7470A and 245.1 CLP-M 4.1
(NJDEP DOES NOT ACCEPT CLPILM 04.1 AFTER JUNE, 2003),
ADDENDUM FOR USEPA CLP ILM 05.2**

APPROVALS:

Lab Director:  Date: 11/19/10

Data Quality Manager:  Date: 11/19/10

Section Supervisor:  Date: 11/19/10

Changes Summary

Revision 19, 11/17/10

- The SOP is an update from Revision 18 dated 04/11/10
- Revised to require a matrix spike duplicate for TCLP extracts.
- Requirement to hold samples 24 hours after in-house preservation was added to section 11.1.
- Quality systems SOP references updated.

Revision 18, 04/11/10

- The SOP is an update from Revision 17 dated 03/25/10
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DOD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.
- Tables have been updated to reflect the current limits/processes.

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1.0 Identification of the Test Method

This method is a cold-vapor atomic absorption procedure for determining the concentration of mercury, and is compliant with SW846 Method 7470A, USEPA Method 245.1, and USEPA SOW ILM04.1.

2.0 Applicable Matrix or Matrices

This method is a cold-vapor atomic absorption procedure for determining the concentration of mercury in mobility-procedure extracts, aqueous wastes, and ground waters. This method can also be used for sludge-type wastes. All samples must be subjected to an appropriate dissolution procedure prior to analysis.

3.0 Detection Limit

Method Detection Limit (MDL), Empirical Laboratories' Reporting Limit (ERL), Contract Required Quantitation Limit (CRQL) and Analyte Wavelength:

Limits Table

Aqueous Method Detection Limits(MDL)/Detection Limit(DL), Limit of Detection(LOD) Empirical Laboratories' Reporting Limits(ERL)/Limit of Quantitation(LOQ), CLP OLM04.1 & OLM05.2 Contract Required Quantitation Limits (CRQL)					
Mercury by EPA 245.1, 7470A, SOW 4.1 & 5.2	AQUEOUS MDL/DL (ug/L)	AQUEOUS LOD (ug/L)	AQUEOUS ERL/LOQ (ug/L)	AQUEOUS CRQL ILMO 4.1 (ug/L)	AQUEOUS CRQL ILMO 5.2 (ug/L)
Mercury	0.080	0.16	0.20	0.20	0.20

Wavelength Table

ANALYTE	WAVELENGTH
Mercury	253.7

4.0 Scope of Application, Including Components to Be Analyzed

- 4.1 Each parameter that is analyzed and reported under the scope of this SOP is listed in **Table 1** of this SOP. This table also lists the associated Reporting Limit (also defined as the LOD) and the lowest Calibration level for each analyte. When applicable, surrogate and Internal Standard Analytes are listed and indicated as such within this table.
- 4.2 This method is a cold-vapor atomic absorption procedure for determining the concentration of mercury in mobility-procedure extracts, aqueous wastes, and ground waters. This method can also be used for sludge-type wastes. All samples must be subjected to an appropriate dissolution procedure prior to analysis.

- 4.3 In addition to inorganic forms of mercury, organic materials may also be present. These organo-mercury compounds will not respond to the cold vapor atomic absorption technique unless they are first broken down and converted to mercuric ions. Potassium permanganate oxidizes many of these compounds, but recent studies have shown that a number of organic mercurials, including phenol mercuric acetate and methyl mercuric chloride, are only partially oxidized by this reagent. Potassium persulfate has been found to give approximately 100% recovery when used as the oxidant step following the addition of the permanganate has been included to insure that organo-mercury compounds, if present, will be oxidized to the mercuric ion before measurement. A heat step is required for methyl mercuric chloride when present in or spiked to a natural system. For distilled water the heat step is not necessary.
- 4.4 The range of the method may be varied through instrument and/or recorder expansion. Using a 30 mL sample, a detection limit of 0.2 µg Hg/L can be achieved.
- 4.3 Extreme care should be taken when working with pure standard and stock standard solutions of these compounds and all handling of standards should be done in a hood. These compounds have been classified as known or suspected human or mammalian carcinogens.

5.0 Summary of the Test Method

The flameless AA procedure is a physical method based on the absorption of radiation at 253.7 nm by mercury vapor. Organic mercury compounds are oxidized and the mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of a flow injection Mercury system. Absorbance (peak height) is measured as a function of mercury concentration and recorded in the usual manner.

6.0 Definitions

- 6.1 Laboratory Quality System SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.

7.0 Interferences

- 7.1 Possible interference from sulfide is eliminated by the addition of potassium permanganate. Concentrations as high as 20 mg/L of sulfide as sodium sulfide do not interfere with the recovery of added inorganic mercury from distilled water.
- 7.2 Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/L had no effect on recovery of mercury from spiked samples.
- 7.3 Sea waters, brines and industrial effluents high in chlorides require additional permanganate (as much as 6.25 mL in 30 mL of sample). During the oxidation step, chlorides are converted to free chlorine which will also absorb radiation at 253 nm. Care must be taken to assure that free chlorine is absent before the mercury is reduced and swept into the cell. This is accomplished by using an excess of hydroxylamine sulfate reagent (6.25 mL to 30 mL of sample).
- 7.4 Samples containing high concentrations of oxidizable organic materials, as evidenced by high chemical oxygen demand values, may not be completely oxidized of organic

mercury will be low. The problem can be eliminated by reducing the sample volume or by increasing the amount of potassium persulfate (and consequently stannous chloride) used in the digestion.

8.0 Safety

- 8.1. Normal accepted laboratory practices should be followed while performing this procedure.
- 8.2. The toxicity and carcinogenicity of each reagent in this method have not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be minimized by good laboratory practices. Normal accepted laboratory practices should be followed during reagent preparation and instrument operation. Always wear safety glasses or full-face shield for eye protection when working with these reagents. Each laboratory is responsible for maintaining a current safety plan, a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method.
- 8.3 Mercury compounds are highly toxic if swallowed, inhaled, or absorbed through the skin. The analyst should use chemical resistant gloves when handling concentrated mercury standards.
- 8.4 The analyst should make sure that the system is vented to fresh permanganate in a bottle located at the back. Otherwise Hg vapors could be vented to the room.

9.0 Equipment & Supplies

- 9.1 Perkin Elmer Flow injection Mercury system.
- 9.2 Mod Block Digester set to maintain $95 \pm 2^\circ\text{C}$ for 2 hours.
- 9.3 Polypropylene sample digestion vessels with snap or screw caps or equivalent.
Five vessels of each lot of digestion vessels must be taken through analysis to check for mercury.

10.0 Reagents and Standards

Reagent grade chemicals shall be used in all tests. All reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. Certified stock standards are purchased from Spex, Ultra Scientific and other vendors depending on their availability. The date they are received is noted on the label or container they are received in and in the LIMS system. The date the standards are opened they are recorded and given a sequential number in the LIMS system. All stock standards are stored at room temperature.

10.1 REAGENTS

- 10.1.1 Concentrated sulfuric acid suitable for Hg determination.
- 10.1.2 Concentrated nitric acid suitable for Hg determination.

- 10.1.3 Stannous chloride: In a 1000 mL volumetric flask add approximately 500 mLs D.I. water, 30 mLs concentrated HCl, add 11 grams stannous chloride crystals swirl to mix and dilute to 1000 mLs. Prepare fresh daily.
- 10.1.4 3% HCl Carrier Solution: Dilute 30 mLs of concentrated metals grade HCl to one liter. Prepare fresh daily.
- 10.1.5 Sodium chloride-hydroxylamine chloride solution: Dissolve 120 grams of sodium chloride and 120 grams of hydroxylamine hydrochloride (very high grade --Do not get from Tennessee Reagents) in D.I. water and dilute to 1 liter. Note: this is normally made up 2 Liters at a time.
- 10.1.6 Potassium permanganate: 5% solution, w/v: dissolve 200 grams of potassium permanganate in 4000 mLs of D.I. water. Should have "suitable for mercury determination" written on the side of the potassium permanganate bottle. This reagent takes overnight stirring (minimum of 3 hours if absolutely necessary). Use stirring bar already in the reagent bottle for this purpose. It is very easy to contaminate with mercury.
- 10.1.7 Potassium persulfate: 5% solution, w/v: dissolve 100 grams of potassium persulfate in 2000 mLs D.I. water. Slight heating with stirring may be necessary to completely dissolve. The formation of crystals in this solution is not a problem.

10.2 STANDARDS

10.2.1 Traceability

- 10.2.1.1 All reference materials are given a unique identifier within Element and labeled with the Element #. This record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique number within Element as well as on the container's label.
- 10.2.1.2 All working standards made from reference materials shall be labeled with a unique Element ID number with complete information on preparation date, concentration of each compound, solvent, preparer's name, and expiration date. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded within Element. Measurements made during standards preparation (e.g., from weighing operations, volume diluted to, etc.) shall also be recorded. There should be no container with sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.
- 10.2.1.3. **NOTE:** All standard solutions should be prepared using class A volumetric flasks, class A volumetric pipettes (or calibrated Eppendorfs). All standards, blanks, and samples are taken through the digestion process.
- 10.2.1.4 Stock mercury solution: (100 µg/mL). Order from manufacturer already prepared. This solution is given a unique Element identifier.

10.2.1.5 Primary source and secondary source mercury standard solutions at 200 ug/L: dilute 2 mLs of stock solution to 1000 mLs in a 1000 mL volumetric flask, with 1.5 mLs concentrated HNO₃. This solution is recorded in Element and given a unique Element identifier.

10.2.2 Calibration Standards

Prepared from the primary source working standard. The preparation of the calibration standards, etc. is described below.

10.2.2.1 Dilute the volumes below to 30 mLs in a 70 mL polypropylene vessel. (Note: The standards are diluted to 10 mLs for the initial step of the digestion. From that point when 25 mLs of DI water are added to samples, 15 mLs of DI water is added to the standards.

<u>ug/L Hg</u>	<u>mLs of 200 ug/L standard in 30 mLs</u>
0.20	0.03
0.50	0.075
1.0	0.15
2.0	0.30
4.0	0.60
6.0	0.90
10.0	1.5

10.2.2.2 Appropriate reagents are added as below in the sample preparation section.

10.2.2.3 Prepare one vessel for each.

10.2.2.4 It is necessary to digest the calibration standards.

10.2.3 Calibration Verification Standards

10.2.3.1. Initial calibration verification (ICV) solution – 4.0 ug/L

10.2.3.1.1 Prepared by diluting 0.6 mL of the second source standard to 30 mL with reagent water in a 70 mL polypropylene vessel. (TV = 4.0 ug/L)

10.2.3.1.2 Appropriate reagents are added as below in the sample preparation section.

10.2.3.1.3 It is necessary to digest the ICV standards for Method 7470A, Method 245.1 does not require digestion of standards.

10.2.3.2 Continuing calibration verification (CCV) solution

10.2.3.2.1 Prepared from the primary source standard.

10.2.3.2.2 Prepared by diluting 0.3 mL of the primary standard at 200 ug/L to 30 mLs with reagent water in a 70 mL polypropylene vessel for 2.0 ug/L or 0.6 ml to 30 mls for 4.0 ug/L.

10.2.3.2.3 Appropriate reagents are added as below in the sample preparation section.

10.2.3.2.4 It is necessary to digest the CCV standards for Method 7470A, Method 245.1 does not require digestion of standards.

10.2.4 Digestion standards

10.2.4.1 Blank Spike

10.2.4.1.1 Prepared from the secondary source standard.

10.2.4.1.2 Prepared by diluting 0.3 mL of the second source standard to 30 mL with reagent water in a 70 mL polypropylene vessel.

10.2.4.1.3 Appropriate reagents are added as below in the sample preparation section.

10.2.4.1.4 This solution should be given a unique identifier within Element.

10.2.1.2 Matrix Spikes

10.2.1.2.1 Prepared from the secondary source working standard.

10.2.1.2.2 Prepared by diluting 0.3 mL of the second source standard to 30 mL with sample in a 70 mL polypropylene vessel. Project specific or method specific requirements may over-ride the spiking level.

10.2.1.2.3 Appropriate reagents are added as below in the sample preparation section.

11.0 Sample Collection, Preservation, Shipment, and Storage

11.1 Samples are preserved by acidification with nitric acid to a pH of 2 or lower immediately at the time of collection, and refrigeration to 4°C. Note – samples received unpreserved and preserved in-house must be held 24 hours prior to preparation.

11.2 The holding time for the mercury digestion is 28 days from time of sampling.

12.0 Quality Control

12.1 Quality Systems SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” outlines details related to laboratory wide protocols on quality control.

12.2 An initial demonstration must be performed by each analyst performing this method. Four BS’s are analyzed at 0.10ug/L. See [Table 2](#) for acceptance criteria.

12.3 (Reference SW-846, 7470A Update III, USEPA CLP ILMO 4.1 or 245.1, Rev 3.0, 5/94 for further clarification)

12.4 Daily

12.4.1. **The instrument must be calibrated daily for all projects.**

12.4.2 Begin each analysis with an ICV(QCS) second source. The control limits are $\pm 10\%$ and IPC (CCV) for 245.1, limits are $\pm 5\%$ and subsequent analyses are $\pm 10\%$.

12.4.3 Analyze ICB. Control limits ($<\pm$ MDL for USACE or \pm RL/CRDL for others and CLP), depending on method. **No analyte detected >2 xMDL for DOD.**

12.4.4 If the ICV (QCS) is not in control a new curve must be analyzed prior to sample analysis.

12.4.5 If the IPC (initial CCV) for 245.1 is not within the limits of $\pm 5\%$, try preparing another undigested CCV and reanalyzing before recalibrating. If this fails then a recalibration is necessary.

12.4.6 Follow each set of 10 samples with a CCV and also must end up with a CCV after the last sample. The control limits are $\pm 20\%$ for SW846-7470 and $\pm 10\%$ for 245.1.

12.6.7 A CCB must always follow a CCV, the control limit is ($<\pm$ MDL for USACE or \pm RL/CRDL for others and CLP). CCB must be run at the beginning and end of a sequence and after every 10 samples. **No analyte detected >2 xMDL for DOD.**

12.5 Quarterly or as needed when doing straight CLP work.

12.5.1 IDL's for CLP 4.1.

12.6 Digestion

12.6.1 BS data should be maintained and available for easy reference or inspection.

12.6.2 BLK ($<1/2$ \pm RL or \pm RL/CRDL for common contaminants (DOD) and \pm RL/CRDL for others and CLP).

12.6.2.1 Employ a minimum of one preparation blank (BLK) per sample batch to determine if contamination or any memory effects are occurring. The BLK is taken through the same digestion/preparation steps as the samples being tested. The result for the preparation blank must be below the method detection limit. If not, the analyst must use good judgment to evaluate the impact upon the associated samples. There is no impact if an associated sample is below the method detection limit nor if the level in the sample is greater than 10X the level found in the preparation blank. If the level of mercury in a sample is above the method detection limit but less than 10X the level found in the preparation blank, the sample must be re-digested and re-analyzed or the data must be qualified on the final report. The project manager or QA manager will make this determination.

12.6.3 Laboratory control sample (BS)

12.6.3.1. Employ a minimum of one laboratory control sample (BS) per sample batch to verify the digestion procedure. The BS is taken through the same digestion/preparation steps as the samples being tested. The minimum control limits are $\pm 20\%$ for SW846-7470 and $\pm 15\%$ for 245.1. If the BS is not in control, the impact upon the client data should be evaluated and the associated sample(s) should be either re-digested or the data should be

qualified. The project manager or QA Officer will make this determination.

12.7 Sample matrix:

12.7.1 Analyze one replicate sample for every twenty samples. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. It is acceptable to substitute a matrix spike duplicate for the sample replicate. CLP does not allow this. Project specific requirements will take precedence in these situations.

12.7.2 Analyze one spiked sample and spiked sample duplicate for every twenty samples. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. Project specific requirements will take precedence in these situations. CLP requires 1 duplicate and 1 spike per batch. If the analyte level in the sample is not greater than four times the spiking level, the spike recoveries should be within $\pm 25\%$ of the true value (**$\pm 20\%$ for DOD projects**). If not, check with supervisor to determine appropriate action. The final analytical report must document this situation.

NOTE: For TCLP extracts, a matrix spike **and a matrix spike duplicate** must be performed for each different matrix. The method of standard additions must be used if the sample spike recoveries are not at least 50% and the concentration of Hg does not exceed the regulatory level and if the concentration of Hg measured in the extract is within 20% of the regulatory level.

12.7.3 The relative percent difference (RPD) between replicate determinations is to be calculated as referenced in the laboratory QA manual. (A control limit of $\pm 20\%$ RPD shall be used for sample values greater than ten times the instrument detection limit.) Supervisor must be notified if the control limit is not met. Supervisor will determine corrective action if required. The final analytical report must document this situation.

12.7.4 For 245.1 analyze one serial dilution (1 to 5 dilution) for every 20 samples or per analytical batch, whichever is more frequent. Percent recovery should be $\pm 10\%$. The concentration of the original sample should be a minimum of 50X the IDL in order to apply the recovery criterion; if not, the serial dilution approach is not used.

12.7.5 When the sample matrix is so complex that viscosity, surface tension, and components can not be accurately matched with standards, the method of standard addition (MSA) is recommended. Section 8.6 of SW846-7000A provides tests to evaluate the need for using the MSA.

13.0 Calibration and Standardization

Quality Systems **SOP QS08** "Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures" related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.

13.1 Set up the instrument with proper operating parameters.

13.1.1 Perkin Elmer Flow Injection Mercury System (FIMS).

- 13.1.1.1. Replace any old tubing that is around the pump cylinder. The sample transfer tubing connected to the separator cover must not have any moisture in it. If it does replace it. (**Perkin-Elmer tygon tubing, waste and carrier 1.52mm I.D., waste only 3.17mm I.D., stannous chloride 1.14mm I.D.**)
- 13.1.1.2 Also replace the filter membrane with the rough side up. (for instructions refer to page 1-22 in maintenance manual.)
- 13.1.1.3 Turn on PE 100 spectrophotometer; (Note: this must be on in order to start up the software on the computer.)
- 13.1.1.4 Turn on computer and go to icon "AA Win LAB Analyst".
- 13.1.1.5 Go to method; select "Hg CAL 2" then OK.
- 13.1.1.6 Wavelength = 253.7; smoothing points =9; measurement = peak height; read time =18sec.; BCC time = 2 sec.
- 13.1.1.7 Go to "Sample Info" and enter the order of the samples and other information that may be needed.
- 13.1.1.8 Save entered sample list under "Savesample info file" Note: description and batch ID are normally the date of analysis.
- 13.1.1.9 Go to "auto"; then to set-up. Select Browse in both spaces. One is to bring up your saved "Sample Information" File. The other is to select a results library. Double click on heading and choose.
- 13.1.1.10 Turn the printer on.
- 13.1.1.11 Connect all tubing to the pump and blocks.
- 13.1.1.12 Start the pump by going to "FIAS" and click the pump 1 Icon (120).
- 13.1.1.13 The pump will start, then lock down and tighten the tubes onto the pump.
- 13.1.1.14 Turn on the nitrogen tank, it should be above 500 psi on the gauge. Replace the nitrogen tank when it is at 500 psi.
- 13.1.1.15 The pressure gauge on the PE100 should be just below 100.
- 13.1.1.16 Use the tension adjuster to press down the tubing magazine to the pump head on the top and bottom. Start the pump and then lock them down. This technique needs to be demonstrated so that a new user will be able to understand what is needed here and how to do it.
- 13.1.1.17 Adjust the spring tension tubing until there is a constant "bubble of low rate" coming out to the waste tube.
- 13.1.1.18 Place carrier tubes into carrier and stannous chloride tube into SnCl₂. (Click the valve fill inject and make sure flow is correct and the line is rinsed).
- 13.1.1.19 Make sure the permanganate waste bottle is bubbling in order to absorb any Hg vapors which could be vented into the room.
- 13.1.1.20 Allow a few minutes for reagents to flow through the system before starting analysis.
- 13.1.1.21 Calibrate: Go to "Auto" click on "Analyze", click on "calibrate".
- 13.1.1.22 "Select Location" enter #'s to be ran, and then press "OK". Samples are done in increments of 10 samples

13.2 Analyze the calibration standards as below.

- 13.2.1 New calibration points must be analyzed when the ICV analysis is not within $\pm 5\%$. **A curve must be analyzed daily for all projects especially USACE and CLP projects.**
- 13.2.2 The curve should be linear with a calculated intercept with a minimum correlation coefficient (r) of ≥ 0.995 (USACE) or 0.998 (other). If not, a new curve must be analyzed.

14.0 Procedure

14.1 Glassware preparation

- 14.1.1 After use, samples are neutralized and disposed down an acid sink with running water and rinsed with tap water. Or the sample may be discarded into the Mercury waste drum.
- 14.1.2 Acid clean the glassware used for mercury prep as follows:
 - 14.1.2.1 Rinse with low Hg content 1:1 HCl.
 - 14.1.2.2 Rinse with D.I. water.

14.2 Label the vessels indicating which sample will be in each.

14.3 Prepare calibration standards as detailed above. Add all reagents to the standards which are added to the samples as outlined below.

14.4 Sample preparation

- 14.4.1. Transfer 30 mLs, or an aliquot diluted to 30 mLs of sample to the 30 mL mark on a 50 mL digestion vessel previously marked for this sample.

NOTE: Normally, an automatic dilution of 10X to 100X is performed for all TCLP extracts. All TCLP samples get one matrix spike unless several come in at one time from the same client with the same matrix. Then one in ten of the same matrix gets spiked. Check with your manager.

- 14.4.2 Add 1.5 mLs of concentrated sulfuric acid to each vessel and mix.
- 14.4.3 Add 0.75 mL of concentrated nitric acid to each bottle and mix.
- 14.4.4 Add 4.5 mLs potassium permanganate solution to each vessel and mix. For sewage samples additional permanganate may be required. Shake and add additional portions of potassium permanganate to the solution if necessary, until the purple color persists for at least 15 minutes (not more than 7.5 mLs). If the purple color does not persist after the addition of 7.5 mLs KMnO_4 the sample must be diluted prior to digestion. Inform your manager that the minimum detection limit cannot be reached for that particular matrix.

NOTE: The same amount of KMnO_4 added to the samples should be present in the standards and blanks.

- 14.4.5 Add 2.4 mLs of potassium persulfate to each vessel and mix. Cover.

- 14.4.6 Heat for 2 hours in the block digester at $95 \pm 2^\circ\text{C}$ (the block temperature must be monitored and documented. Record observed temperature, correction factor, and the corrected temperature), cool.
- 14.4.7 Samples may be saved at this point if there is not time to run the whole set that day.

NOTE: Stannous Chloride (VII. A 5.) and 3% HCl (VII. A 8.) are added by the instrument during analysis.

14.5 Sample analysis

- 14.5.1 Set up the instrument as described in the calibration section above.
- 14.5.2 When ready to run samples, add 1.8 mLs of sodium chloride-hydroxylamine chloride to reduce the excess permanganate. Sample analysis must be preceded by the analysis of an ICV with control limits of $\pm 10\%$ for SW846-7470 and $\pm 5\%$ for 245.1. Followed by the ICB ($< \pm\text{MDL}$ for USACE or $\pm\text{RL}/\text{CRDL}$ for others and CLP).
- 14.5.3 Each set of ten samples and at the end of the analytical run must be followed by a CCV with control limits of $\pm 20\%$ for SW846-7470 and $\pm 10\%$ for 245.1.
- 14.5.4 CCB must always follow the CCV. Control limits are ($< \pm\text{MDL}$ for USACE or $\pm\text{RL}/\text{CRDL}$ for others and CLP). CCB must be run at the beginning and end of a sequence and after every 10 samples. **No analyte must be detected $> 2x\text{MDL}$ for DOD.**
- 14.5.5 The auto-sampler log is set up to analyze 106 samples at a time.
Instrument Run Log example:

AS LOC	Sample ID
0	Wash
1	0.0
2	0.02
3	0.05
4	0.1
5	0.2
6	0.4
7	0.6
8	1.0
9	SEQ-ICV
10	SEQ-ICB
11	BS

AS LOC	Sample ID
12	BLK
13	Sample
14	Sample
15	Sample
16	Sample
17	Sample

18	Sample
19	Sample
20	Sample
21	SEQ-CCV
22	SEQ-CCB
23	Sample
24	Sample
25	Sample
26	Sample
27	Sample
28	Sample
29	Sample
30	Sample
31	MS
32	MSD
33	SEQ-CCV
34	SEQ-CCB

14.6 Data Reporting

14.6.1 Reduce data to result which will be reported.

14.6.2 Complete the data review checklist (attached). Must be completed and attached to each set of USACE data.

15.0 Data Analysis and Calculations

15.1 Quality Systems SOP QS09 “General and Commonly used Laboratory Calculations” provides details on general calculations used throughout the laboratory.

15.2 Apply a least squares fit to the calibration standards plotting $\mu\text{g Hg/L}$ versus the absorbance. For the concentration of the standards, assume 30 mL of solution volume (the 0.1 $\mu\text{g Hg}$ standard will be input as 1.0 $\mu\text{g Hg/L}$) (0.1 $\mu\text{g Hg}$ / 0.030 L solution).

15.3 Input the sample absorbance into the mercury spreadsheet making sure that you are using the correct spreadsheet for the matrix of the sample.

15.4 Also make sure that the appropriate dilution factor is inputted in the correct space on the spreadsheet.

15.5 Report the data as $\mu\text{g Hg/L}$ of sample.

16.0 Method Performance

16.1 Demonstration of Capability (DOC): Each analyst must perform a DOC prior to reporting data. The analyst must prepare (for prep technicians) and analyze (analysts reviewing and reporting data) 4-BS samples. The data is calculated for accuracy and precision requirements. The DOC form, as listed within section 2.5 of the Quality is completed by each analyst and then provided to the supervisor for further processing and approval. See **Table 2** for acceptance criteria. **When analyzing DOCs for DOD QSM Version 4.1, DOD limits will be used.**

DOC BS Preparation: Dilute 0.3 mL of the second source standard to 30 mLs with reagent water in a 70 mL polypropylene vessel. Follow SOP procedure for preparation and analysis steps.

DOC Accuracy and Precision Criteria: The four BS's for the DOC need to be within the methods recovery ranges. Duplicates should be below 20% relative percent difference.

17.0 Pollution Prevention

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on data assessment and acceptance criteria for Quality Control Measures. **Table 2** of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19.0 Contingencies for Handling out-of-control or unacceptable data

19.1 Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on handling out of control data. **Table 2** within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

19.2 CORRECTIVE ACTIONS: INSTRUMENT RELATED

19.2.1 ICV (**QCS for 245.1**)- second source not within $\pm 10\%$.

- A. If the problem is with the solution, re-prepare, obtain new stock if necessary.
- B. If the problem is with the calibration, recalibrate through analysis of appropriate standards and recheck ICV.

19.2.2 CCV not within $\pm 20\%$ for SW846 and $\pm 10\%$ for (**245.1, $\pm 5\%$ for initial IPC and $+ 10\%$ for subsequent IPCs**)

- A. If the problem is with the solution, re-prepare, obtain new stock if necessary.
- B. If the problem is with the calibration, recalibrate through analysis of appropriate standards and re-prepare/reanalyze the previous ten sample according the following guidelines.
 1. If the CCV was biased high, any of the previous ten samples which were below the detection limit do not require reanalysis.

2. If the CCV was biased low, the previous ten samples must be reanalyzed.

19.3 CORRECTIVE ACTION: DIGESTION RELATED

19.3.1 The preparation blank less than $<1/2$ RL or \pm RL/CRDL for common contaminants (DOD) and \pm RL/CRDL for others and CLP.

- A. If the problem is with the instrument or stannous chloride.
Analyze a reagent blank to determine the stannous chloride and the instrument are behaving properly. If this check has detectable mercury, re-prepare the stannous chloride or determine if there are any problems with the instrument. Contact supervisor immediately.
- B. If the problem is with the digestion.
All associated samples which are below the RL, CRDL or have a level of mercury greater than 5X the level found in the preparation blank can be reported. If the level of mercury in an associated sample is not BMDL nor greater than 5X the level found in the preparation blank, the sample must be re-digested/re-analyzed or reported as qualified. The project manager or QA manager will make this determination.
- C. LCS not within control limits (or $\pm 20\%$, $\pm 15\%$ for **245.1**).
 1. If the problem is with the instrument, reanalyze when instrument is in control if further sample bottles are available.
 2. If the problem is with the digestion.
 - a. If biased low, associated samples must be re-digested.
 - b. If biased high, the impact upon the data user must be evaluated. The samples will be re-digested or the data will be qualified on the final report.

19.4 CORRECTIVE ACTION: SAMPLE MATRIX RELATED

19.4.1 Replicate analysis RPD not within $\pm 20\%$

The associated sample data must be qualified on the final report.

19.4.2 Spike analysis recovery not within $\pm 25\%$ (**$\pm 20\%$ for DOD projects**)

- A. If the analyte level in the sample is greater than 4X the spiking level, the %recovery can not be evaluated and no action is taken.
- B. If the analyte level in the sample is not greater than 4X the spiking level, the associated sample data must be qualified on the final report. TCLP extracts must be evaluated as in section XI.D.2 above. The associated sample data must be qualified on the final report.

19.4.3 When the sample matrix is so complex that viscosity, surface tension, and components can not be accurately matched with standards, the method of standard addition (MSA) is recommended. Section 8.6 of SW846-7000A provides tests to evaluate the need for using the MSA.

20.0 Waste Management

- 20.1 Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.
- 20.2 Please see Waste Disposal SOP QS14, for instruction of proper disposal of waste generated from this area. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

21.0 References

- 21.1 *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Update III); Method 7470A.*
- 21.2 *USEPA Code of Federal Regulations, 40, CH 1,PT 136; Method 245.1; APX-B.*
- 21.3 *USEPA Contract Laboratory Program(CLP) for Inorganics ILM04.1; ILM05.2*

22.0 Tables, Diagrams, Flowcharts and Validation Data

- 22.1 Table 1, all applicable parameters, including the surrogates and internals with the applicable RL and lowest calibration standard.
- 22.2 Table 2, for all technical methods, should always be the QA/QC summary table and I am including a format for this at the end.
- 22.3 Table 3, Technical Completeness / Accuracy Checklist
- 22.4 Table 4, Data Reviewers Checklist
- 22.5 Validation data would be actual documentation (eg: a pdf email from a regulator explaining the approach to a method, etc.) or a side by side study performed to reach to our approach on how we handle the method.

APPENDIX:

ADDENDUM FOR USEPA SOW ILM05.2

1. The CCV concentration must be different from the ICV.
2. The same CCV shall be used throughout analysis for an SDG.
3. Calibration standards must be within 5% of the standard concentration.
4. A CRA must be analyzed after the ICV/ICB and after each batch of 20 samples, but before the final CCV/CCB. The control limit is $\pm 30\%$.
5. Spike samples at 1 ug/L for water.

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Table 1

Aqueous Method Detection Limits(MDL)/Detection Limit(DL), Limit of Detection(LOD) Empirical Laboratories' Reporting Limits(ERL)/Limit of Quantitation(LOQ), CLP OLM04.1 & OLM05.2 Contract Required Quantitation Limits (CRQL)					
Mercury by EPA 245.1, 7470A, SOW 4.1 & 5.2	AQUEOUS MDL/DL (ug/L)	AQUEOUS LOD (ug/L)	AQUEOUS ERL/LOQ (ug/L)	AQUEOUS CRQL ILMO 4.1 (ug/L)	AQUEOUS CRQL ILMO 5.2 (ug/L)
Mercury	0.080	0.16	0.20	0.20	0.20

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Table 2 - Method Quality Control Requirements Summary

QC Check	Minimum Frequency / Requirements	Acceptance Criteria	Corrective Action for Failures / Data Useability
Initial calibration (ICAL)	<ul style="list-style-type: none"> Daily ICAL prior to sample analysis Low standard at the RL/LOD level 	<ul style="list-style-type: none"> If more than one calibration standard is used, $r \geq 0.995$ Must follow curve processing requirements from SOP QS08 	<ul style="list-style-type: none"> Re-run curve Check instrument for maintenance needs <p>Samples cannot be analyzed until there is a passing calibration</p>
Second source calibration verification (ICV)	Once after each ICAL, prior to beginning a sample run.	Must be within $\pm 10\%$ of true value	<ul style="list-style-type: none"> Re-run ICV Repeat ICAL
Continuing calibration verification (CCV)	<ul style="list-style-type: none"> After every 10 field samples and at the end of analysis sequence. 	<ul style="list-style-type: none"> $\pm 20\%$ of true value 	<ul style="list-style-type: none"> Correct problem, rerun CCV. If that fails, then repeat ICAL. Reanalyze all samples since the last successful CCV.
Method Blank (BLK)	One per prep batch	No analytes detected $> \frac{1}{2}$ RL and greater than $\frac{1}{10}$ the amount measured in any sample or $\frac{1}{10}$ the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected $> RL$	<ul style="list-style-type: none"> Re-analysis to confirm the positive value Notify the PM for further action Re-prep of samples associated with the BLK NCR will be required for data reported
Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence.	No analytes detected $> LOD$.	Correct problem. Re-analyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.
BS	One per prep batch	Most stringent criteria listed within the LIMS.	<ul style="list-style-type: none"> Re-analyze to confirm failed. Re-prep and reanalyze BS and all samples in the associated prep batch for failed analytes, if sufficient sample material is available. NCR will be required for data reported
MS	One per prep batch, if sample volume available.	Criteria listed within LIMS or specified by client.	<ul style="list-style-type: none"> Follow guidelines from SOP QS05
MSD	One per prep batch, if sample volume available.	Criteria listed within LIMS or specified by client.	<ul style="list-style-type: none"> Follow guidelines from SOP QS05

Table 2 - Method Quality Control Requirements Summary

QC Check	Minimum Frequency / Requirements	Acceptance Criteria	Corrective Action for Failures / Data Useability
DOC Study	<ul style="list-style-type: none"> • Initially per analyst prior to reporting data • Annually • Follow specific guidelines from section 16 for the preparation and analysis of DOC samples 	<ul style="list-style-type: none"> • Average percent recovery should be between 80-120%, with a 20% standard deviation. 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis
MDL Study	Once per year	<ul style="list-style-type: none"> • Calculated value must be less than the Spike level 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis • Follow guidelines from SOP QS05
LOD Verification	Every quarter	<ul style="list-style-type: none"> • Parameter must be detected • the response must be 3-times the noise level 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis • Follow guidelines from SOP QS05
LOQ Verification	Every quarter	<ul style="list-style-type: none"> • Bias Requirement: Inorganics 50-150% • The LOQ value must be greater than the LOD value 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis • Follow guidelines from SOP QS05

Table 3, Technical Completeness / Accuracy Checklist

1. Were all the QC check elements analyzed – refer to Table 2 of the SOP
2. Were the QC criteria met
3. In cases of failures, was there an NCR written
4. Were dilution factors applied correctly
5. Was the data uploaded into LIMS via direct upload – if yes, then was a cross check subset of the uploaded values performed
6. If the data was entered into LIMS manually, was a check of all entered values performed
7. Was the red marked data in LIMS checked for accuracy and the corresponding hard copy data documented appropriately
8. Were proper data qualifiers applied to the data in LIMS
9. Was the hard copy package checked for completeness to include all data for the sequence such that the data reviewer could reconstruct sample analyses and validate / approve the data

Table 4, Data Reviewers Checklist (Prior to approving data)

ANALYST DATA REVIEW CHECKLIST

Sample Number(s):	
Batch Number(s):	Sequence ID:
Method: 7470A/245.1 (Mercury)	

QA/QC Item	Yes	No	NA	Second Level Review
1. Were samples analyzed within USACE holding times?	_____	_____	_____	_____
2. Was initial calibration curve QC criteria met?	_____	_____	_____	_____
3. Was all continuing calibration criteria in control?	_____	_____	_____	_____
4. Did any sample exceed the highest calibration standard? (If yes, were appropriate dilutions made to generate samples concentration within calibration range?)	_____	_____	_____	_____
5. Did BS meet control limits?	_____	_____	_____	_____
6. Did MS/MSD meet control limits?	_____	_____	_____	_____
7. Was the preparation Blank (BLK) below the project required detection limits?	_____	_____	_____	_____
8. Did you return samples back to cold storage immediately after use?	_____	_____	_____	_____
9. Was water bath temperature monitored/documented and did you apply the thermometer correction factor?	_____	_____	_____	_____

- 10. Sample preparation information is correct and complete. _____
- 11. Analytical results are correct and complete. _____
- 12. The appropriate SOP's have been used and followed. _____
- 14. "Raw data" including all manual integration's have been correctly interpreted. _____
- 15. "Special" sample preparation and analytical requirements have been met. _____
- 16. Documentation complete (e.g., all anomalies in the analytical sequence have been documented, corrective action forms are complete. _____

Comments on any "No" response:

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

METALS: SOP 104 REVISION #: 19 EFFECTIVE DATE: 041110

**MERCURY ANALYSIS IN SOIL/SEDIMENT
BY MANUAL COLD VAPOR TECHNIQUE
METHODS SW846 7471A 7471B, EPA 245.5 AND CLPILM 04.1
(NJDEP DOES NOT ACCEPT CLPILM 04.1 AFTER JUNE, 2003),
ADDENDUM FOR USEPA CLP ILM 05.2**

APPROVALS:

Lab Director:  Date: 4/12/10

Data Quality Manager:  Date: 4/11/10

Section Supervisor:  Date: 4/13/10

Changes Summary

Revision 19, 04/11/10

- The SOP is an update from Revision 18 dated 03/25/10.

Revision 18, 03/08/10

- The SOP is an update from Revision 17 dated 01/29/09.
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DOD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DOD samples are analyzed.
- Numerous improvements/modifications were made to this SOP. Details/specifications were added that require evaluation from start to finish.

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1.0 Identification of the Test Method

1.1 This SOP is compliant with USEPA method 245.5, SW-846 method 7471A&B and CLP SOW ILM04.1.

2.0 Applicable Matrix or Matrices

2.1 This procedure measures total mercury (organic and inorganic) in soils, sediments, bottom deposits and sludge type materials.

3.0 Detection Limit

- 3.1 The range of the method is 0.2 to 2 µg/g. The range may be extended above or below the normal range by increasing or decreasing sample size or through instrument and recorder control.
- 3.2 Method Detection Limit (MDL), Empirical Laboratories' Reporting Limit (ERL), Contract Required Quantitation Limit (CRQL) and Analyte Wavelength:

Limits Table

Soil/Solid Method Detection Limits(MDL)/Detection Limit(DL), Limit of Detection(LOD) Empirical Laboratories' Reporting Limits(ERL)/Limit of Quantitation(LOQ), CLP OLM04.1 & OLM05.2 Contract Required Quantitation Limits (CRQL)					
Mercury by EPA 245.1, 245.5 7471A, SOW 4.1 & 5.2	SOLID/SOIL MDL/DL (mg/Kg)	SOLID/SOIL LOD (mg/Kg)	SOLID/SOIL ERL/LOQ (mg/Kg)	SOLID/SOIL CRQL ILMO 4.1 (mg/Kg)	SOLID/SOIL CRQL ILMO 5.2 (mg/Kg)
Mercury	0.013	0.026	0.033	0.10	0.10

Wavelength Table

ANALYTE	WAVELENGTH
Mercury	253.7

4.0 Scope of Application, Including Components to Be Analyzed

- 4.1 Each parameter that is analyzed and reported under the scope of this SOP is listed in **Table 1** of this SOP. This table also lists the associated Reporting Limit (also defined as the LOD) and the lowest Calibration level for each analyte. When applicable, surrogate and Internal Standard Analytes are listed and indicated as such within this table.
- 4.2 This method is a cold-vapor atomic absorption procedure for determining the concentration of mercury in soils, sediments, bottom deposits, and sludge-type materials. All samples must be subjected to an appropriate dissolution procedure prior to analysis.
- 4.3 Extreme care should be taken when working with pure standard and stock standard solutions of these compounds and all handling of standards should be done in a hood.

These compounds have been classified as known or suspected human or mammalian carcinogens.

5.0 Summary of the Test Method

- 5.1 A weighed portion of the sample is acid digested for 2 minutes at $95\pm 2^{\circ}\text{C}$, followed by oxidation with potassium permanganate and with a secondary digestion at 95°C for 30 minutes. Mercury in the digested sample is then measured by the conventional cold vapor technique.

6.0 Definitions

- 6.1 Laboratory Quality System SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.
- 6.2 Refer to SOP-431 for common definitions.

7.0 Interferences

- 7.1 Potassium permanganate is added to eliminate possible interference from sulfide. Concentrations as high as 20 mg/kg of sulfide, as sodium sulfide, do not interfere with the recovery of added inorganic mercury in reagent water.
- 7.2 Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/Kg had no effect on recovery of mercury from spiked samples.
- 7.3 **Samples high in chlorides require additional permanganate (as much as 12.5 mLs) because, during the oxidation step, chlorides are converted to free chlorine, which also absorbs radiation of 253 nm. Care must therefore be taken to ensure that free chlorine is absent before the mercury is reduced and swept into the cell.**
- 7.4 Certain volatile organic materials that absorb at this wavelength may also cause interference. A preliminary run without reagents should determine if this type of interference is present.

8.0 Safety

- 8.1 Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed lab-wide.
- 8.2 Normal accepted laboratory practices should be followed while performing this procedure.
- 8.3 The toxicity and carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be minimized by good laboratory practices. Normal accepted laboratory safety practices should be followed during reagent preparation and instrument operation. Always wear safety glasses or full-face shield for eye protection when working with these reagents. Each laboratory is responsible for maintaining a current safety plan, a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method.
- 8.4 Mercury compounds are highly toxic if swallowed, inhaled, or absorbed through the skin. Analyses should be conducted in a laboratory exhaust hood. The analyst should use chemical resistant gloves when handling concentrated mercury standards.

9.0 Equipment & Supplies

- 9.1 Perkin Elmer Flow Injection Mercury System (FIMS).
- 9.2 Perkin Elmer AS 90.
- 9.3 Mercury lamp.
- 9.4 Environmental Express Mod-Block digestion block capable of holding 95+2°C for 2 hours.
- 9.5 A scale or balance capable of weighing to 0.01 + 0.02 gram.
- 9.6 Snap cap digestion polypropylene vessels for use with the mod block digester. Five vessels of each lot must be taken through analysis to check for mercury.
- 9.7 Polypropylene watch glasses suitable for use with the above vessels in F above.
- 9.8 Manual Sample Mill
- 9.9 Wiley Sample Mill
- 9.10 Clippers for cutting vegetation

10.0 Reagents and Standards

- 10.0.1 The laboratory's LIMS system allows for complete documentation and for the traceability of reagents and standards used within the laboratory. The following information relates to the specific reagents and standards used for the performance of the method:
- 10.0.2 Reagent grade chemicals shall be used in all tests. All reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. Certified stock standards are purchased from Spex, Ultra and other vendors depending on their availability. The date they are received is noted on the label or container they are received in and in the LIMS system. The date the standards are opened they are recorded and given a sequential number in the LIMS system. All stock standards are stored at 4 ° C.

10.1 REAGENTS

- 10.1.1 Reagent Water: Reagent water will be interference free. All references to water in this method refer to reagent water unless otherwise specified.
- 10.1.2 Aqua Regia: Prepare immediately before use by carefully adding three volumes of concentrated HCl to one volume of concentrated HNO₃. Both HNO₃ and HCl must be of the reagent grade suitable for mercury determinations.
NOTE: This reagent is required for use when USACE project samples are being digested.
- 10.1.3 Concentrated HCl.
- 10.1.4 Concentrated HNO₃.
- 10.1.5 Stannous chloride in a one liter volumetric flask add ~500 mL D.I. H₂O, 30 mL concentrated HCl, and 11g stannous chloride crystals. Swirl to mix and dilute to 1 L.

- 10.1.6 Sodium chloride-hydroxylamine chloride solution: Dissolve 120 g of sodium chloride and 120 g of hydroxylamine sulfate in reagent water and dilute to 1 L. Note: this is normally made up 2 liters at a time.
- 10.1.7 Potassium permanganate, mercury-free, 5% solution (w/v): Dissolve 200 g of potassium permanganate in 4 L of reagent water.
- 10.1.8 3 % HCl carrier solution: 30 mLs HCl – 1 L DI H₂O; Prepare fresh daily.
- 10.1.9 Potassium persulfate 5% solution: Dissolve 100g in 2 liters of D.I. water. Used with digestion of CLP soils.

10.2 STANDARDS

10.2.1 Traceability

10.2.1.1 All reference materials are given a unique identifier within Element and labeled with the Element #. This record shall include date of receipt, source, purity, all compositional information, storage conditions and expiration date. These materials/solutions are to be identified by a unique number within Element as well as on the container's label.

10.2.1.2 All working standards made from reference materials shall be labeled with a unique Element ID number with complete information on preparation date, concentration of each compound, solvent, preparer's name, and expiration date. Reagents shall be labeled with date received and expiration date, if applicable. All of the information described above shall also be recorded within Element. Measurements made during standards preparation (e.g., from weighing operations, volume diluted to, etc.) shall also be recorded. There should be no container with sample, sample extract, standard solution, etc. that is not correctly labeled and properly stored.

10.2.2 Preparation

10.2.2.1. **NOTE:** All standard solutions should be prepared using class A volumetric flasks, class A volumetric pipettes (or calibrated Eppendorfs). All Standards, blanks, and samples are taken through the digestion process.

10.2.2.2 Stock mercury solution: (100 µg/mL). Order from manufacturer already prepared. This solution is given a unique identifier.

10.2.2.3 Primary source and secondary source mercury standard solutions: dilute 2 mLs of stock solution to 1000 mLs in a 1000 mL volumetric flask, with 1.5 mLs concentrated HNO₃ (200 ug/L).

10.2.3 Calibration standards:

Prepared from the primary source standard. The preparation of the calibration standards, etc. is described below.

10.2.3.1 Dilute the volumes below to 5 mLs in a 70 mL polypropylene vessel. (Note: The standards are diluted to 5 mLs for the initial step of the digestion.)

ug/L Hg

mLs of 200 ug/L standard in 50 mL

0.20	0.050
0.50	0.125
1.0	0.25
<u>ug/L Hg</u>	<u>mLs of 200 ug/L standard in 50 mL</u>
2.0	0.50
4.0	1.0
6.0	1.5
10.0	2.5

10.2.3.2 Appropriate reagents are added as below in the sample preparation section.

10.2.3.3 Prepare one vessel of each.

10.2.3.4 It is necessary to digest the calibration standards when following all mercury methods.

10.2.4. Calibration verification standards:

10.2.4.1. Initial calibration verification (ICV) solution – 4.0 ug/L.

10.2.4.1.1 Prepared from the secondary source mercury standard (200 ug/L).

10.2.4.1.2 Prepared by diluting 1.0 mL of the second source mercury standard to 5 mLs in a polypropylene digestion vessel.

10.2.4.1.3 Appropriate reagents are added as below in the sample preparation section.

10.2.4.1.4 It is necessary to digest the ICV standards when using all mercury methods for soil.

10.2.4.2 Continuing calibration verification (CCV) solution:

10.2.4.2.1 Prepared from the primary or secondary source mercury standard. The concentration is alternated from 2.0 ug/L to 4.0 ug/L every 20 samples.

10.2.4.2.2 Prepared by diluting 0.50 for a 2.0 ug/L and 1.0 mL for a 4.0 ug/L of the secondary 200 ug/L standard to 5.0 mLs with reagent water in a polypropylene digestion vessel.

10.2.4.2.3 Appropriate reagents are added as below in the sample preparation section.

10.2.4.2.4 It is necessary to digest the CCV standards when following all mercury methods for soil.

10.2.5 Digestion standards:

10.2.5.1 Laboratory control sample:

10.2.5.1.2 The Laboratory Control Sample (BS) is prepared from the secondary source mercury standard (200 ug/L) and added to ~ 0.3 grams of teflon chips.

10.2.5.1.3 Prepared by diluting 0.50 mL of the secondary mercury standard (200 ug/L) to 5 mLs in a polypropylene digestion vessel with 0.30 grams of teflon chips.

10.2.5.1.4 Appropriate reagents are added as below in the sample preparation section.

10.2.5.1.5 This solution is given a unique identifier in Element.

10.2.5.2 Matrix Spikes

10.2.5.2.1 Prepared from the primary or secondary source mercury standard (200 ug/L).

10.2.5.2.2 Prepared by adding 0.50 mL of the mercury standard (200 ug/L) to the sample in a polypropylene digestion vessel. Project specific requirements may over-ride the spiking level.

C10.2.5.2.3 Appropriate reagents are added as below in the sample preparation section.

11.0 Sample Collection, Preservation, Shipment, and Storage

11.1 Quality Systems SOP QS10 related to Sample Receipt, Handling, & Processing provides details for collection, preservation, shipment, and storage.

11.2 Because of the extreme sensitivity of the analytical procedure and the omnipresence of mercury, care must be taken to avoid extraneous contamination. Sampling devices and sample containers should be ascertained to be free of mercury; the sample should not be exposed to any condition in the lab that may result in contact with solid, liquid or airborne mercury.

11.3 Refrigerate solid samples at 4°C ($\pm 2^\circ\text{C}$) upon receipt until digestion and analysis.

11.4 The sample should be analyzed without drying. A separate percent solids determination is required

11.5 The holding time for digestion of mercury samples is 28 days.

12.0 Quality Control

12.1 Quality Systems SOP QS08 "Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures" outlines details related to laboratory wide protocols on quality control.

12.2 An initial demonstration must be performed by each analyst performing this method. Four BSs are analyzed at 0.10ug/L. See **Table 2** for acceptance criteria.

12.3 QUALITY CONTROL (Reference SW-846, 7471A Update III, 7471B Revision 2 February 2007, USEPA CLP ILMO 4.1 or EPA 245.5 for further clarification)

12.3.1 Daily

12.3.1.1 The instrument must be calibrated daily for all projects.

12.3.1.2 Begin each analysis with an ICB (concentration at or near mid range). The control limits are +10% for 7471A and 245.5, $\pm 20\%$ for 7471B and $\pm 5\%$ for 245.5.

12.3.1.3 Analyze ICB. Control limit is $< \pm \text{MDL}$ or $\pm \text{RL/CRDL}$ for other or CLP. For DOD, no analyte detected $> 2x \text{MDL}$.

- 12.3.1.4 If the ICV is not in control a new curve must be analyzed prior to sample analysis.
- 12.3.1.5 Follow each set of 10 samples with a CCV and also must end up with CCV after last sample. The control limits are +20% for SW846-7471A, SW846 7471B and $\pm 10\%$ for 245.5. If an exceedance occurs, analyze another CCV, if the second CCV fails, then a new calibration curve should be generated and all affected samples should be reanalyzed.
- 12.3.1.6 Follow each CCV with a CCB. Control limit is $< \pm \text{MDL}$ or $\pm \text{RL}/\text{CRDL}$ for others or CLP. For DOD, no analyte detected $> 2x \text{MDL}$.

12.3.2 Quarterly

- 12.3.2.1 IDLs for CLP (Follow SOP - 414).

12.3.3 Annually

- A. MDLs must be analyzed for all matrixes (Follow SOP - 414).

12.3.4 Digestion

- 12.3.4.1 BS data should be maintained and available for easy reference or inspection.

- 12.3.4.2 BLK ($< \pm \frac{1}{2} \text{RL}$ or $\pm \text{RL}$ for common contaminants or $\pm \text{RL}/\text{CRDL}$ for others or CLP)

- 12.3.4.2.1 Employ a minimum of one BLK per sample batch to determine if contamination or any memory effects are occurring. The preparation blank is taken through the same digestion/preparation steps as the samples being tested. The result for the preparation blank must be $< \pm \frac{1}{2} \text{RL}$ for USACE or $\pm \text{RL}/\text{CRDL}$ for others or CLP. If not, the analyst must use good judgment to evaluate the impact upon the associated samples. There is no impact if an associated sample is below the method detection limit or if the level in the sample is greater than 10X the level found in the preparation blank. If the level of mercury in a sample is above the method detection limit, but less than 10X the level found in the preparation blank, the sample must be redigested and reanalyzed or the data must be qualified on the final report. The project manager or QA officer will make this determination.

- 12.3.4.3 Laboratory control sample (BS).

- 12.3.4.3.1 Employ a minimum of one BS per sample batch to verify the digestion procedure. The BS is taken through the same digestion/preparation steps as the samples being tested. The minimum control limits are +20% for SW846-7471A, 7471B and 245.5 solid samples. A BS will accompany each batch of soil samples. If the BS is not in control, the Inorganic Manager and QA Officer must be notified immediately. Several possibilities exist at this point and a thorough investigation and data evaluation is essential. The first question is to evaluate the impact upon the

data. All samples may need to be retested or flagged with the appropriate qualifier. The next question is to find out why it occurred and to proceed with a corrective action plan to prevent reoccurrence. This corrective action is documented in a CAR.

12.3.5 Sample matrix

12.3.5.1 Analyze one replicate sample for every twenty samples or per analytical batch, whichever is more frequent. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. It is acceptable to substitute a matrix spike duplicate for the sample replicate. Project specific requirements will take precedence in these situations.

12.3.5.2 Analyze one spiked sample and spiked sample duplicate for every twenty samples or per analytical batch, whichever is more frequent. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. Project specific requirements will take precedence in these situations. CLP requires 1 duplicate and 1 spike per batch. If the analyte level in the sample is not greater than four times the spiking level, the spike recoveries should be within +25% for 7471A and $\pm 20\%$ for 7471B of the true value (+20% for DOD projects). If results do not fall within the control limit redigestion/reanalysis may be required. If reanalysis is not required, the associated batch of samples will be flagged accordingly. Discuss the situation with your supervisor. A Corrective Action Report (CAR) must be filled out and attached to the data as well as emailed or sent to the supervisor when the control limits are exceeded.

12.3.5.3 The relative percent difference (RPD) between replicate determinations is to be calculated as referenced in the laboratory QA manual. (A control limit of + 20% RPD (non-aqueous samples may routinely exceed this amount) shall be used for sample values greater than ten times the instrument detection limit.) Supervisor must be notified if the control limit is not met. Supervisor will determine corrective action if required. The final analytical report must document this situation. A Corrective Action Report (CAR) must be filled out and attached to the data as well as emailed or sent to the supervisor when the control limits are exceeded.

12.3.5.4 For 245.5 analyze one serial dilution (1 to 5 dilution) for every 20 samples or per analytical batch, whichever is more frequent. Percent recovery should be 10%. The concentration of the original sample should be a minimum of 50X the IDL in order to apply the recovery criterion; if not, the serial dilution approach is not used.

12.3.5.5 When the sample matrix is so complex that viscosity, surface tension, and components can not be accurately matched with standards, the method of standard addition (MSA) is recommended. Section 8.6

13.0 Calibration and Standardization

- 13.0.1 Quality Systems **SOP QS08** “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.
- 13.0.2 Set up the instrument with proper operating parameters.
- 13.0.3 Perkin Elmer Flow Injection Mercury System (FIMS).
 - 13.0.3.1 Prepare the instrument for calibration by the following steps:
 - 13.0.3.1.1 Replace any old tubing that is around the pump cylinder. The sample transfer tubing connected to the separator cover must not have any moisture in it, if it does replace it. (Perkin-Elmer tygon tubing, waste and carrier 1.52mm I.D., waste only 3.17mm I.D., stannous chloride 1.14mm I.D.)
 - 13.0.3.1.2 Also replace the filter membrane with the rough side up. (for instructions refer to page 1-22 in maintenance manual.)
 - 13.0.3.1.3 Turn on PE 100 spectrophotometer; (Note: this must be on in order to start up the software on the computer.)
 - 13.0.3.1.4 Turn on computer and go to icon “AA Win LAB Analyst”
 - 13.0.3.1.5 Go to method; select “Hg CAL 2” then OK.
 - 13.0.3.1.6 Wavelength = 253.7; smoothing points =9; measurement = peak height; read time = 18 sec.; BCC time = 2 sec.
 - 13.0.3.1.7 Go to “Sample Info” and enter the order of the samples and other information that may be needed.
 - 13.0.3.1.8 Save entered sample list under “Save ...sample info file” Note: description and batch ID are normally the date of analysis.
 - 13.0.3.1.9 Go to “auto”; then to set-up. Select Browse in both spaces. One is to bring up your saved “Sample Information.” File. The other is to select a results library. Double click on heading and choose.
 - 13.0.3.1.10 Turn the printer on.
 - 13.0.3.1.11 Connect all tubing to the pump and blocks.
 - 13.0.3.1.12 Start the pump by going to “FIAS” and click the pump 1 Icon (120).
 - 13.0.3.1.13 The pump will start, then lock down and tighten the tubes onto the pump.
 - 13.0.3.1.14 Turn on the nitrogen tank, it should be >500 psi on the gauge. Replace the nitrogen tank when it is at 500 psi.
 - 13.0.3.1.15 The pressure gauge on the PE100 should be just below 100.
 - 13.0.3.1.16 Use the tension adjuster to press down the tubing magazine to the pump head on the top and bottom. Start the pump and then lock them down. This technique needs to be demonstrated so that a new user will be able to understand what is needed here and how to do it.
 - 13.0.3.1.17 Adjust the spring tension tubing until there is a constant “bubble of low rate” coming out to the waste tube.
 - 13.0.3.1.18 Place carrier tubes into carrier and stannous chloride tube into SnCl₂. (click valve fill inject and make sure flow is correct and the line is rinsed)
 - 13.0.3.1.19 Make sure the permanganate waste bottle is bubbling in order to absorb any Hg vapors which could be vented into the room.

13.0.3.1.20 Allow a few minutes for reagents to flow through the system before starting analysis.

13.0.3.1.21 Calibrate: Go to “Auto” click on “Analyze”, click on “calibrate”.

13.0.3.1.22 “Select location” enter the #'s of the samples to be analyzed, then “OK”.

13.0.3.2 Analyze the calibration standards as below.

13.0.3.2.1 A curve must be analyzed daily for all projects. A new curve must be analyzed when the ICV analysis is not within $\pm 10\%$ for SW846 7471A and $\pm 5\%$ for 245.5 methods, or $\pm 20\%$ for 7471B.

13.0.3.2.1 The curve should be linear with a calculated intercept with a minimum correlation coefficient of >0.995 (USACE) or 0.998 (other). If not, a new curve must be analyzed.

13.0.3.2.2 CLP requires a blank + 5 calibration standards (0, .02, .05, .1, .5 and $1.0\ \mu\text{g}$). (One standard must be at CRDL or IDL whichever is greater.)

14.0 Procedure

14.1 Prepare calibration standards as detailed above. Add all reagents to the standards which are added to the samples as outlined below. Record the standard preparation in the standard log.

14.2 Sample preparation:

14.2.1 It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

14.2.1.1 The material in the sample pan (inorganic-plastic/organic-aluminum) should be divided into quarters and each quarter should be mixed individually.

14.2.1.2 Two quarters should then be mixed to form halves.

14.2.1.3 The two halves should be mixed to form a homogenous matrix.

14.2.1.4 This procedure should be repeated several times until the sample is adequately mixed.

14.2.1.5 NOTE: Samples that are clay type materials must be handled in a different manner. Due to these type sample matrices having an affinity to stick to most anything that touches it, another approach must be followed. Obtain a representative sub-sample aliquot from the center or middle section of the sample container.

14.2.2 Grinding of Vegetation Samples

14.2.2.1 Remove sample from shipping container and brush off dirt particles. Chop sample into about half inch pieces with clippers or other cutting tool. Place the sample in an aluminum pan and air-dry in an exhaust hood to the appropriate dryness for grinding. It should be dry enough where it won't stick to the inside of the mill. Grind the dried sample to

- fineness in either the manual sample mill or the Wiley mill or both if needed. Place the ground sample in a container and label immediately.
- 14.2.2.2 Transfer 0.30 g (for USACE work use anywhere from 0.20 to 1.0 g and record the weight in the digestion log) of sample to a polypropylene digestion vessel previously marked for this sample. Record the exact sample mass on the bottle and on the Element Batch Sheet. (Note: the balance must be calibrated for the specific task. Calibrate by weighing a 0.5 and a 0.1g weight on the balance along with a digestion vessel. (Record in specific balance calibration log.)
 - 14.2.2.3 Add 2.5 mLs of reagent water, and 2.5 mLs of aqua regia and mix for samples. Add 2.5 mLs of aqua regia to standards and mix.
 - 14.2.2.4 Cover samples and standards with watch glasses and heat for 2 minutes in the hot block at $95 \pm 2^\circ\text{C}$ (The hot block temperature must be monitored and documented. Record observed temperature, correction factor, and the corrected temperature).
 - 14.2.2.5 Cool, bring to 30 ml with D.I. water.
 - 14.2.2.6 Add 7.5 mLs potassium permanganate solution to each vessel and mix. For sewage samples additional permanganate may be required. Shake and add additional portions of potassium permanganate to the solution if necessary, until the purple color persists for at least 15 minutes (not more than 12.5 mLs).
- NOTE: The same amount of KMnO_4 added to the samples should be present in the standards and blanks.
- 14.2.2.7 Heat for 30 minutes on the hot block at $95 \pm 2^\circ\text{C}$ (The temperature must be monitored and documented. Record observed temperature, correction factor, and the corrected temperature), cool. Samples may be saved at this point if there is not time to run the whole set that day.
 - 14.2.2.8 Add 3 mLs of sodium chloride-hydroxylamine chloride solution to each vessel.
 - 14.2.2.9 Bring to 50 mLs with D.I. water both standards and samples. Cap mix and vent to decolor and release Cl gas. The samples are now ready for analysis.
 - 14.2.2.10 NOTE: Stannous Chloride (10.1.5) and 3% HCl (10.1.8) are added by the instrument during analysis.

14.2.3 Sample analysis

- 14.2.3.1 Set up the instrument as described in the calibration section above.
- 14.2.3.2 When ready to run samples, transfer samples and standards to autosampler tubes and load the auto sampler according to the sample information sheet set up previously. If chlorides are suspected, purge the head space in the polyethylene tube for at least 1 minute to get rid of any chlorine gas collected there. After a delay of at least 30 seconds the sample is ready for step "3". NOTE: When aqua-regia is added assume that all samples and standards have chlorine and treat accordingly. Purging the samples of chlorine is accomplished by putting a pasteur pipette on the end of some air tubing hooked to a fish pump. The

pasteur pipette is then placed at an angle into the top of the polyethylene vessel without breaking the surface of the sample. It takes about one minute to purge the air above the sample of chlorine.

- 14.2.3.3 Analysis must be preceded by the analysis of an ICV (concentration at or near mid range) with control limits of +10% for SW846-7471A or $\pm 20\%$ for 7471B and $\pm 5\%$ for 245.5 methods.
- 14.2.3.4 The ICB must follow the calibration standards ($< \pm \text{MDL}$ (USACE) or $\pm \text{RL/CRDL}$ for other or CLP), but not before the ICV. No analyte must be detected $> 2x\text{MDL}$ for DOD.
- 14.2.3.5 Each set of ten samples must be followed by a CCV with control limits of +20% for SW846-7471A and B and $\pm 10\%$ for 245.5 method. The run must also end with a CCV, then CCB.
- 14.2.3.6 Analyze CCB after calibration and each CCV. The CCB frequency is 10% or every 2 hours whichever is more frequent. (control limit is $< \pm \text{MDL}$ or $\pm \text{RL/CRDL}$ for other or CLP). For DOD, CCB at beginning and end of sequence and after every 10 samples. No analyte detected $> 2x\text{MDL}$.

14.2.3.7 Instrument Run Log example:

<u>AS LOC</u>	<u>Sample ID</u>
0	Wash
1	0.0
2	0.02
3	0.05
4	0.1
5	0.2
6	0.4
7	0.6
8	1.0
9	SEQ- ICV
10	SEQ-ICB
11	BS
12	BLK
13	Sample
14	Sample
15	Sample
16	Sample
17	Sample
18	Sample
19	Sample
20	Sample
21	SEQ-CCV
22	SEQ-CCB
23	Sample
24	Sample
25	Sample
26	Sample
27	Sample
28	Sample
29	Sample
30	Sample
31	MS
32	MSD
33	SEQ-CCV
34	SEQ-CCB

14.2.3.8 Sample analysis:

14.2.3.8.1 Go to “Analyze”, “select location” and type in the range of numbers needed to complete analysis. (ie. 9-54). Press enter and the autosampler will proceed to enter the selected range.
NOTE: Check standards are loaded as part of the tray.

14.2.3.8.2 Make sure that the sample wash beaker is filled with 3% HCl.

14.2.3.8.3 Dilute and reanalyze samples that are more concentrated than within 10% of the high standard. Soil sample dilutions are

made from the digested aliquot. Sample concentration results that are below the calibration curve but above the MDL are reported flagged as estimated, (“B” flag).

14.2.4 Data reporting

14.2.4.1 Reduce data to result which will be reported using the soil spreadsheet found on the network..

14.2.4.2 Complete the data review checklist (attached). Must be completed and attached to each set of USACE data.

15.0 Data Analysis and Calculations

15.1 Quality Systems SOP QS09 “General and Commonly used Laboratory Calculations” provides details on general calculations used throughout the laboratory.

15.2 Pull up the blank spreadsheet at V: lab\metals\tests\mercury and transfer all the information pertinent to the current analysis. Save as the date of analysis. This information can be obtained from your mercury batch sheet.

15.3 Transfer the sample absorbance into the excel spreadsheet in the appropriate cell. The spreadsheet uses the current calibration to calculate the Hg results.

15.4 Make sure that the appropriate dilution factors are entered into the spreadsheet in the correct cells.

15.5 The spreadsheet should divide the result which is the $\mu\text{g Hg}$ obtained from the sample mass by the sample mass in grams. This will yield a result of $\mu\text{g Hg/g}$ sample on a wet weight basis. Calculations in the spreadsheet should be checked occasionally to make sure that they are working correctly.

15.6 If available, divide the result by the %solids to obtain the result on a dry weight basis.

15.7 Report the data as $\mu\text{g Hg/g}$ of sample (mg/kg wet or mg/kg dry when % solids are available).

16.0 Method Performance

16.1 Demonstration of Capability (DOC): Each analyst must perform a DOC prior to reporting data. The analyst must prepare (for prep technicians) and analyze (analysts reviewing and reporting data) 4-LCS samples. The data is calculated for accuracy and precision requirements. The DOC form, as listed within section 2.5 of the Quality is completed by each analyst and then provided to the supervisor for further processing and approval. See **Table 2** for acceptance criteria. **When analyzing DOCs for DOD QSM Version 4.1, DOD limits will be used.**

DOC BS Preparation: Dilute 0.5 mL of the second source standard (200 ug/L) add to ~0.3g to 5 mLs with reagent water/aqua-regia in a 70 mL polypropylene vessel. Follow SOP procedure for preparation and analysis steps.

DOC Accuracy and Precision Criteria: The four BS’s for the DOC need to be within the methods recovery ranges. Duplicates should be below 20% relative percent difference.

17.0 Pollution Prevention

14.1 Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

14.2 Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on data assessment and acceptance criteria for Quality Control Measures. **Table 2** of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19.0 Contingencies for Handling out-of-control or unacceptable data

19.1 Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on handling out of control data. **Table 2** within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

19.2 CORRECTIVE ACTIONS: INSTRUMENT RELATED

19.2.1 ICV not within + 10% (SW846) and (245.5)

19.2.1.1 If the problem is with the solution, re-prepare, obtain new stock if necessary.

19.2.1.2 If the problem is with the calibration, recalibrate thru analysis of appropriate standards and recheck ICV.

19.2.2 CCV not within + 20% (SW846) and (245.5)

19.2.2.1 If the problem is with the solution, reprepare, obtain new stock if necessary.

19.2.2.2 If the problem is with the calibration, recalibrate thru analysis of appropriate standards and reprepare/reanalyze the previous ten sample according the following guidelines.

19.2.2.2.1 If the CCV was biased high, any of the previous ten samples which were below the minimum detection limit do not require reanalysis.

19.2.2.2.2 If the CCV was biased low, the previous ten samples must be reanalyzed.

19.3 CORRECTIVE ACTION: DIGESTION RELATED

19.3.1 The preparation blank less than $\pm \frac{1}{2}$ RL for DOD or \pm RL/CRDL for others or CLP.

19.3.1.1. If the problem is with the instrument or stannous chloride.

19.3.1.1.1 Analyze a reagent blank to determine the stannous chloride and the instrument are behaving properly. If this check has detectable mercury, reprepare the stannous chloride or determine if there are any problems with the instrument.

19.3.1.1.2 If the problem was with the instrument or the stannous chloride and the situation is corrected continue analysis with a second aliquot of the preparation blank.

19.3.1.2 If the problem is with the digestion, all associated samples which are below the method detection limit (MDL) or have a level of mercury

greater than 10X the level found in the preparation blank can be reported. If the level of mercury in an associated sample is not <MDL nor greater than 10X the level found in the preparation blank, the sample must be redigested/reanalyzed or reported as qualified. The project manager or QA manager will make this determination.

19.3.2 BS not within control limits.

19.3.2.1 If the problem is with the instrument, reanalyze when instrument is in control with another aliquot of the sample.

19.3.2.2 If the problem is with the digestion.

19.3.2.2.1 If biased low, associated samples must be redigested.

19.3.2.2.2 If biased high, the impact upon the data user must be evaluated. The samples will be redigested or the data will be qualified on the final report.

19.4 **CORRECTIVE ACTION: SAMPLE MATRIX RELATED**

19.4.1 Replicate analysis RPD not within +20%

19.4.1.1 The associated sample data must be qualified on the final report.

19.4.2 Spike analysis recovery not within +25% 7471A and ±20% 7471B (+20% for DOD projects)

19.4.2.1 If the analyte level in the sample is greater than 4X the spiking level, the % recovery can not be evaluated and no action is taken.

19.4.2.2 If the analyte level in the sample is not greater than 4X the spiking level, the associated sample data must be qualified on the final report. A corrective action report must accompany the data and be emailed or given to the supervisor.

20.0 Waste Management

20.1 Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

20.2 Please see Waste Disposal SOP-405, for instruction of proper disposal of waste generated from this area.

21.0 References

21.1 *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Update III/IV); Method 7471A, 7471B*

21.2 *USEPA Code of Federal Regulations, 40, CH 1, PT 136; Method 245.1; APX-B*

21.3 *USEPA Contract Laboratory Program (CLP) for Inorganics ILM04.1; ILM05.2*

22.0 Tables, Diagrams, Flowcharts and Validation Data

22.1 Table 1, all applicable parameters, including the surrogates and internals with the applicable RL and lowest calibration standard.

22.2 Table 2, for all technical methods, should always be the QA/QC summary table and I am including a format for this at the end.

22.3 Table 3, Technical Completeness / Accuracy Checklist

22.4 Table 4, Data Reviewers Checklist

- 22.5 Validation data would be actual documentation (eg: a pdf email from a regulator explaining the approach to a method, etc.) or a side by side study performed to reach to our approach on how we handle the method.

APPENDIX:

Addendum for USEPA CLP ILM 05.2

1. CCV concentration must be different from ICV.
2. The same CCV shall be used throughout analysis for a sample delivery group.
3. Calibration standards must be within 5% of the standard concentration.
4. 0.2 grams of sample must be used for the sample aliquot, add enough reagent water to each sample to make a total volume of 10 mL. Proceed with method as in the water method SOP 103.0 Revision 9.
5. The ICV and CCV must be at $\pm 20\%$ recovery.
6. A CRA must be analyzed at the beginning and end of each batch of 20 samples. Right after the ICV/ICB and right before the final CCV/CCB. The control limit is $\pm 30\%$.
7. The matrix spike must be analyzed at the concentration of 0.5 mg/Kg.

Table 1

Soil/Solid Method Detection Limits(MDL)/Detection Limit(DL), Limit of Detection(LOD) Empirical Laboratories' Reporting Limits(ERL)/Limit of Quantitation(LOQ), CLP OLM04.1 & OLM05.2 Contract Required Quantitation Limits (CRQL)					
Mercury by EPA 245.1, 245.5 7471A, SOW 4.1 & 5.2	SOLID/SOIL MDL/DL (mg/Kg)	SOLID/SOIL LOD (mg/Kg)	SOLID/SOIL ERL/LOQ (mg/Kg)	SOLID/SOIL CRQL ILMO 4.1 (mg/Kg)	SOLID/SOIL CRQL ILMO 5.2 (mg/Kg)
Mercury	0.013	0.026	0.033	0.10	0.10

Table 2 - Method Quality Control Requirements Summary

QC Check	Minimum Frequency / Requirements	Acceptance Criteria	Corrective Action for Failures / Data Useability
Initial calibration (ICAL)	<ul style="list-style-type: none"> Daily ICAL prior to sample analysis Low standard at the RL/LOD level 	<ul style="list-style-type: none"> If more than one calibration standard is used, $r \geq 0.995$ Must follow curve processing requirements from SOP QS08 	<ul style="list-style-type: none"> Re-run curve Check instrument for maintenance needs <p>Samples cannot be analyzed until there is a passing calibration</p>
ICV	Alternate source standard to be analyzed after every calibration curve	Must be within $\pm 10\%$ for SW846 7471A, $\pm 20\%$ for 7471B, or $\pm 5\%$ for 245.5 of true value	<ul style="list-style-type: none"> Re-run ICV Repeat ICAL
CCV	<ul style="list-style-type: none"> After every 10 field samples and at the end of analysis sequence. 	<ul style="list-style-type: none"> $\pm 20\%$ for SW846-7471A&B, $\pm 10\%$ for 245.5 of true value 	<ul style="list-style-type: none"> Follow guidelines for SOP QS05
Closing CCV	<ul style="list-style-type: none"> At the end of every sequence 	<ul style="list-style-type: none"> $\pm 20\%$ for SW846-7471A&B, $\pm 10\%$ for 245.5 of true value 	<ul style="list-style-type: none"> Follow guidelines for SOP QS05
BLK	One per prep batch	No analytes detected $> \frac{1}{2}$ RL and greater than $\frac{1}{10}$ the amount measured in any sample or $\frac{1}{10}$ the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected $> RL$	<ul style="list-style-type: none"> Re-analysis to confirm the positive value Notify the PM for further action Re-prep of samples associated with the BLK NCR will be required for data reported
BS	One per prep batch	Most stringent criteria listed within the LIMS.	<ul style="list-style-type: none"> Re-analyze to confirm failed. Re-prep and reanalyze BS and all samples in the associated prep batch for failed analytes, if sufficient sample material is available. NCR will be required for data reported Follow guidelines from SOP QS05
Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence.	No analytes detected $> LOD$.	<ul style="list-style-type: none"> Correct problem. Re-analyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.
MS	One per prep batch, if sample volume available.	Criteria listed within LIMS or specified by client.	<ul style="list-style-type: none"> Follow guidelines from SOP QS05
MSD	One per prep batch, if sample volume available.	Criteria listed within LIMS or specified by client.	<ul style="list-style-type: none"> Follow guidelines from SOP QS05

Table 2 - Method Quality Control Requirements Summary

QC Check	Minimum Frequency / Requirements	Acceptance Criteria	Corrective Action for Failures / Data Useability
DOC Study	<ul style="list-style-type: none"> • Initially per analyst prior to reporting data • Annually • Follow specific guidelines from section 16 for the preparation and analysis of DOC samples 	<ul style="list-style-type: none"> • Average percent recovery should be between 80-120%, with a 20% standard deviation. 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis
MDL Study	Once per year	<ul style="list-style-type: none"> • Calculated value must be less than the Spike level • 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis • Follow guidelines from SOP QS05
LOD Verification	Every quarter	<ul style="list-style-type: none"> • Parameter must be detected • the response must be 3-times the noise level 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis • Follow guidelines from SOP QS05
LOQ Verification	Every quarter	<ul style="list-style-type: none"> • Bias Requirement: Inorganics 50-150% • The LOQ value must be greater than the LOD value 	<ul style="list-style-type: none"> • Re-prep and / or re-analysis • Follow guidelines from SOP QS05

Table 3, Technical Completeness / Accuracy Checklist

1. Were all the QC check elements analyzed – refer to Table 2 of the SOP
2. Were the QC criteria met
3. In cases of failures, was there an NCR written
4. Were dilution factors applied correctly
5. Was the data uploaded into LIMS via direct upload – if yes, then was a cross check subset of the uploaded values performed
6. If the data was entered into LIMS manually, was a check of all entered values performed
7. Was the red marked data in LIMS checked for accuracy and the corresponding hard copy data documented appropriately
8. Were proper data qualifiers applied to the data in LIMS
9. Was the hard copy package checked for completeness to include all data for the sequence such that the data reviewer could reconstruct sample analyses and validate / approve the data

Table 4, Data Reviewers Checklist (Prior to approving data)

ANALYST DATA REVIEW CHECKLIST

Sample Number(s):
Batch Number(s):
Method: SW846 7471A/B, EPA245.5 (Mercury)

QA/QC Item	Yes	No	NA	Second Level Review
1. Were samples analyzed within USACE holding times?				
2. Was initial calibration curve QC criteria met?				
3. Was all continuing calibration criteria in control?				
4. Did any sample exceed the highest calibration standard? (If yes, were appropriate dilutions made to generate samples concentration within calibration range?)				
5. Did blank spike(BS) meet control limits?				
6. Did MS/MSD meet control limits?				
7. Was the preparation blank (BLK) below the project required detection limits?				
8. Did you return samples back to cold storage immediately after use?				
9. Was water bath temperature monitored/documentd and did you apply the thermometer correction factor?				
10. Sample preparation information is correct and complete.				

- 11. Analytical results are correct and complete. _____
- 12. The appropriate SOP's have been used and followed. _____
- 14. "Raw data" including all manual integration's have been correctly interpreted. _____
- 15. "Special" sample preparation and analytical requirements have been met. _____
- 16. Documentation complete (e.g., all anomalies in the analytical sequence have been documented, corrective action forms are complete. _____

Comments on any "No" response:

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

1.

EMPIRICAL LABS, LLC.
Record of SOP Review and Implementation

TRAINING TOPIC SOP104 Rev19 - Mercury Analysis in Soil/Sediment by Manual Cold Vapor Technique Methods SW846 7471A, 7471B, 245.5 & CLPILM 04.1

Group: Inorganic

ATTENDEES:						
	NAMES (print)	SIGNATURE	REMARK	DATE	TIME	INSTRUCTOR
1	KACU HUA	<i>[Signature]</i>		8/30/10	2:45	
2						
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**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

METALS: SOP 105

REVISION #: 16

EFFECTIVE DATE: 041110

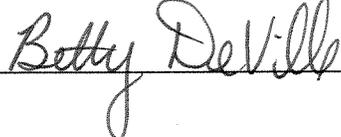
**METALS
BY INDUCTIVELY COUPLED PLASMA-ATOMIC EMISSION
SPECTROMETRY (ICP-AES) TECHNIQUE**

**References: SW-846, Method 6010B, December 1996; SW-846, Method 6010C, Revision 3
February 2007; USEPA, Method 200.7, June 1991; Standard Methods 19th Edition 2340B;
1995 USEPA CLP, ILM 04.1. See Addendum for USEPA CLPILM 05.2**

APPROVALS:

Lab Director:  Date: 4/12/10

Data Quality Manager:  Date: 4/11/10

Section Supervisor:  Date: 4/13/10

Changes Summary

Revision 16, 04/11/10

- The SOP is an update from Revision 15 dated 05/08/09
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

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16. Method Performance
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1. Identification of the Test Method

This SOP is compliant with methods – SW846 6010B, SW846 6010C, EPA 200.7, (SM 19th Edition 2340B) Hardness Calculation, (USEPA CLP) ILMO 4.1 (NJDEP does not accept CLPILM 04.1 after June, 2003) and Addendum for USEPA CLPILM 05.2.

2. Applicable Matrix or Matrices

This SOP is applicable to all matrices, including ground water, aqueous samples, TCLP, SPLP and EP extracts, industrial and organic wastes, soils, sludge samples, sediments, and other solid wastes, require digestion prior to analysis.

3. Detection Limit: Detection limits, sensitivity, and optimum ranges of the metals may be found in the ICP method file.

4. Scope of Application, Including components to be Analyzed

Each parameter that is analyzed and reported under the scope of this SOP is listed in **Table 1** of this SOP. This table also lists the associated Method Detection Limit and the Reporting Limit (also defined as the Limit of Quantitation).

5. Summary of the Test Method

5.1 Prior to analysis, samples must be solubilized or digested using appropriate Sample Preparation Methods (e.g., Methods 3005-3050 and SOW ILM 04.1/05.2). When analyzing for dissolved constituents, acid digestion is not always necessary if the samples are filtered and acid preserved prior to analysis. If particulates form after filtration and preservation the sample must be digested prior to analysis.

NOTE: When selenium is required soluble samples must always be digested.

5.2 This method describes the simultaneous multi-elemental determination of elements by ICP. The method measures element-emitted light by optical spectrometry. Samples are nebulized and the large droplets are removed by a spray chamber and the small droplets then pass through to the plasma. The solvent is evaporated. The residual sample decomposed to atoms and ions that become excited and emit characteristic light which is measured, giving a measurement of the concentration of each element type in the original sample. Background correction is required for trace element determination. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background-intensity measurement, on either or both sides of the analytical line, will be determined by the complexity of the spectrum adjacent to the analyte line. The position used must be free of spectral interference and reflect the same change in background intensity as occurs at the analytic wavelength measured. Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. Control of the spectrometer is provided by PC based *ITEVA* software.

5.3 Inductively Coupled Argon Plasma (ICAP) primary advantage is that it allows simultaneous determination of any elements in a short time. The primary disadvantage of ICP is background radiation from other elements and the plasma gases. Although all ICP instruments

utilize high-resolution optics and background correction to minimize these interferences, analysis for traces of metals in the presence of a large excess of a single metal is difficult. Examples would be traces of metals in an alloy or traces of metals in a limed (high calcium) waste. ICP and Flame AA have comparable detection limits (within a factor of 4) except that ICP exhibits greater sensitivity for refractories (Al, Ba, etc.). Furnace AA, in general, will exhibit lower detection limits than either ICP or FAA.

5.4 It is standard procedure to use an internal standard (scandium) with samples to increase the stability of the instrument as recommended by the manufacturer (Thermo Fisher). (When samples are suspected of containing scandium, internal standard cannot be used.)

6. Definitions

Laboratory Quality System SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.

Additional definitions specific to this SOP are listed below:

- 6.1 **ICP or ICAP**- Inductively Coupled Plasma or Inductively Coupled Argon Plasma.
- 6.2 **Inter-element correction (IEC)**- Defined as a correction factor applied by the instrument when there is an overlap of the spectrum from the plasma gases or from another metal into the spectrum of another metal causing that metals concentration to either be inflated or deflated.

7. Interferences

7.1 Spectral interferences are caused by background contribution from continuum or recombination phenomena, stray light from the line emission of high-concentration elements, overlap of a spectral line from another element, or unresolved overlap of molecular band spectra.

- 7.1.1. Background emission and stray light can usually be compensated for by subtracting the background emission determined by measurements adjacent to the analyte wavelength peak. Spectral scans of samples or single element solutions in the analyte regions may indicate when alternate wavelengths are desirable because of severe spectral interference. These scans will also show whether the most appropriate estimate of the background emission is provided by an interpolation from measurements on both sides of the wavelength peak or by measured emission on only one side. The locations selected for the measurement of background intensity will be determined by the complexity of the spectrum adjacent to the wavelength peak. The locations used for routine measurement must be free of off-line spectral interference (inter-element or molecular) or adequately corrected to reflect the same change in background intensity as occurs at the wavelength peak. For multivariate methods

using whole spectral regions, background scans should be included in the correction algorithm. Off-line interferences are handled by including spectra on interfering species in the algorithm.

7.1.2. To determine the appropriate location for off-line background correction, the user must scan the area on either side adjacent to the wavelength and record the apparent emission intensity from all other method analytes. This spectral information must be documented and kept on file. The location selected for background correction must be either free of off-line inter-element spectral interference or a computer routine must be used for automatic correction on all determinations. If a wavelength other than the recommended wavelength is used, the analyst must determine and document both the overlapping and nearby spectral interference effects from all method analytes and common elements and provide for their automatic correction on all analyses. Tests to determine spectral interference must be done using analyte concentrations that will adequately describe the interference. Normally, 100 mg/L single element solutions are sufficient; however, for analytes such as iron that may be found at high concentration, a more appropriate test would be to use a 200 mg/L or 500 mg/L concentration near the upper analytical range limit.

7.1.3. Spectral overlaps may be avoided by using an alternate wavelength or can be compensated by equations that correct for inter-element contributions. Instruments that use equations for inter-element correction require the interfering elements be analyzed at the same time as the element of interest. When operative and uncorrected, interferences will produce false positive determinations and be reported as analyte concentrations. More extensive information on interferant effects at various wavelengths and resolutions is available in reference wavelength tables and books. Users may apply inter-element correction equations determined on their instruments with tested concentration ranges to compensate (off line or on line) for the effects of interfering elements. Some potential spectral interferences observed for the recommended wavelength are listed in the method in table 2. For multivariate methods using whole spectral regions, spectral interferences are handled by including spectra of the interfering elements in the algorithm. The interferences listed are only those that occur between method analytes. Only interferences of a direct overlap nature are listed. These overlaps were observed with a single instrument having a working resolution of 0.035 nm.

7.1.4. When using inter-element correction equations, the interference may be expressed as analyte concentration equivalents (i.e. false analyte concentrations) arising from 100 mg/L of the interference element. For example, assume that Arsenic is to be determined (at 193.696 nm) in a sample containing approximately 10 mg/L of Aluminum. According to Table 2 from the method, 100 mg/L of Aluminum would yield a false signal for Arsenic equivalent to approximately 1.3 mg/L. Therefore, the presence of 10 mg/L of Aluminum would result in a false signal for Arsenic equivalent to approximately 0.13 mg/L. The user is cautioned that other instruments may exhibit somewhat different levels of interferences than that shown in Table 2 from the method. The

interference effects must be evaluated for each individual instrument since the intensities will vary.

7.1.5. Inter-element corrections will vary for the same emission line among instruments because of differences in resolution, as determined by the grating, the entrance and exit slit widths, and by the order of dispersion. Inter-element corrections will also vary depending upon the choice of background correction points. Selecting a background correction point where an interfering emission line may appear should be avoided when practical. Inter-element corrections that constitute a major portion of an emission signal may not yield accurate data. Users should not forget that some samples may contain uncommon elements that could contribute spectral interferences.

7.1.6. The interference effects must be evaluated for each individual instrument. For each instrument, intensities will vary not only with optical resolution but also with operating conditions (such as power, viewing height and argon flow rate). When using the recommended wavelengths, the analyst is required to determine and document for each wavelength the effect from referenced interferences as well as any other suspected interferences that may be specific to the instrument or matrix. The instrument utilizes a computer routine for automatic correction on all analyses.

7.1.7. If the correction routine is operating properly, the determined, apparent analyte(s) concentration from analysis of each interference solution should fall within a specific concentration range around the calibration blank. The concentration range is calculated by multiplying the concentration of the interfering element by the value of the correction factor being tested and divided by 10. If after the subtraction of the calibration blank the apparent analyte concentration falls outside of this range in either a positive or negative direction, a change in the correction factor of more than 10% should be suspected. The cause of the change should be determined and corrected and the correction factor updated. The interference check solutions should be analyzed more than once to confirm a change has occurred. Adequate rinse time between solutions and before analysis of the calibration blank will assist in the confirmation.

7.1.8 When inter-element corrections are applied, their accuracy should be verified, daily, by analyzing spectral interference check solutions (IFA/IFB). If the correction factors or multivariate correction matrices tested on a daily basis are found to be within 20% criteria for 5 consecutive days, the required verification frequency of those factors in compliance may be extended to a weekly basis. Also, if the nature of the samples analyzed is such they do not contain concentrations of the interfering elements at \pm one reporting limit from zero, daily verification is not required. All inter-element spectral correction factors or multivariate correction matrices must be verified and updated every six months or when an instrumentation-change, such as in the torch, nebulizer, injector, or plasma conditions occurs.

Standard solution should be inspected to ensure that there is no contamination that may be perceived as a spectral interference.

7.2. Physical interferences are effects associated with the sample nebulization and transport processes. Changes in viscosity and surface tension can cause significant inaccuracies, especially in samples containing high dissolved solids or high acid concentrations. If physical interferences are present, they must be reduced by diluting the sample or by using a peristaltic pump, by using an internal standard or by using a high solids nebulizer. Another problem that can occur with high dissolved solids is salt buildup at the tip of the nebulizer, affecting aerosol flow rate and causing instrumental drift. The problem can be controlled by wetting the argon prior to nebulization, using a tip washer, using a high solids nebulizer or diluting the sample. Also it has been reported that better control of the argon flow rate, especially to the nebulizer, improves instrument performance: this may be accomplished with the use of mass flow controllers.

7.3. Memory interferences result when analytes in a previous sample contribute to the signals measured in a new sample. Memory effects can result from sample deposition on the uptake tubing to the nebulizer and from the build-up of sample material in the plasma torch and spray chamber. The site where these effects occur is dependent on the elements and can be minimized by flushing the system with a rinse blank between samples. The possibility of memory interferences should be recognized

7.4 Users are advised that high salt concentrations can cause analyte signal suppressions and confuse interference tests. When the instrument displays negative values, dilution of the samples may be necessary.

8. Safety

Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed lab-wide.

8.1 Normal accepted laboratory safety practices should be followed while performing this analysis.

8.1.1. Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of appropriate safety gloves and lab coats is highly recommended.

8.1.2 Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples that need special consideration have applicable notes on the sample logs.

8.1.3 MSDS sheets are available for all reagents and standards that have been purchased. These are located in the bookshelves in the Quality Assurance Officers office.

9. Equipment & Supplies

- 9.1. Inductively coupled argon plasma emission spectrometer: Thermo Scientific 6500 DUO.
- 9.2. Computer-controlled emission spectrometer with background correction: Thermo Scientific 6500 DUO or equivalent.
- 9.3. Radio frequency generator compliant with FCC regulations: Thermo Fisher or equivalent.
- 9.4. Auto-sampler: Thermo Fisher or equivalent.
- 9.5. Printer capable of printing results every 4 minutes.
- 9.6. Cooling Water recycler.
- 9.7. Iteva software.
- 9.8. Argon gas supply – Liquid Argon
- 9.9. Class A volumetric flasks
- 9.10. Analytical balance - capable of accurate measurement to a minimum of three significant figures (0.001 gm).
- 9.11. Variable Eppendorf Pipettes 1000 μ L; 5000 μ L
- 9.12. Disposable beakers 10, 20 and 50 mL size.
- 9.13. Hood system capable of venting the heat from the system off of the instrument during analysis.

10. Reagents and Standards

The laboratory's LIMS system allows for complete documentation and for the traceability of reagents and standards used within the laboratory. The following information relates to the specific reagents and standards used for the performance of the method:

- 10.1. Reagent Water. All references to water in the method refer to reagent grade water unless otherwise specified. Reagent water will be interference free.
- 10.2. Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. If the purity of a reagent is in question analyze for contamination. If the concentration is less than the MDL then the reagent is acceptable.

10.3. Hydrochloric acid (concentrated), HCl. A method blank is digested and analyzed before a new lot number of HCl is put into use, to ascertain purity. The lot # is logged into Element and the data kept on file.

10.4. Nitric acid (concentrated), HNO₃. A method blank is digested and analyzed before a new lot number of HNO₃ is put into use, to ascertain purity. The lot # is logged into Element and the data kept on file.

10.5. Calibration standards

10.5.1. All standards have an acid matrix of 2% HNO₃ and 5% HCl and should be prepared using class A volumetric flasks and calibrated Eppendorfs).

10.5.2. CAL1 is the calibration blank: Reagent grade water **matrix matched as in 10.5.1. Note: when this standard is analyzed the intensities should be compared to a previous run to make sure that no contamination has occurred. Prepare this solution fresh daily.**

10.5.3. Stock QC21 solution: (100 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element and includes the following metals - Sb, As, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, Se, Sr, Tl, Ti, V, and Zn.

10.5.4. Stock QC7 solution: Order from the manufacturer already prepared. This solution is given a unique identifier within Element and includes the following metals- (50 ug/mL)- silver; (100 ug/mL)- aluminum, boron, barium and sodium; (1000 ug/mL)- potassium; (500 ug/mL or 100 ug/mL note we use two sources of this standard and each have different concentrations for Si) –Silica.

10.5.5. Boron solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.6. Stock Tin solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element. Note: Two sources are needed.

10.5.7. Stock Silver solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.8. Stock Aluminum solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element. Note: Two sources are needed.

- 10.5.9. Stock Calcium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier. Note: Two sources are needed.
- 10.5.10. Stock Magnesium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element. Note: Two sources are needed.
- 10.5.11. Stock Iron solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element. Note: Two sources are needed.
- 10.5.12. Stock Potassium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element. Note: Two sources are needed.
- 10.5.13. Stock Barium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.14. Stock Sodium solution: (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element. Note: Two sources are needed.
- 10.5.15. Stock Arsenic solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.16. Stock Cobalt solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.17. Stock Chromium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.18. Stock Copper solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.19. Stock Manganese solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.20. Stock Nickel solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.21. Stock Lead solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.
- 10.5.22. Stock Selenium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.23. Stock Thallium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.24. Stock Beryllium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.25. Stock Cadmium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.26. Stock Antimony solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.27. Stock Molybdenum solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.28. Stock Strontium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.29. Stock Titanium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.30. Stock Vanadium solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.31. Stock Zinc solution: (1000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.5.32. Stock Scandium solution (10000 ug/mL). Order from the manufacturer already prepared. This solution is given a unique identifier within Element.

10.6. Calibration and Calibration Verification standards

10.6.1. The calibration standards and calibration verification standards preparations are recorded in Element. Please find method of preparation in Appendix I.

10.6.2. The CRL solution is analyzed to check the accuracy of the instrument at the reporting limit. The stock standard solutions A and B are prepared from single element standards listed in 10.5 above. Please find method of preparation in Appendix I. This solution is stable for 6 months. The working solutions are made up as needed or every 3 months as follows: Prepared by adding 1.0 ml of RL Stock solution A and 1.0 ml of RL Stock Solution B to de-ionized water with 2% HNO₃ and 5% HCL matrix and diluting to 100 mLs , mix well. This solution is stable for 3 months.

10.6.3. The interference check standard solutions (IFA and IFB) are prepared to provide an adequate test of the IECs. A purchased solution containing 500

ug/mL Al, Ca, Mg and 200 ug/mL Fe is diluted 10x to prepare the IFA. The IFB is prepared by diluting 100x a purchased solution containing 10 ug/mL of As and Tl; 20 ug/mL Ag; 50 ug/mL Ba, Be, Cr, Co, Cu, Mn, and V; 100 ug/mL Cd, Ni and Zn; 5 ug/mL Pb and Se; and 60 ug/L Sb. Add to this a purchased solution containing 500 ug/mL Al, Ca, Mg and 200 ug/mL Fe diluted 10x. These solutions are prepared as needed or monthly and assigned an Element # for traceability.

10.7 Digestion standards

10.7.1 The Blank Spike (BS) is prepared from High Purity solutions CLP-CAL-1 solution A and B; CLP-CAL-2 and CLP-CAL-3. 0.50 mL of CLP-CAL-1 A and B; and 0.50 mLs of the 1000 ug/mL single element standards for Molybdenum, Boron, Titanium and Strontium is diluted to 500 mL with 0.125 mL of CLP-CAL-2 and CLP-CAL-3 and 0.050 mLs of 10000 ug/mL Tin. 25 mL of HCl and 10 mL of HNO₃ are added for preservation. This solution is stored in a Teflon bottle. A portion is reserved in case of a problem with digestion. When there is a problem with the analysis of the BS the solution is checked first before action is taken to make sure that it was made properly and has not deteriorated since it was made up. This solution is given a unique identifier within Element. The BS is prepared from a source independent from that used in the calibration standards. This solution is prepared daily or as needed. 50 mLs of this solution is used for digestion for normal level water samples and the sample is brought back to 50 mLs after digestion. Low level water samples start with two 50 mLs vials with only 1.0 mL of the stock blank spike solution in each taken to 50 mLs. The samples are cooked down to below 25 mLs and combined and then cooked down to below 25 mLs again and then brought back to 25 mLs. This low level BS is given a unique identifier in Element.

10.7.2. The solid BS used with soil samples is prepared by weighing up 1.0 gram of Teflon chips for regular level and 2.0 grams of Teflon chips for low level and spiking using the same spiking solutions used to spike the sample matrix. This standard is given a unique identifier i.e. Batch #-BS1. Note: Amount of spiking solution used varies according to whether the samples are being digested for normal level or low level soils. See spiking solutions in 10.7.3.1 for how to prepare the BS for a solid sample, it is prepared the same way that a soil spike is prepared only the known amounts of metals are added to laboratory water.

10.7.3. The spiking solutions are prepared as follows:

10.7.3.1. Stock Multi-element Spiking Solutions: High Purity CLP-CAL-1 solution A: 2000 ug/mL Al and Ba; 50 ug/mL Be; 200 ug/mL Cr; 500 ug/mL Co, Mn, Ni, V and Zn; 250 ug/mL Cu; 1000 ug/mL Fe; 5000 ug/mL Ca, Mg, K and Na; solution B: 250 ug/mL Ag; CLP-CAL-2: 1000 ug/L Sb; CLP-CAL-3: 1000 ug/mL As, Pb, Se, Tl; 500 ug/mL Cd. Order from the manufacturer already prepared. These solutions are given a unique identifier within Element. Add 0.050 mL for water samples and 0.20 mL for normal level soil samples and 0.10 for low

level soil samples of CLP-CAL-1 solutions A and B, and 0.0125 mL for water samples and 0.05 mLs for normal level soil samples and 0.025 mLs for low level soil samples of CLP-CAL-2 and 3 to 50 mL of sample for water samples and 1 gram of sample for normal level soils and 2 grams of sample for low level soils for the following spike values: 2000 ug/L Al and Ba; 50 ug/L Be; 200 ug/L Cr; 500 ug/L Co, Mn, Ni, V and Zn; 250 ug/L Cu; 1000 ug/L Fe; 5.0 mg/L Ca, Mg, K and Na, 250 ug/L Ag, Sb, As, Pb, Se and Tl; 125 ug/L Cd. A blank spike should be prepared at the time the samples are spiked to check the actual spike value and accuracy.

10.7.3.2. TCLP Spiking Solution: Use 0.50 mL diluted to 50 mL for digestion:

2.5 mL 10000 mg/L Ba stock standard diluted to 100 mL; 2.5 mL Cr, Pb and As 1000 mg/L stock standard diluted to 100 mL; 0.50 mL Cd and Se diluted to 100 mL. Store in a Teflon bottle. A blank spike should always be prepared at the same time a sample is being spiked. This solution should produce a spike value of 2500 ug/L Ba; 250 ug/L Cr, Pb and As; and 50 ug/L of Cd and Se. Note: Since the samples are diluted 10x when digested the spike value will appear to be 10x greater when analyzed.

10.7.3.3. TCLP Silver Spiking Solution: Use 5.0 mL diluted to 50 mL for digestion:

0.40 mL of 1000 mg/L stock Ag solution diluted to 200 mL. Store this solution in a Teflon bottle. A blank spike should always be prepared at the same time a sample is being spiked. This solution should produce a spike value of 200 ug/L. Note: Since the samples are diluted 10x when digested the spike value will appear to be 10x greater when analyzed. Also this solution is not very stable and may require fresh preparation at least weekly.

11. Sample Collection, Preservation, Shipment, and Storage

Quality Systems SOP QS10 related to Sample Receipt, Handling, & Processing provides details for collection, preservation, shipment, and storage.

11.1. Preliminary treatment of most matrices is necessary because of the complexity and variability of sample matrices. Water samples which have been pre-filtered and acidified will not need acid digestion as long as the samples and standards are matrix matched and particulates do not form after the filtration and preservation take place. Solubilization and digestion procedures are presented in Sample Preparation Methods (Methods 3005A-3050A).

11.2. Sample digestates are stored at room temperature for at least 2 months unless a longer time is requested by the client. The samples contain an acid matrix of 3:1. All metal samples are neutralized before disposal in the receiving section of the laboratory.

11.3. The appropriate SOPs should be consulted regarding sample preparation. The following is a brief summary of the methods we use for metals preparation.

11.3.1. Method 3005A prepares groundwater and surface water samples for total recoverable and dissolved metals determination by ICP. The unfiltered or filtered sample is heated with dilute HCl and HNO₃ prior to metal determination.

11.3.2. Method 3010A prepares waste samples for total metal determination by ICP. The samples are vigorously digested with a mixture of nitric acid and hydrochloric acid followed by dilution with laboratory water. The method is applicable to aqueous samples, TCLP and mobility-procedure extracts.

11.3.3. Standard Methods 19th Edition Method 3030C prepares ground-waters and surface water samples for acid extractable metals: (lead and chromium.) This preparation has a holding time of 72 hours. The samples are preserved at collection with 5mL/L of HNO₃, in the laboratory 5 mL/100mL of 1+1 HCl is added and the sample is heated for 15 minutes in a block digester. The sample is filtered through a membrane filter and the filtrate is carefully transferred to a volumetric flask and brought back to 100 mLs.

11.3.4. Method 3050B prepares wastes samples for total metals determination by ICP. The samples are vigorously digested in nitric acid and hydrogen peroxide followed by dilution with either laboratory water or hydrochloric acid and laboratory water. The method is applicable to soils, sludges, and solid waste samples.

12. Quality Control

Quality Systems SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” outlines details related to laboratory wide protocols on quality control.

12.1. Daily run and batch QC

12.1.1. Calibration is required daily. Either a blank and a high standard or a client specific three standard concentration points and a blank calibration is required daily.

12.1.2. IEC correction standards for aluminum and iron are required daily.

12.1.3. ICV within $\pm 5\%$ for 200.7 and within $\pm 10\%$ for all other methods.

12.1.4. ICB/CCB less than two times \pm MDL or less than \pm LOD for DOD. The ICB/CCB must immediately follow the ICV/CCV.

12.1.5. RL standard run against the curve within $\pm 20\%$ initially and client specific requirement of $\pm 30\%$ at the end of the analysis.

12.1.6. IFA/IFB analyzed daily. IFA must be less than two times \pm MDL or less than \pm LOD unless verified standard contamination for DOD. The IFB must recover within \pm 20% for all analytes in the IFB standard solution. If the IFA/IFB solution is not within the required limits- if possible reanalyze all associated samples, if not possible to reanalyze all associated samples must be flagged with an "Q" on the final report for DOD.

12.1.7. CCV must be analyzed every ten samples or at the end of the analysis within \pm 10% or the samples are reanalyzed if possible. If samples cannot be reanalyzed, all samples are flagged with a "Q" for DOD.

12.1.8. CCB must be analyzed every ten samples immediately following the CCV or at the end of the analysis less than two times \pm MDL or $<\pm$ LOD for DOD. If the CCB is out of the allowable range the samples are flagged with "B".

12.1.9. *The following should be analyzed with each preparation batch containing a matrix spike.*

- Serial dilution: If the analyte concentration is sufficiently high (minimally, a factor of 50 above the instrumental detection limit after dilution), an analysis of a 1:4 dilution (volumetric glassware must be used) should agree within \pm 10% of the original determination. If not, a chemical or physical interference effect should be suspected. The analyst and or section manager must note this situation on the final analytical report.
- Post digestion spike addition: An analyte spike added to a portion of a prepared sample, or its dilution, should be recovered to within 75% to 125% of the known value for SW6010B and 80 to 120% for SW6010C and is required especially if the pre-digestion matrix spike is outside of control limits. The spike addition should produce a minimum level of 10 times and a maximum of 100 times the instrumental detection limit. If the spike is not recovered within the specified limits, a matrix effect should be suspected. Run all associated samples in the preparatory batch by method of standard additions (MSA) or apply "J" flag. The analyst and or section manager must note this situation on the final analytical report. Apply "J" flag if the post spike is outside the range of 75 to 125% for 6010B or 80 to 120% for 6010C.

12.2 Quarterly and/or every six months

12.2.1. Linear range standards must be analyzed at a frequency no less than once every six months. The linear range standard is required for verification that samples are actually linear to the degree claimed. The analyst is responsible for completing this task in a timely manner. The linear range standard must be within \pm 10% of true value. This standard can be analyzed as the linear dynamic range.

12.2.2. The inter-element correction factors (IEC) should be verified at the time the linear range standards are analyzed or whenever there is any question about whether an IEC is correcting correctly.

12.2.3. IDL's, linear range and IEC checks must be performed quarterly if straight CLP work is required.

12.3. Digested Batch QC

12.3.1. All quality control data should be maintained and available for easy reference or inspection.

12.3.2. Employ a minimum of one method blank per sample batch to determine if contamination or any memory effects are occurring. A method blank (BLK), sometimes referred to as the preparation blank is a volume of reagent water acidified with the same amounts of acids as were the standards and samples. These blanks are taken through the same digestion/preparation steps as the sample being tested. The result for the method blank should not indicate contamination greater than $\pm \frac{1}{2}$ RL for DOD or \pm RL/CRDL for other or CLP. If exceeded, the impact upon the data should be evaluated and the associated sample(s) should be either re-digested or the data should be qualified. The extracted blank associated with TCLP batches must be less than 100 X the regulatory limit for barium.

12.3.3. Employ a minimum of one blank spike (BS) for aqueous samples or one Teflon chip spiked sample per sample batch to verify the digestion procedure. These blank spikes are taken through the same digestion/preparation steps as the sample being tested. The control limits are $\pm 15\%$ method 200.7 - aqueous and soil samples or $\pm 20\%$ for all other methods aqueous and soil samples. If the BS is not in control, the impact upon the client data should be evaluated and the associated sample(s) should be re-digested. Consult your supervisor for further action. Qualifying the associated data may not be permissible for some clients.

12.4. Sample

12.4.1. Analyze one replicate sample for every twenty samples or per analytical batch, whichever is more frequent. A replicate sample is a sample brought through the whole sample preparation and analytical process in duplicate. It is acceptable to substitute a matrix spike duplicate for the sample replicate. Project specific requirements will take precedence in these situations. NJDEP demands that this requirement be met with a client specific duplicate rather than a spike duplicate. The control limits are less than or equal to 20% RPD (if both are $>5x$ RL) or \pm the RL (if either are $<5x$ RL). Supervisor must be notified if the control limit is not met. Supervisor will dictate corrective action if required. The final analytical report must document this situation. Apply "J" flag for DOD if acceptance criteria are not met. Apply "*" flag for CLP and other work if acceptance criteria are not met.

12.4.2. Analyze a minimum of one spiked sample and/or spiked sample duplicate for every twenty samples or per analytical batch, whichever is more frequent. Project

specific requirements will take precedence in determining whether a matrix spike duplicate is employed in these situations. If the analyte level in the sample is not greater than 4X the spiking level, the spike recoveries should be within $\pm 20\%$ of the true value. If not, and sufficient sample volume exist, a post digestion spike should be analyzed. Apply “J” flag for DOD if acceptance criteria are not met. Apply “N” flag or CLP and other work if acceptance criteria are not met.

13. Calibration and Standardization

Quality Systems **SOP QS08** “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.

- 13.1. Set up the instrument with proper operating parameters. The instrument must be allowed to become thermally stable before beginning (usually requiring at least 30 minutes of operation prior to calibration).
- 13.2. Operating conditions - **The instrument settings can be found in method file within the iTEVA software.** For operation with organic solvents, use of the auxiliary argon inlet is recommended, as are solvent-resistant tubing, increased plasma (coolant) argon flow, decreased nebulizer flow, and increased RF power to obtain stable operation and precise measurements. Sensitivity, instrumental detection limit, precision, linear dynamic range, and interference effects must be established for each individual analyte line on that particular instrument. The analyst must (1) verify that the instrument configuration and operating conditions satisfy the analytical requirements and (2) maintain quality control data confirming instrument performance and analytical results.
- 13.3. Auto-peak when some change has been made to the introductory system and calibrate the instrument according to the instrument manufacturers recommended procedures, using the specified calibration standard solutions. Flush the system with 2% HNO₃ / 5% HCl between each standard or as the manufacturer recommends. (Use the average intensity of multiple exposures for both standardization and sample analysis to reduce random error.) The calibration curve consists of a blank and three standards ($r \geq 0.998$). If a three point calibration curve is not required for the client samples being analyzed by Empirical Laboratories may use a blank and one standard as referenced in USEPA - CLP protocols.
- 13.4. Before beginning the sample run, analyze single element Iron and Aluminum standards at their linear range to check for IEC drifts. Analyze these standards first as QC samples with an IEC check table and action taken should be to calculate IECs using the iTEVA software. Make sure to rinse thoroughly after running these linear range standards, they can cause carry over into the initial QC samples which are analyzed next. The analysis order follows as: ICV ($\pm 10\%$) for 200.7 ($\pm 5\%$) and ICB ($< \pm 2 \times \text{MDL}$, $< \pm \text{LOD-DOD}$ or $\pm \text{RL/CRDL}$ for others or CLP, first, then analyze a reporting limit standard (a standard at the concentration of the reporting limit). This standard should be within $\pm 20\%$ for DOD projects and $\pm 30\%$ for samples analyzed for 6010C. Then reanalyze the

highest mixed calibration standard(s) as if it were a sample. Concentration values obtained should not deviate from the actual values by more than 5%. If they do, follow the recommendations of the instrument manufacturer to correct for this condition. Note: Supervisor must be notified if the control limit is not met. Supervisor will dictate corrective action if required. The final analytical report must document this situation.

13.5. For **CLP projects**, verify the validity of the curve in the region of 2x the contract required detection limit (CRDL) before and after each batch of 20 samples in the specific order of CRI, ICSA, ICSAB, CCV and CCB (CCB criteria: $< \pm\text{MDL}$ or $\pm\text{RL}/\text{CRDL}$ for others or CLP, or twice during every 8-hour work shift, whichever is more frequent. Results should be within $\pm 20\%$. Supervisor must be notified if the control limit is not met. Supervisor will dictate corrective action if required. The final analytical report must document this situation. (For Internal QC)

13.6. Verify the inter-element and background correction factors at the beginning of the sequence in the specific order of IFA, IFB, CCV and CCB (IFA criteria: non-spiked analytes $< \pm 2 \times \text{MDL}$ or $< \pm \text{LOD}$ for DOD beginning of sequence. Do this by analyzing the interference check solution IFA and IFB. Absolute value of concentration for all non-spiked analytes in the IFA must be $< \text{LOD}$ (unless they are verified trace impurity from one of the spiked analytes) for DOD. Results must be within $\pm 20\%$ of the true value for IFB. If corrective action fails, apply Q-flag to all results for specific analyte(s) in all samples associated with the ICS. (CRI, ICSA and ICSAB required at the end for CLP projects only).

Note: Supervisor must be notified if the control limit is not met. Supervisor will dictate corrective action if required. The final analytical report must document this situation.

13.7. The instrument must be calibrated once every 24 hours.

13.8. Instrument Autosampler Report example:

Calibration Rack (used by instrument software to insert QC)

- 1) Cal Std 1 (blank)
- 2) Cal Std 2 (Low Cal)
- 3) Cal Std 3 (Mid Cal)
- 4) Cal Std 4 (Ba @ 5000 ppb)
- 5) Cal Std 5 (QC5)
- 6) Cal Std 6 (QC 21)
- 7) Cal Std 7 (NAK 100)
- 8) Cal Std 8 (QC3)
- 9) Cal Std 9 (Ag)
- 10) Al IEC-(correction using ITEVA software)
- 11) Fe IEC-(correction using ITEVA software)

Sample Sequence RACK 1

- 1) SEQ-ICV
- 2) SEQ-ICB
- 3) SEQ-CRL1-reporting limit standard 1
- 4) SEQ-CRL2-reporting limit standard 2
- 5) Ba@ 5000 ppb (readback)
- 6) QC5
- 7) NAK High-(readback)
- 8) QC 21 High-(readback)
- 9) Salt Cal at 500 ppm (readback)
- 10) Rinse
- 11) SEQ-IFA1
- 12) SEQ-IFB1
- 13) Rinse
- 14) SEQ-CCV
- 15) SEQ-CCB
- 16) Method Blank (*Batch # -BLK1*)
- 17) Blank Spike (*Batch # -BS1*)
- 18) Sample 1
- 19) Sample 2
- 20) Sample 3
- 21) Sample 4
- 22) Sample 5
- 23) Sample 6
- 24) Sample 7
- 25) Sample 8
- 26) Sample 9
- 27) Sample 10
- 28) SEQ-CCV
- 29) SEQ-CCB
- 30) Sample 11
- 31) Sample 12
- 32) Sample 13
- 33) Sample 14
- 34) Sample 15
- 35) Sample 16
- 36) Sample 17
- 37) Sample 18
- 38) Sample 19
- 39) Sample 20
- 40) Sample matrix spike (*batch#- MS1*)
- 41) Sample matrix spike duplicate (*batch# -MSD1*)
- 42) Sample post digestion spike (*batch# -PS1*)
- 43) Sample serial dilution (*batch# -DUP1*)
- 44) SEQ-CCV

- 45) SEQ-CCB
- 46) Preparation Blank (*batch# -BLK1*)
- 47) Blank Spike (*batch# -BS1*)
- 48) Sample 1
- 49) Sample 2
- 50) Sample 3
- 51) Sample 4
- 52) Sample 5
- 53) Sample 6
- 54) Sample 7
- 55) Sample 8
- 56) Sample 9
- 57) Sample10
- 58) SEQ-CCV
- 59) SEQ-CCB
- 60) Sample 11

RACK 2

- 1) Sample 12
- 2) Sample 13
- Etcetera...

Each rack holds 60 samples and there are 4 racks that are used for samples, CCVs and CCBs and run QC.

14. Procedure

14.1. Once the instrument has been calibrated, begin the analysis of samples.

14.2. If particulates are visible in the digestate, the sample must be filtered prior to analysis. If filtration is required, a filter blank must be prepared by filtering reagent grade water which has been properly acidified. **In the event USACE samples are filtered, all USACE samples and the QC samples in that QC batch must be filtered. All USACE solid samples and their associated batch QC samples must be filtered prior to analysis.**

14.3. Flush the system with 2% HNO₃ / 5% HCl for at least 1 minute before the analysis of each sample.

14.4. Dilute and reanalyze samples that are more concentrated than the linear calibration limit or, for 200.7, $\pm 10\%$ of the linear range standard. **In the case of USACE samples, the criterion changes and requires dilution and reanalysis of all samples which produce a concentration that exceeds the highest calibration standard. Sample results detected between the MDL and LOQ are flagged as estimated with a "J" flag.**

14.5. Verify calibration every 10 samples or every 2 hours, whichever is more frequent and at the end of the analytical run, using a continuing calibration verification (CCV) sample and a continuing calibration blank (CCB) sample.

14.5.1. The results of the CCV are to agree within $\pm 10\%$ for 6010 (5% for 200.7) on initial verification of the expected value, with relative standard deviation (RSD) $< 5\%$ from 3 replicates (minimum of three integrations). If not, terminate the analysis, correct the problem, and reanalyze the previous ten samples. The analyst may continue the analytical run, and after conferring with the section manager it may be necessary to reanalyze a group of samples. The analyst must notify the section manager within 24 hours.

14.5.2. The results of the calibration blank (this is not the method/preparation blank) are to be $< 2x \pm MDL$, for CLP $< RL$, for **DOD no analytes detected $> \pm LOD$** . If the calibration blank is not in control, evaluate the impact upon the previous 10 samples. Reanalysis may be required after an evaluation of the data. If the blank $< 1/10$ the concentration of the action level of interest and no sample is within 10% of the action limit, samples need not be reanalyzed. One must also evaluate the reporting limit (RL) as it relates to 3X the IDL/MDL. If the RL is significantly above 3X IDL or MDL then reanalysis may not be required (Na, K, Mg and Ca are good examples of this situation).

14.6. Demonstration of Capability (DOC) – Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP-413 for guidance.

15. Data Analysis and Calculations

Quality Systems SOP QS09 “General and commonly used Laboratory Calculations” provides details on general calculations used throughout the laboratory.

15.1. Total hardness is reported from HNO_3 preserved sample. The final concentration is calculated from the calcium and magnesium results as follows: $Ca \text{ mg/L} \times 2.5 + Mg \text{ mg/L} \times 4.1 = \text{total Hardness in mg/L as } CaCO_3$.

15.2. The instrument will generate data results in mg/L or $\mu\text{g/L}$ (labeled appropriately). Each result represents an average of three individual readings per metal channel.

15.3. For aqueous samples, if a post/pre-digestion dilution is performed, the result must be multiplied by this factor or the dilution factor must be entered into the instrument data table in which case the instrument will generate data corrected for the dilution.

15.4. For solid samples, if a post-digestion dilution is performed, the result must be multiplied by this factor or the dilution factor must be entered into the instrument data table in which case the instrument will generate data corrected for the dilution. Also, the result must be converted to reporting units which are usually mg/kg.

$$SR \text{ (ug/g or mg/kg)} = IR * DF * FED / SM$$

SR = Sample result
IR = Instrument result ($\mu\text{g/L}$)
DF = Dilution factor (post digestion)
FED = Final volume of digestate (L)
SM = Sample mass digested (g)

16. Method Performance

Demonstration of Capability (DOC): Each analyst must perform a DOC prior to reporting data. The analyst must prepare (for prep technicians) and analyze (analysts reviewing and reporting data) 4-LCS samples. The data is calculated for accuracy and precision requirements. The DOC form, as listed within section 2.5 of the Quality Manual is completed by each analyst and then provided to the supervisor for further processing and approval.

DOC LCS Preparation: See BS preparation under 10.7.1 through 10.7.3 above.

DOC Accuracy and Precision Criteria: The LOD is analyzed at 2 times the MDL and must result in an concentration 3 times the noise. The LOQ is analyzed at the RL or 2 times the RL and must be recovered within $\pm 50\%$.

17. Pollution Prevention:

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18. Data Assessment and Acceptance Criteria for Quality Control Measures

Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on data assessment and acceptance criteria for Quality Control Measures. Table 2 of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19. Contingencies for Handling out-of-control or unacceptable data

Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on handling out of control data. Table 2 within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

CORRECTIVE ACTIONS

19.1. INSTRUMENT RELATED

- 19.1.1. ICV not within $\pm 10\%$ or $\pm 5\%$ for 200.7
- a. Is the problem with the solution?
 - i. Re-prepare or obtain new stock.

- b. Is the problem with the calibration?
 - i. Recalibrate through analysis of appropriate standards and recheck ICV.
- 19.1.2. ICB not \pm MDL or within \pm 3X IDL or CRDL for CLP, **DOD no analytes detected >LOD**
- a. Is the problem with the solution?
 - i. Re-prepare
 - b. Is the problem with the calibration?
 - i. Recalibrate with the blank solution or the low level standard. Restart analysis with the ICV.
- 19.1.3. Check standards not within \pm 5%
- a. Is the problem with the solution?
 - i. Re-pour, re-prepare or obtain new stock.
 - b. Is the problem with the calibration?
 - i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.
- 19.1.4. CLP only-CRI not within \pm 20% (Internal QC, only required for CLP work).
- a. Is the problem with the solution?
 - i. Re-prepare or obtain new stock.
 - b. Is the problem with the calibration?
 - i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.
- 19.1.5. IFA metals not present are not less than the detection limit for that metal, **for IFA DOD, absolute value of concentration for all non-spiked analytes \leq LOD.**
- a. Is the problem with the solution?
 - i. Re-prepare or obtain new stock.
 - b. Is the problem with the calibration?
 - i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.
- 19.1.6. IFB not within \pm 20%
- a. Is the problem with the solution?
 - i. Re-prepare or obtain new stock.
 - b. Is the problem with the calibration?
 - i. Recalibrate thru analysis of appropriate standards. Restart analysis with the ICV.
- 19.1.7. CCV not within \pm 10%
- a. Is the problem with the solution?
 - i. Re-prepare or obtain new stock.
 - b. Is the problem with the calibration?
 - i. If appropriate, continue the analysis. Discuss effect of the out of control situation with your supervisor. The samples will be reanalyzed or the data will be qualified.

- 19.1.8.. CCB not $\pm 2 \times$ MDL or CRDL for CLP, DOD no analytes detected $> \pm$ LOD.
 - a. Is the problem with the solution?
 - i. Re-prepare
 - b. Is the problem with the calibration?
 - i. Re-calibrate and reanalyze.

19.2. DIGESTION RELATED

- 19.2.1. Preparation blank (BLK) not within $\pm \frac{1}{2}$ RL and \pm RL for common contaminants DOD or RL/CRDL for other or CLP
 - a. Is the problem with the instrument?
 - i. Evaluate with respect to instrumental bias or reanalyze when instrument is in control.
 - b. Is the problem with the digestion?
 - i. If associated samples are less than 10X the level of the preparation blank but above the RL, the sample must be re-digested or the data must be qualified on the final report.
- 19.2.2. BS not within control limits
 - a. Is the problem with the instrument?
 - i. Evaluate with respect to instrumental bias or reanalyze when instrument is in control.
 - b. Is the problem with the digestion?
 - i. If biased low, associated samples must be re-digested.
 - ii. If biased high, the impact upon the data user must be evaluated. The samples will be re-digested or the data will be qualified on the final report.

19.3. SAMPLE MATRIX RELATED

- 19.3.1. Replicate analysis RPD not within $\pm 20\%$ (if both are $> 5X$ CRDL) or \pm the CRDL (if either are $< 5X$ CRDL).
 - a. The associated sample data must be qualified on the final report.
- 19.3.2. Spike analysis recovery not within $\pm 20\%$.
 - a. Is the analyte level in the sample greater than 4X the spiking level?
 - i. If yes, the spike recovery is not evaluated.
 - ii. If no, a post digestion spike must be analyzed and the associated sample data must be qualified on the final report.
- 19.3.3. When required, post digestion spike analysis recovery not within $\pm 25\%$ for SW6010B, DOD or $\pm 20\%$ SW6010C.
 - a. The associated sample data must be qualified on the final report.
 - b. For USACE analysis by MSA is required.
- 19.3.4. Serial dilution analysis percent difference not within $\pm 10\%$
 - a. Is the analyte concentration a factor of 50 above the instrumental detection limit after dilution?

- i. If no, the serial dilution data can not be evaluated.
- iii. If yes, a chemical or physical interference effect should be suspected. The analyst and or section manager must note this situation on the final analytical report.

20. Waste Management

Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

21. References

21.1. *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Update III)*; Method 6010B and Method 6010C.

21.2. *USEPA Code of Federal Regulations, 40, CH 1,PT 136*; Method 200.7; APX-B.

21.3. *USEPA Contract Laboratory Program (CLP) for Inorganics ILM04.1; ILM05.2*

21.4. DOD Quality Systems Manual for Environmental Laboratories Version 4.1. (Based on NELAC Voted Revision June 5, 2003. 4/22/09

22. Tables, Diagrams, Flowcharts and Validation Data

Table 1 contains all applicable parameters with the applicable RL/LOQ, LOD and Detection Limit.

Table 1A, contains a list of the wavelengths used for each analyte.

Table 2, for all technical methods, contains the QA/QC summary table.

Table 3, Technical Completeness / Accuracy Checklist

Table 4, Data Reviewers Checklist

Table 1 Water				
Analyte	MDL	LOD	MRL	Units
Aluminum	50.0	100	200	ug/L
Antimony	5.00	8.00	15.0	ug/L
Arsenic	3.00	6.00	10.0	ug/L
Barium	5.00	10.0	40.0	ug/L
Beryllium	1.00	2.00	5.00	ug/L
Boron	10.0	20.0	30.0	ug/L
Cadmium	1.00	2.00	5.00	ug/L
Calcium	1000	2000	5000	ug/L
Chromium	2.00	4.00	10.0	ug/L
Cobalt	5.00	10.0	12.5	ug/L
Copper	4.00	8.00	10.0	ug/L
Iron	30.0	60.0	100	ug/L
Lead	1.50	3.00	3.00	ug/L
Magnesium	1000	3000	5000	ug/L
Manganese	3.00	6.00	15.0	ug/L
Molybdenum	5.00	10.0	15.0	ug/L
Nickel	3.00	6.00	10.0	ug/L
Potassium	1000	3000	5000	ug/L
Selenium	3.00	5.00	6.00	ug/L
Silver	1.00	2.00	10.0	ug/L
Sodium	1000	3000	5000	ug/L
Thallium	3.00	4.00	8.00	ug/L
Tin	10.0	20.0	30.0	ug/L
Titanium	5.00	10.0	15.0	ug/L
Vanadium	5.00	10.0	12.5	ug/L
Zinc	5.00	10.0	20.0	ug/L
Table 1 TCLP				
Analyte	MDL	LOD	MRL	Units
Antimony	0.00500	0.00800	0.0150	mg/L
Arsenic	0.00300	0.00600	0.0100	mg/L
Barium	0.00500	0.0100	0.0400	mg/L
Cadmium	0.00100	0.00200	0.00500	mg/L
Chromium	0.00200	0.00400	0.0100	mg/L
Copper	0.00400	0.00800	0.0100	mg/L
Lead	0.00150	0.00300	0.00300	mg/L
Selenium	0.00300	0.00500	0.00600	mg/L
Silver	0.00100	0.00200	0.0100	mg/L

Table 1 Soil				
Analyte	MDL	LOD	MRL	Units
Aluminum	10.0	20.0	40.0	mg/Kg
Antimony	1.00	1.60	3.00	mg/Kg
Arsenic	0.600	1.20	2.00	mg/Kg
Barium	1.00	2.00	8.00	mg/Kg
Beryllium	0.200	0.400	1.00	mg/Kg
Boron	2.00	4.00	6.00	mg/Kg
Cadmium	0.200	0.400	1.00	mg/Kg
Calcium	200	400	1000	mg/Kg
Chromium	0.400	0.800	2.00	mg/Kg
Cobalt	1.00	2.00	2.50	mg/Kg
Copper	0.800	1.60	2.00	mg/Kg
Iron	6.00	12.0	20.0	mg/Kg
Lead	0.300	0.600	0.600	mg/Kg
Magnesium	200	600	1000	mg/Kg
Manganese	0.600	1.20	3.00	mg/Kg
Molybdenum	1.00	2.00	3.00	mg/Kg
Nickel	0.600	1.20	2.00	mg/Kg
Potassium	200	600	1000	mg/Kg
Selenium	0.600	1.00	1.20	mg/Kg
Silver	0.200	0.400	2.00	mg/Kg
Sodium	200	600	1000	mg/Kg
Thallium	0.600	0.800	1.60	mg/Kg
Tin	2.00	4.00	6.00	mg/Kg
Titanium	1.00	2.00	3.00	mg/Kg
Vanadium	1.00	2.00	2.50	mg/Kg
Zinc	1.00	2.00	4.00	mg/Kg

TABLE 1A

METAL	WAVELENGTH
Aluminum	396.1
Antimony	206.8
Arsenic	189.0
Barium	233.5
Beryllium	313.0
Boron	249.7
Cadmium	228.8
Calcium	317.9
Chromium	267.7
Cobalt	228.6
Copper	324.7
Iron	261.1
Lead	220.3
Magnesium	279.0
Manganese	257.6
Molybdenum	202.0
Nickel	231.6
Potassium	766.4
Selenium	196.0
Silver	328.0
Sodium	589.5
Strontium	421.5
Thallium	190.8
Tin	189.9
Titanium	334.9
Vanadium	292.4
Zinc	206.2

Table 2 - Method Quality Control Requirements Summary

QC Check	Minimum Frequency / Requirements	Acceptance Criteria	Corrective Action for Failures / Data Useability
Interference Check	<ul style="list-style-type: none"> once per calibration 	<ul style="list-style-type: none"> IFA less than LOD if not verified contamination of standard. IFB must be within $\pm 20\%$. 	<ul style="list-style-type: none"> Check IEC corrections for metals in the IFA.
Calibration Curve	<ul style="list-style-type: none"> Prior to analyzing any samples A minimum of a blank and 3-points for linear fits client specific requirement or a blank and high standard. Low standard at the RL level run against the curve within 20% initially and within 30% for subsequent analysis (6010C). 	<ul style="list-style-type: none"> Linear calibration Corr. of 0.998 Must follow curve processing requirements from SOP QS08 	<ul style="list-style-type: none"> Re-evaluate curve mix and makeup Re-run curve Check instrument for maintenance needs Re-prepare the curve standards <p>Samples cannot be analyzed until there is a passing calibration</p>
ICB	At the beginning of every sequence	Must meet the $< \pm \text{LOD}$ for DOD or $< 2 \times \text{MDL}$	Re-run
ICV	Alternate source standard to be analyzed after every calibration curve	<ul style="list-style-type: none"> Must be in the range 90 to 110% for 6010B&C, or 95 to 115% for 200.7. 	<ul style="list-style-type: none"> Re-analyze an ICV from a different source Re-prepare and re-analyze the ICV Re-calibrate and verify standard preps and sources
CCV	<ul style="list-style-type: none"> At the beginning of every sequence For every 10-client samples 	<ul style="list-style-type: none"> Must be in the range 90 to 110% 	<ul style="list-style-type: none"> Samples must be reanalyzed if possible, if not samples are flagged with a "Q".
Closing CCV	<ul style="list-style-type: none"> At the end of every sequence 	<ul style="list-style-type: none"> Must be in the range 90 to 110% 	<ul style="list-style-type: none"> Samples must be reanalyzed if possible, if not samples are flagged with a "Q".
BLK	One per prep batch	<ul style="list-style-type: none"> Must be less than $\frac{1}{2} \pm \text{RL}$. 	<ul style="list-style-type: none"> Re-analysis to confirm the positive value Ascertain if there are any samples within the batch that meet the MB criteria and provide the information for the decision makers If results are between the LOD or RL/LOQ, then assess the data and notify the PM for further action Re-prepare of samples associated with the MB NCR will be required for data reported Final Report data flagging will be required

Table 2 - Method Quality Control Requirements Summary

QC Check	Minimum Frequency / Requirements	Acceptance Criteria	Corrective Action for Failures / Data Useability
BS	One per prep batch	Must be in the range of 80 to 120% for 6010B, DOD; or 85 to 115% for 200.7.	<ul style="list-style-type: none"> • Rerun to confirm problem. • All samples associated with the LCS must be re-digested, reanalyzed if possible. • NCR will be required for data reported • If samples cannot be re-digested or re-analyzed Final Report data flagging will be required
MS	One per prep batch	Must be in the range of 80 to 120%	Final Report data flagging will be required
MSD	One per prep batch	Must be in the range of 80 to 120%	Final Report data flagging will be required
Sample Duplicate	One per prep batch	20%	Flag samples
Post Digestion Spike	One per batch	±25% for DOD/6010B, ±20% 6010C	If possible MSA required, Flag samples
DOC Study	<ul style="list-style-type: none"> • Initially per analyst prior to reporting data • Annually • Follow specific guidelines from section 16 for the preparation and analysis of DOC samples 	<ul style="list-style-type: none"> • Must meet the criteria of the BS for average accuracy 	<ul style="list-style-type: none"> • Re-prep and / or • Re-analysis
MDL Study	Once per year		
LOD Verification	Every quarter		
LOQ Verification	Every quarter		
Linear Dynamic Range Study (LDR)	Every six months		

Table 3, Technical Completeness / Accuracy Checklist

1. Were all the QC check elements analyzed – refer to Table 2 of the SOP
2. Were the QC criteria met
3. In cases of failures, was there an NCR written
4. Were dilution factors applied correctly
5. Was the data uploaded into LIMS via direct upload – if yes, then was a cross check subset of the uploaded values performed
6. Was the red marked data in LIMS checked for accuracy and the corresponding hard copy data documented appropriately
7. Were proper data qualifiers applied to the data in LIMS
8. Was the hard copy package checked for completeness to include all data for the sequence such that the data reviewer could reconstruct sample analyses and validate / approve the data

Table 4, Data Reviewers Checklist (Prior to approving data)

1. Does the hard copy raw data (or electronic raw data) package look complete and include all data points
2. Were QA objectives met and for failures were the appropriate actions taken
3. For direct uploads to LIMS, did a subset cross check match the raw data
4. Did all the manual entries into LIMS match the raw data
5. Were there appropriate signatures and documentation on the raw data
6. Were appropriate LIMS flags used
7. Were manual calculations verified

ANALYST DATA REVIEW CHECKLIST Sample Number(s):			
Batch Number(s):			
Method: 6010B or 6010C (ICP)			

QA/QC Item	Yes	No	NA	Second Level Review
1. Were samples analyzed within USACE holding times?	_____	_____	_____	_____
2. Was initial calibration curve QC criteria met?	_____	_____	_____	_____
3. Was all continuing calibration criteria in control?	_____	_____	_____	_____
4. Did any sample exceed the highest calibration standard? (If yes, were appropriate dilutions made to generate samples concentration within calibration range?)	_____	_____	_____	_____
5. Did BS or blank spike meet control limits?	_____	_____	_____	_____
6. Did MS/MSD meet control limits?	_____	_____	_____	_____
7. Was the preparation (Method) Blank (BLK) below the project required detection limits?	_____	_____	_____	_____
8. Did you return samples back to cold storage immediately after use?	_____	_____	_____	_____
9. Was hot plate temperature monitored/documented and did you apply the thermometer correction factor?	_____	_____	_____	_____
10. Sample preparation information is correct and complete.	_____	_____	_____	_____
11. Analytical results are correct and complete.	_____	_____	_____	_____
12. The appropriate SOP's have been used and followed.	_____	_____	_____	_____
14. "Raw data" including all manual integration's have been correctly interpreted.	_____	_____	_____	_____
15. "Special" sample preparation and analytical requirements have been met.	_____	_____	_____	_____
16. Documentation complete (e.g., all anomalies in the analytical sequence have been documented, corrective action forms are complete.	_____	_____	_____	_____

Comments on any "No" response:

Analyst: _____ Date: _____

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Record of SOP Review and Implementation

TRAINING TOPIC SOP105 Rev16 - Metals Analysis by ICP Technique Methods 200.7, (SW846) 6010B, (SW-846) 6010C, (SM 19th Edition 2340B) USEPA CLP ILMO 4.

Group: Inorganic

ATTENDEES:					
NAMES (print)	SIGNATURE	REMARK	DATE	TIME	INSTRUCTOR
1 Roger Burr			0830/10	11:15	
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
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EMPIRICAL LABS, LLC.
Record of SOP Review and Implementation

SOP 105 to be updated to indicate "after rounding to the nearest whole number" where recoveries and percent TRAINING TOPIC differences are evaluated.

Group: Inorganic Metals

ATTENDEES:					
NAMES (print)	SIGNATURE	REMARK	DATE	TIME	INSTRUCTOR
1 Kendra Gentry	<i>Kendra Gentry</i>		9/28/10	15:42	BLD
2 Roger Burr	<i>Roger Burr</i>		9/28/10	15:43	BLD
3					
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**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 201 REVISION #: 20 EFFECTIVE DATE: 042610

**GC/MS SEMIVOLATILES and LOW-CONCENTRATION PAHs
BY EPA METHOD 625 AND SW846 METHOD 8270C AND 8270D
INCLUDING ADDITIONAL APPENDIX IX COMPOUNDS**

APPROVALS:

Lab Director:  Date: 4/27/10

Data Quality Manager:  Date: 4/27/10

Section Supervisor:  Date: 4/27/10

Changes Summary

Revision 20, 4/13/10

- The SOP is an update from Revision 19 dated 4/11/2010
- The SOP is formatted to simplify the text and place all method/program specifications in the SOP tables.

Revision 19, 4/11/10

- The SOP is an update from Revision 18 dated 9/16/08
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DOD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DOD samples are analyzed.

Table of Contents

1. Identification of the Test Method
2. Applicable Matrix or Matrices
3. Detection Limit
4. Scope of Application, Including components to be Analyzed
5. Summary of the Test Method
6. Definitions
7. Interferences
8. Safety
9. Equipment & Supplies
10. Reagents and Standards
11. Sample Collection, Preservation, Shipment, and Storage
12. Quality Control
13. Calibration and Standardization
14. Procedure
15. Data Analysis and Calculations
16. Method Performance
17. Pollution Prevention
18. Data Assessment and Acceptance Criteria for Quality Control Measures
19. Contingencies for Handling out-of-control or unacceptable data
20. Waste Management
21. References
22. Tables, Diagrams, Flowcharts and Validation Data

1.0 Identification of the Test Method

This SOP is based primarily on SW-846 Methods 8000B/8000C/8270C/8270D. Methods *Federal Register* Method 625 and CLP Method for Semi-volatiles have also been used in the development of this SOP.

2.0 Applicable Matrix or Matrices

This SOP is used for the analysis of semi-volatile organic compounds (including low concentration PAHs) in a variety of matrices (soils, sediments, waters, etc.).

3.0 Detection Limits – Reporting Limits

See Table 1

4.0 Scope of Application, Including Components to Be Analyzed

4.1 Each parameter that is routinely analyzed and reported under the scope of this SOP is listed in the Appendix of this SOP. This table also lists the associated Detection Limit, Limit of Detection and Reporting Limit (also defined as the Limit of Quantitation).

4.2 Extreme care should be taken when working with pure standard and stock standard solutions of these compounds and all handling of standards should be done in a hood. These compounds have been classified as known or suspected human or mammalian carcinogens.

5.0 Summary of the Test Method

5.1 After sample preparation using the appropriate extraction technique, the sample is introduced into the GC/MS using direct injection. The analytes are separated in the gas chromatograph by a combination of the temperature program, the pressure program and the capillary column. The analytes are then detected by the mass spectrometer. Analytes are identified by comparing the mass spectra of known standards with the mass spectra from the sample. Analytes are quantitated relative to known standards using the internal standard method.

6.0 Definitions –

Laboratory Quality System SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.

7.0 Interferences

7.1 All raw data (samples & QC) must be evaluated for interferences. If contamination occurs, determine whether the source of interference is in the preparation or clean-up of the samples and take corrective action to eliminate the problem.

7.2 Contamination by carryover can occur when samples of high-concentration and low-concentration are analyzed sequentially. To reduce carryover, the sample syringe must be rinsed with solvent between injections. If an unusually high sample is detected, a solvent blank should be analyzed for cross contamination or the subsequent sample should be evaluated for cross-contamination.

8.0 Safety

8.1 Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed lab-wide.

- 8.2 Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of gloves and lab coats is highly recommended.
- 8.3 Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples which need special consideration have applicable notes on the sample logs.
- 8.4 MSDS sheets are available for all reagents and standards which have been purchased. These are located on the bookshelf outside the office supply storage room.

9.0 Equipment & Supplies

- a HP 5890/6890/7890GC complete with electronic pressure control and temperature programmable gas chromatograph suitable for split-less injection.
- b Column: RTX-5MS (or equivalent) 30 m x 0.25 mm I.D. x 0.25 µm film thickness fused silica capillary column.
- c HP 5971/5973/5975 mass spectrometer capable of scanning from 35 to 500 amu every second or less, using 70 volts electron energy in electron impact ionization mode. The mass spectrometer is capable of producing a mass spectrum for decafluorotriphenylphosphine, DFTPP, which meets all the tuning criteria of the EPA methods.
- d HP 7673/7683 autosampler capable of reproducibility from one injection to another proven by meeting QC and calibration criteria.
- e HP GC/MS interface that gives acceptable calibration points at 50 ng per injection for each compound of interest and achieves acceptable tuning performance criteria.
- f Acquisition Software: HP Chemstation system is interfaced to the GC/MS. The system acquires and stores data throughout the chromatographic programs.
- g Data Processing Software: Target DB on Windows NT server data system is interfaced to the HP Chemstation. The system accepts and stores acquired data. It plots by extracted ion current profile (EICP). The system is also capable of integrating the abundances in any EICP between specified times or scan-number limits.
- h Micro syringes – gas tight 5µL and larger.
- i Liners – 2mm or 4mm single goose-neck.
- j Septa 11mm.
- k Seals- dual vespel stainless steel or gold plated 0.8mm.
- l Vials- 2ml and larger amber.
- m Volumetric flasks- 10ml and larger class A with glass stopper.

10.0 Reagents and Standards –

- 10.1 The laboratory's LIMS system allows for complete documentation and for the traceability of reagents and standards used within the laboratory.
- 10.2 Reagent grade chemicals shall be used in all tests unless otherwise specified. All reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

- 10.3 Methylene chloride (Please read SOP-336 before handling this solvent in our laboratory.) – Trace analysis grade.
- 10.4 Stock standards are purchased in mixtures from reputable vendors. The date they are received is noted on the label and recorded on the certificate of analysis sheet. The date they are opened is noted on the label and recorded in LIMS. Each standards label is completed with the standard number, name, preparation date, expiration date, solvent and analyst initials. All stocks and standards are stored in the freezer at a temperature of $-15^{\circ}\text{C} \pm 5^{\circ}\text{C}$ from the date they are received/prepared. Standards are brought to room temperature before being used to make standards. Sonication is used if precipitation is observed after bringing to room temperature. The refrigerator and freezer temperature are monitored daily with an annually calibrated thermometer and recorded with calibration correction in the Extraction temperature/calibration logbook.
- 10.5 Individual standard makeup is recorded in LIMS with specific details concerning the standard being used, concentration, amount, solvent and expiration date.

11.0 Sample Collection, Preservation, Shipment, and Storage

Section 3.0 and table 3-1 of the Empirical Laboratories' Quality Assurance Manual include details concerning sample preservation, containers and handling of semi-volatile samples and extracts. All water and soil samples are stored in the appropriate walk-in coolers at a temperature of 4°C . All extracts are stored in the Hobart in the Extraction lab at a temperature of 4°C . Water samples have a holding time of 7 days from date of sampling while soil samples have a holding time of 14 days from date of sampling (unless otherwise specified for the project). Extracts have 40 days from date of extraction to be analyzed.

12.0 Quality Control

- 12.1 Internals - All samples and QC are spiked with internal standards prior to analysis.
- 12.2 Surrogates - All samples and QC are spiked with surrogates prior to extraction. See **Table 2** for criteria and corrective action.
- 12.3 LCS Sample - The LCS is extracted 1 per extraction batch of up to 20 samples to provide accuracy results. It is spiked using an alternate source or lot number than the calibration standards. See **Table 2** for criteria and corrective action.
- 12.4 Method Blanks - The Method Blank is extracted 1 per extraction batch of up to 20 samples. See **Table 2** for criteria and corrective action.
- 12.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample - 1 in 20 samples are spiked for a MS/MSD, if sample is available. If no sample is available, an LCSD must be extracted to provide precision results. See **Table 2** for criteria and corrective action. Some factors that may affect MS/MSD results are:
 - 12.5.1 Sample matrix - If the sample is a soil, grab sample or sequentially collected water sample it may affect the %R and RPD of the MS/MSD. Corrective action must be taken in the form of reanalysis if a method problem is indicated.
 - 12.5.2 Original sample concentration - If a spiked compound has a problem and the concentration of that compound in the original sample was four or more times the concentration of the spike, no further corrective action may be necessary other than the generation of a corrective action report to document the problem.

- 12.5.3 MS vs. MSD - If a spiked compound has a similar problem in both the MS and MSD and is not traced to a method problem, no further action may be necessary other than the generation of a non-conformance report to document the problem.
- 12.5.4 Non-target Interference - The presence of significant non-target interference should be brought to the immediate attention of your supervisor who should discuss the problem with the client/project manager to determine the action to be taken.
- 12.6 Demonstration of Capability (DOC) – Each new analyst must complete a demonstration of capability by analyzing four LCSs with acceptable precision and accuracy. This also must be done when a new instrument is installed or a significant change to the method has been made.

13.0 Calibration and Standardization

- 13.1 Quality Systems **SOP QS08** “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.
- 13.2 Initial Calibration - An initial multi-point calibration curve must be analyzed and shown to meet the initial calibration criteria before any sample analyses may be performed. See **Table 2** for criteria and corrective action. The lowest standard must be less than or equal to the reported quantitation limit and the highest standard must not exceed the linear range of the detector. Generally, levels for the curve range from 1.0ug/mL to 100ug/mL for regular SVOCs and 0.1µg/mL to 50µg/mL for low-concentration PAHs.. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, reason indicated and dated with the quantitation report and chromatogram. All integrations are second-checked for acceptability by a senior analyst. Refer to SOP-QS07 for guidance.
- 13.3 Initial Calibration Verification (ICV) - A second source standard at the continuing calibration verification (CCV) level must be analyzed and calculated against the initial calibration curve, then shown to meet the ICV criteria before any sample analyses may be performed. See **Table 2** for criteria and corrective action. For ICV standard preparation, refer to LIMS. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, reason indicated and dated with the quantitation report and chromatogram. All integrations are second-checked for acceptability by a senior analyst. Refer to SOP-QS07 for guidance.
- 13.4 Continuing Calibration Verification (CCV) - Every 12 hours, a CCV must be analyzed and calculated against the initial calibration curve, then shown to meet the calibration check criteria before any sample analyses may be performed. See **Table 2** for criteria and corrective action. For ICV standard preparation, refer to LIMS. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, reason indicated and dated with the quantitation report and chromatogram. All integrations are second-checked for acceptability by a senior analyst. Refer to SOP-QS07 for guidance.

14.0 Procedure

Prior to analysis the samples are prepared for chromatography using the appropriate sample preparation and clean up methods (generally SW-846 methods 3510, 3520, 3541, 3546 3550, 3580, EPA method 625 or CLP).

- 14.1 Chromatographic conditions: Refer to corresponding instrument maintenance log for current gas chromatograph and mass spectrometer conditions.
- 14.2 Tuning - Prior to any calibration or analysis, DFTPP tuning criteria must be met for a 50 ng injection of the tuning standard. The injection port performance compounds (pentachlorophenol, benzidine and 4,4'-DDT) are also injected to verify the performance of the injection port . See **Table 2** for criteria and corrective action.
- 14.3 Extracts - Prior to analysis, 1.0 mL extracts are prepared by verifying volume and spiking with 20uL of the internal standard solution.

14.5 Instrument sequence-The instrument sequence log is filled out prior to sample analyses. An example of a typical instrument sequence log follows:

- 1-SEQ-TUN1 (12:00 am)
- 2-SEQ-CCV1
- 3-SEQ-BS1
- 4-SEQ-BLK1
- 5-Sample
- 6-Sample
- 7-Sample
- 8-Sample
- 9-Sample
- 10-Sample
- 11-Sample
- 12-Sample
- 13-Sample
- 14-SEQ-MS1
- 15-SEQ-MSD1
- 16-SEQ-TUN2 (12:00pm - 12 hours since last DFTPP/CCV)
- 17-SEQ-CCV2
- 18-Sample
- 19-Sample
- 20-Sample

14.6 Data Reduction/Evaluation - Each sample analysis sequence is documented using the computer run log generated on the Chemstation. This run log is signed, dated and paginated then placed in a 3 ring binder for that instrument. After the sample has been analyzed, the data is processed through Target DB on the Windows NT data system. The following must be checked to determine if the sample will need reanalysis or dilution. Criteria and corrective action are found in Table 2. Formal data evaluation is detailed in SOP QS05 and documented using the Analyst Data Review Checklist (see Appendix). Manual integration guidance is found in SOP QS07.

14.6.1 Internal Standard Area Counts and Retention Times

14.6.2 Surrogate Recoveries and Retention Times

- 14.6.3 Analyte concentration.
- 14.6.4 Analyte identification based on spectrum and retention time.
- 14.6.5 Analyte quantitation verification.

15.0 Data Analysis and Calculations

15.1 Quality Systems SOP QS09 “General and Commonly used Laboratory Calculations” provides details on general calculations used throughout the laboratory.

15.2 The RF is calculated as follows:

$$RF = \frac{A_s \times C_{is}}{A_{is} \times C_s}$$

where:

A_s = Peak area (or height) of the analyte or surrogate.

A_{is} = Peak area (or height) of the internal standard.

C_s = Concentration of the analyte or surrogate.

C_{is} = Concentration of the internal standard.

15.2 Calibration verification involves the calculation of the percent drift (linear or quadratic) or the percent difference (average) of the instrument response between the initial calibration and each subsequent analysis of the verification standard. Use the equations below to calculate % Drift or % Difference, depending on the calibration procedure used.

$$\% \text{ Drift} = \frac{(\text{Calculated concentration} - \text{Theoretical concentration}) * 100}{\text{Theoretical Concentration}}$$

where:

Calculated concentration is determined from the initial calibration.

Theoretical concentration is the concentration at which the standard was prepared.

$$\% \text{ Difference} = \frac{(\text{CCV RF} - \text{Average RF}) * 100}{\text{Average RF}}$$

where:

CCV RF is the response factor from the analysis of the verification standard

Average RF is the average of the response factors from the initial calibration.

15.3 Concentration in water samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to $\mu\text{g/L}$.]

$$\text{Concentration } (\mu\text{g/L}) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(RF)(V_s)(1000)}$$

where:

A_s = Area (or height) of the peak for the analyte in the sample.

A_{is} = Area (or height) of the peak for the internal standard.

C_{is} = Concentration of the internal standard in the volume extracted in $\mu\text{g/L}$.

D = Dilution factor, if the sample was diluted prior to analysis. If no dilution was made, $D = 1$. The dilution factor is always dimensionless.

V_i = Volume of the extract injected (μL). The nominal injection volume for samples and calibration standards must be the same.

- \overline{RF} = Mean response factor from the initial calibration.
 V_s = Volume of the aqueous sample extracted (mL). If units of liters are used for this term, multiply the results by 1000.

The 1000 in the denominator represents the number of μL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

- 15.4 Concentration in non-aqueous samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to $\mu\text{g}/\text{kg}$.]

$$\text{Concentration } (\mu\text{g}/\text{kg}) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{RF})(W_s)(1000)}$$

where: A_s ,

A_{is} , C_{is} , D , and \overline{RF} are the same as for aqueous samples, and

W_s = Weight of sample extracted (g). Either a dry weight or wet weight may be used, depending upon the specific application of the data. If units of kilograms are used for this term, multiply the results by 1000.

The 1000 in the denominator represents the number of μL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

- 15.3 Any questions left unanswered by this SOP should be clarified by reading the referenced method. If questions still remain unanswered, check with the Section Manager, Technical Director and/or Data Quality Manager.

16.0 Method Performance

See SOP QS08 and Table 2 for criteria and corrective actions associated to the following method performance items:

- 16.1 Method Detection Limit Study or Detection Limit Determination
- 16.2 Limit of Detection Verification
- 16.3 Limit of Quantitation or Reporting Limit Verification
- 16.4 Demonstration of Capability (DOC)
- 16.5 PT Studies

17.0 Pollution Prevention

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on data assessment and acceptance criteria for Quality Control Measures. **Table 2** of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19.0 Contingencies for Handling out-of-control or unacceptable data

Quality Control SOP QS05, “Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results”, provides details on handling out of control data. **Table 2** within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

20.0 Waste Management

Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

21.0 References

40 CFR, Part 136; Appendix A

Test Methods for Evaluating Solid Waste, SW-846

National Environmental Laboratory Accreditation Conference; CH. 5, 2003

USACE, EM 200-1-3; Appendix 1; Shell, 2/2001

DOD Quality Systems Manual for Environmental Laboratories,

22.0 Tables, Diagrams, Flowcharts and Validation Data

22.1 Table 1, all applicable parameters with the applicable DL(MDL)/LOD/LOQ(MRL).

22.2 Table 2, QA/QC summary table

22.3 Table 3, Technical Completeness / Accuracy Checklist

22.4 Table 4, Data Reviewers Checklist(s)

22.5 Table 5, 625 QC Limits

22.6 Table 6, Standards Used

22.7 Table 7, INTERNAL STANDARD ASSOCIATION / QUANT MASS – Standard SVOC analysis

22.8 Table 8, LOW CONCENTRATION PAH INTERNAL STANDARD/SURROGATE SPECIFICATIONS

22.9 Figure 1, Tailing Factor Calculation

22.10 Table 9, DFTPP Tuning Criteria

TABLE 1

Analyte (Water)	DL	LOD	MRL/LOQ	Units
1,1'-Biphenyl	1.25	2.50	5.00	ug/L
1,2,4,5-Tetrachlorobenzene	1.25	2.50	5.00	ug/L
1,2,4-Trichlorobenzene	1.25	2.50	5.00	ug/L
1,2-Dichlorobenzene	1.25	2.50	5.00	ug/L
1,3-Dichlorobenzene	1.25	2.50	5.00	ug/L
1,4-Dichlorobenzene	1.25	2.50	5.00	ug/L
2,3,4,6-Tetrachlorophenol	1.25	2.50	5.00	ug/L
2,4,5-Trichlorophenol	1.25	2.50	5.00	ug/L
2,4,6-Trichlorophenol	1.25	2.50	5.00	ug/L
2,4-Dichlorophenol	1.25	2.50	5.00	ug/L
2,4-Dimethylphenol	5.00	10.0	20.0	ug/L
2,4-Dinitrophenol	12.5	25.0	50.0	ug/L
2,4-Dinitrotoluene	1.25	2.50	5.00	ug/L
2,6-Dinitrotoluene	1.25	2.50	5.00	ug/L
2-Chloronaphthalene	1.25	2.50	5.00	ug/L
2-Chlorophenol	1.25	2.50	5.00	ug/L
2-Methylnaphthalene	1.25	2.50	5.00	ug/L
2-Methylphenol	1.25	2.50	5.00	ug/L
2-Nitroaniline	5.00	10.0	20.0	ug/L
2-Nitrophenol	1.25	2.50	5.00	ug/L
3,3'-Dichlorobenzidine	1.25	2.50	5.00	ug/L
3-Nitroaniline	5.00	10.0	20.0	ug/L
4,6-Dinitro-2-methylphenol	5.00	10.0	20.0	ug/L
4-Bromophenyl phenyl ether	1.25	2.50	5.00	ug/L
4-Chloro-3-methylphenol	1.25	2.50	5.00	ug/L
4-Chloroaniline	1.25	2.50	5.00	ug/L
4-Chlorophenyl phenyl ether	1.25	2.50	5.00	ug/L
4-Methylphenol	1.25	2.50	5.00	ug/L
4-Nitroaniline	5.00	10.0	20.0	ug/L
4-Nitrophenol	5.00	10.0	20.0	ug/L
Acenaphthene	1.25	2.50	5.00	ug/L
Acenaphthylene	1.25	2.50	5.00	ug/L
Acetophenone	1.25	2.50	5.00	ug/L
Anthracene	1.25	2.50	5.00	ug/L
Atrazine	1.25	2.50	5.00	ug/L
Benzaldehyde	1.25	2.50	5.00	ug/L
Benzo (a) anthracene	1.25	2.50	5.00	ug/L
Benzo (a) pyrene	1.25	2.50	5.00	ug/L
Benzo (b) fluoranthene	1.25	2.50	5.00	ug/L
Benzo (g,h,i) perylene	1.25	2.50	5.00	ug/L
Benzo (k) fluoranthene	1.25	2.50	5.00	ug/L
Bis(2-chloroethoxy)methane	1.25	2.50	5.00	ug/L
Bis(2-chloroethyl)ether	1.25	2.50	5.00	ug/L
Bis(2-chloroisopropyl)ether	1.25	2.50	5.00	ug/L
Bis(2-ethylhexyl)phthalate	1.25	2.50	5.00	ug/L
Butyl benzyl phthalate	1.25	2.50	5.00	ug/L
Caprolactam	1.25	2.50	5.00	ug/L
Carbazole	1.25	2.50	5.00	ug/L
Chrysene	1.25	2.50	5.00	ug/L
Dibenz (a,h) anthracene	1.25	2.50	5.00	ug/L
Dibenzofuran	1.25	2.50	5.00	ug/L
Diethyl phthalate	1.25	2.50	5.00	ug/L
Dimethylphthalate	1.25	2.50	5.00	ug/L
Di-n-butyl phthalate	1.25	2.50	5.00	ug/L

Table 1 (Continued)

Analyte (Water)	DL	LOD	MRL/LOQ	Units
Di-n-octyl phthalate	1.25	2.50	5.00	ug/L
Fluoranthene	1.25	2.50	5.00	ug/L
Fluorene	1.25	2.50	5.00	ug/L
Hexachlorobenzene	1.25	2.50	5.00	ug/L
Hexachlorobutadiene	1.25	2.50	5.00	ug/L
Hexachlorocyclopentadiene	1.25	2.50	5.00	ug/L
Hexachloroethane	1.25	2.50	5.00	ug/L
Indeno (1,2,3-cd) pyrene	1.25	2.50	5.00	ug/L
Isophorone	1.25	2.50	5.00	ug/L
Naphthalene	1.25	2.50	5.00	ug/L
Nitrobenzene	1.25	2.50	5.00	ug/L
N-Nitrosodi-n-propylamine	1.25	2.50	5.00	ug/L
N-Nitrosodiphenylamine	1.25	2.50	5.00	ug/L
Pentachlorophenol	5.00	10.0	20.0	ug/L
Phenanthrene	1.25	2.50	5.00	ug/L
Phenol	1.25	2.50	5.00	ug/L
Pyrene	1.25	2.50	5.00	ug/L
Analyte (Soil)	DL	LOD	MRL/LOQ	Units
1,1'-Biphenyl	83.3	167	333	ug/Kg
1,2,4,5-Tetrachlorobenzene	83.3	167	333	ug/Kg
1,2,4-Trichlorobenzene	83.3	167	333	ug/Kg
1,2-Dichlorobenzene	83.3	167	333	ug/Kg
1,3-Dichlorobenzene	83.3	167	333	ug/Kg
1,4-Dichlorobenzene	83.3	167	333	ug/Kg
2,3,4,6-Tetrachlorophenol	83.3	167	333	ug/Kg
2,4,5-Trichlorophenol	83.3	167	333	ug/Kg
2,4,6-Trichlorophenol	83.3	167	333	ug/Kg
2,4-Dichlorophenol	83.3	167	333	ug/Kg
2,4-Dimethylphenol	333	667	1330	ug/Kg
2,4-Dinitrophenol	833	1670	3330	ug/Kg
2,4-Dinitrotoluene	83.3	167	333	ug/Kg
2,6-Dinitrotoluene	83.3	167	333	ug/Kg
2-Chloronaphthalene	83.3	167	333	ug/Kg
2-Chlorophenol	83.3	167	333	ug/Kg
2-Methylnaphthalene	83.3	167	333	ug/Kg
2-Methylphenol	83.3	167	333	ug/Kg
2-Nitroaniline	333	667	1330	ug/Kg
2-Nitrophenol	83.3	167	333	ug/Kg
3,3'-Dichlorobenzidine	83.3	167	333	ug/Kg
3-Nitroaniline	333	667	1330	ug/Kg
4,6-Dinitro-2-methylphenol	833	1670	3330	ug/Kg
4-Bromophenyl phenyl ether	83.3	167	333	ug/Kg
4-Chloro-3-methylphenol	83.3	167	333	ug/Kg
4-Chloroaniline	83.3	167	333	ug/Kg
4-Chlorophenyl phenyl ether	83.3	167	333	ug/Kg
4-Methylphenol	83.3	167	333	ug/Kg
4-Nitroaniline	333	667	1330	ug/Kg
4-Nitrophenol	333	667	1330	ug/Kg
Acenaphthene	83.3	167	333	ug/Kg
Acenaphthylene	83.3	167	333	ug/Kg
Acetophenone	83.3	167	333	ug/Kg
Anthracene	83.3	167	333	ug/Kg
Atrazine	83.3	167	333	ug/Kg
Benzaldehyde	83.3	167	333	ug/Kg
Benzo (a) anthracene	83.3	167	333	ug/Kg

Table 1 (Continued)

Analyte (Soil)	DL	LOD	MRL/LOQ	Units
Benzo (a) pyrene	83.3	167	333	ug/Kg
Benzo (b) fluoranthene	83.3	167	333	ug/Kg
Benzo (g,h,i) perylene	83.3	167	333	ug/Kg
Benzo (k) fluoranthene	83.3	167	333	ug/Kg
Bis(2-chloroethoxy)methane	83.3	167	333	ug/Kg
Bis(2-chloroethyl)ether	83.3	167	333	ug/Kg
Bis(2-chloroisopropyl)ether	83.3	167	333	ug/Kg
Bis(2-ethylhexyl)phthalate	83.3	167	333	ug/Kg
Butyl benzyl phthalate	83.3	167	333	ug/Kg
Caprolactam	83.3	167	333	ug/Kg
Carbazole	83.3	167	333	ug/Kg
Chrysene	83.3	167	333	ug/Kg
Dibenz (a,h) anthracene	83.3	167	333	ug/Kg
Dibenzofuran	83.3	167	333	ug/Kg
Diethyl phthalate	83.3	167	333	ug/Kg
Dimethylphthalate	83.3	167	333	ug/Kg
Di-n-butyl phthalate	83.3	167	333	ug/Kg
Di-n-octyl phthalate	83.3	167	333	ug/Kg
Fluoranthene	83.3	167	333	ug/Kg
Fluorene	83.3	167	333	ug/Kg
Hexachlorobenzene	83.3	167	333	ug/Kg
Hexachlorobutadiene	83.3	167	333	ug/Kg
Hexachlorocyclopentadiene	83.3	167	333	ug/Kg
Hexachloroethane	83.3	167	333	ug/Kg
Indeno (1,2,3-cd) pyrene	83.3	167	333	ug/Kg
Isophorone	83.3	167	333	ug/Kg
Naphthalene	83.3	167	333	ug/Kg
Nitrobenzene	83.3	167	333	ug/Kg
N-Nitrosodi-n-propylamine	83.3	167	333	ug/Kg
N-Nitrosodiphenylamine	83.3	167	333	ug/Kg
Pentachlorophenol	333	667	1330	ug/Kg
Phenanthrene	83.3	167	333	ug/Kg
Phenol	83.3	167	333	ug/Kg
Pyrene	83.3	167	333	ug/Kg
Analyte Low PAH (Water)	DL	LOD	MRL/LOQ	Units
1-Methylnaphthalene	0.0500	0.100	0.200	ug/L
2-Methylnaphthalene	0.0500	0.100	0.200	ug/L
Acenaphthene	0.0500	0.100	0.200	ug/L
Acenaphthylene	0.0500	0.100	0.200	ug/L
Anthracene	0.0500	0.100	0.200	ug/L
Benzo (a) anthracene	0.0500	0.100	0.200	ug/L
Benzo (a) pyrene	0.0500	0.100	0.200	ug/L
Benzo (b) fluoranthene	0.0500	0.100	0.200	ug/L
Benzo (g,h,i) perylene	0.0500	0.100	0.200	ug/L
Benzo (k) fluoranthene	0.0500	0.100	0.200	ug/L
Chrysene	0.0500	0.100	0.200	ug/L
Dibenz (a,h) anthracene	0.0500	0.100	0.200	ug/L
Fluoranthene	0.0500	0.100	0.200	ug/L
Fluorene	0.0500	0.100	0.200	ug/L
Indeno (1,2,3-cd) pyrene	0.0500	0.100	0.200	ug/L
Naphthalene	0.0500	0.100	0.200	ug/L
Phenanthrene	0.0500	0.100	0.200	ug/L
Pyrene	0.0500	0.100	0.200	ug/L
Analyte Low PAH (Soil)	DL	LOD	MRL/LOQ	Units
1-Methylnaphthalene	1.67	3.33	6.67	ug/Kg

Table 1 (Continued)

Analyte Low PAH (Soil)	DL	LOD	MRL/LOQ	Units
2-Methylnaphthalene	1.67	3.33	6.67	ug/Kg
Acenaphthene	1.67	3.33	6.67	ug/Kg
Acenaphthylene	1.67	3.33	6.67	ug/Kg
Anthracene	1.67	3.33	6.67	ug/Kg
Benzo (a) anthracene	1.67	3.33	6.67	ug/Kg
Benzo (a) pyrene	1.67	3.33	6.67	ug/Kg
Benzo (b) fluoranthene	1.67	3.33	6.67	ug/Kg
Benzo (g,h,i) perylene	1.67	3.33	6.67	ug/Kg
Benzo (k) fluoranthene	1.67	3.33	6.67	ug/Kg
Chrysene	1.67	3.33	6.67	ug/Kg
Dibenz (a,h) anthracene	1.67	3.33	6.67	ug/Kg
Fluoranthene	1.67	3.33	6.67	ug/Kg
Fluorene	1.67	3.33	6.67	ug/Kg
Indeno (1,2,3-cd) pyrene	1.67	3.33	6.67	ug/Kg
Naphthalene	1.67	3.33	6.67	ug/Kg
Phenanthrene	1.67	3.33	6.67	ug/Kg
Pyrene	1.67	3.33	6.67	ug/Kg
Analyte (TCLP)	DL	LOD	MRL/LOQ	Units
1,4-Dichlorobenzene	0.00125	0.00250	0.00500	mg/L
2,4,5-Trichlorophenol	0.00125	0.00250	0.00500	mg/L
2,4,6-Trichlorophenol	0.00125	0.00250	0.00500	mg/L
2,4-Dinitrotoluene	0.00125	0.00250	0.00500	mg/L
2-Methylphenol	0.00125	0.00250	0.00500	mg/L
3-Methylphenol	0.00125	0.00250	0.00500	mg/L
4-Methylphenol	0.00125	0.00250	0.00500	mg/L
Hexachlorobenzene	0.00125	0.00250	0.00500	mg/L
Hexachlorobutadiene	0.00125	0.00250	0.00500	mg/L
Hexachloroethane	0.00125	0.00250	0.00500	mg/L
Nitrobenzene	0.00125	0.00250	0.00500	mg/L
Pentachlorophenol	0.0050	0.0100	0.0200	mg/L
Pyridine	0.00125	0.00250	0.00500	mg/L

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 625/8270)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Demonstrate acceptable analytical capability	Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix.	QC acceptance criteria published by DoD, if available; otherwise, method-specific criteria.	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f of DoD QSM 4.1).	NA.	This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C of DoD QSM 4.1. No analysis shall be allowed by analyst until successful demonstration of capability is complete.
MDL determination	Initial method demonstration required for some states – not required for DoD	Refer to SOP QS09.			
LOD determination and verification	Prior to initial analysis then quarterly verification.	See Box D-13 of DoD QSM 4.1			
LOQ establishment and verification	Prior to initial analysis then quarterly verification.	See Box D-14 of DoD QSM 4.1			
Tuning	Prior to ICAL and at the beginning of each 12-hour period.	Refer to table 8 of this SOP.	Retune instrument and verify. Rerun affected samples.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be accepted without a valid tune.
Breakdown check (DDT Method 8270 only)	At the beginning of each 12-hour period, prior to analysis of samples.	Degradation $\leq 20\%$ for DDT. Benzidine and pentachlorophenol should be present at their normal responses, and should not exceed a tailing factor of 2. [Method 625 – benzidine and pentachlorophenol tailing limits are 3 and 5, respectively, when benzidine or acids are target analytes. Benzidine tailing is specific to benzidine analysis and pentachlorophenol tailing is specific to acid analyte analyses according to 625.]	Correct problem then repeat breakdown checks.	Flagging criteria are not appropriate.	No samples shall be run until degradation $\leq 20\%$. Not applied when low concentration PAHs are the only target analytes.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 625/8270) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Minimum five-point initial calibration (ICAL) for all analytes	ICAL prior to sample analysis.	<p>1. Average response factor (RF) for SPCCs: SVOCs ≥ 0.050 [2,4-dinitrophenol, hexachlorocyclopentadiene, N-Nitrosodi-n-propylamine, 4-nitrophenol] Note 1: See table 4 of 8270D SPCC analytes and limits. Note 2: ≥ 0.050 for all low-level PAHs</p> <p>2. RSD for RFs for CCCs: SVOCs $\leq 30\%$ and one option below: Option 1: RSD for each analyte $\leq 15\%$; [$\leq 20\%$ for non-DoD 8270D; or, $\leq 35\%$ for non-DoD 625] Option 2: linear least squares regression $r \geq 0.995$ or $r^2 \geq 0.990$; [$r \geq 0.990$ for non-DoD analyses] Option 3: non-linear regression—coefficient of determination (COD) $r^2 \geq 0.990$ (6 points shall be used for second order, 7 points shall be used for third order).</p>	Correct problem then repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin for DoD projects.
Second source calibration verification (ICV)	Once after each ICAL.	All project analytes within $\pm 20\%$ of true value [$\pm 25\%$ for non-DoD 8270C; or, $\pm 30\%$ for non-DoD 8270D]	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples should be run until calibration has been verified.
Retention time window position establishment for each analyte and surrogate	Once per ICAL.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the sequence CCV is used.	NA.	NA.	

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 625/8270) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Evaluation of relative retention times (RRT)	With each sample.	RRT of each target analyte within ± 0.06 RRT units. Note - retention times may be updated based on the CCV to account for minor performance fluctuations or after routine system maintenance (such as column clipping).	Correct problem, then rerun ICAL.	Flagging criteria are not appropriate.	With each sample, the RRT shall be compared with the most recently updated RRT. If the RRT has changed by more than ± 0.06 RRT units since the last update, this indicates a significant change in system performance and the laboratory must take appropriate corrective actions as required by the method and rerun the ICAL to reestablish the retention times.
Continuing calibration verification (CCV)	Daily before sample analysis and every 12 hours of analysis time.	1. Average RF for SPCCs: SVOCs ≥ 0.050 [2,4-dinitrophenol, hexachlorocyclopentadiene, N-Nitrosodi-n-propylamine, 4-nitrophenol] Note 1: See table 4 of 8270D SPCC analytes and limits. Note 2: ≥ 0.050 for all low-level PAHs 2. %Difference/Drift for all target compounds and surrogates: SVOCs $\leq 20\%D$ (Note: D = difference when using RFs or drift when using least squares regression or non-linear calibration). [$\pm 20\%$ for CCCs only non-DoD 8270C]	DoD project level approval must be obtained for each of the failed analytes or corrective action must be taken. Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since last acceptable CCV.	If reanalysis cannot be performed, data should be qualified and explained in the case narrative. Apply qualifier to all results for the specific analyte(s) in all samples since last acceptable CCV. [For non-DoD 8270C, if CCCs exceed, evaluate all analytes for 20%D and qualify as above]	Problem should be corrected. Results should not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed, holding time has been exceeded or client has approved reporting.
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL or daily CCV; EICP area within -50% to +100% of ICAL midpoint standard or daily CCV.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	If corrective action fails in field samples, apply qualifier to analytes associated with the non-compliant IS. Flagging criteria are not appropriate for failed standards.	Sample results are not acceptable without a valid IS verification.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 625/8270) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Method blank	One per preparatory batch.	No analytes detected > ½ RL/LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL/LOQ.	Correct problem. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
LCS containing all analytes to be reported, including surrogates	One per preparatory batch.	QC acceptance criteria specified by client or DoD (appendix G), if available. AFCEE 4.0.02 limits are applied for low concentration PAHs as they are not addressed by DoD. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery. Low concentration PAH limits	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Matrix Spike (MS)	One per preparatory batch per matrix	Use LCS criteria, above.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.
Matrix spike duplicate (MSD) or sample duplicate	One per preparatory batch per matrix	MSD: For matrix evaluation, use LCS acceptance criteria above. MSD or sample duplicate: $RPD \leq 30\%$ or client specified limit (between MS and MSD or sample and sample duplicate).	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	The data shall be evaluated to determine the source of difference.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 625/8270) (continued)

QC Check	Minimum Frequency	Acceptance Criteria			Corrective Action	Flagging Criteria	Comments
Surrogate spike	All field and QC samples.	Surrogate	Water	Solid	For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Apply qualifier to all associated analytes if acceptance criteria are not met. For acid surrogate, qualify acid analytes, for base/neutral surrogates, qualify base/neutral analytes.	
		Nitrobenzene-d5	40-110	35-100			
		2-Fluorobiphenyl	50-110	45-105			
		Terphenyl-d14	50-135	30-125			
		Phenol-d6	10-115	40-100			
		2-Fluorophenol	20-110	35-105			
		2,4,6-Tribromophenol	40-125	35-125			
		QC acceptance criteria specified by DoD (above) or Client. Low PAH surrogate limits are 14%-129% soil and 34%-167% water. Otherwise, in-house control limits may be used. No limits specified for Method 625.					
Results reported between DL and LOQ	NA.	NA.			NA.	Apply J-flag to all results between DL and LOQ.	

Table 3, Technical Completeness / Accuracy Checklist

1. Were all the QC check elements analyzed – refer to Table 2 of the SOP
2. Were the QC criteria met
3. In cases of failures, was there an NCR written
4. Were all manual integrations signed
5. Were dilution factors applied correctly
6. Was there supervisory or senior-scientist approval for manual integrations on standards and batch QC samples
7. Was the data uploaded into LIMS via direct upload (i.e. datatool) – if yes, then was a cross check subset of the uploaded values performed
8. If the data was entered into LIMS manually, was a check of all entered values performed
9. Was the red marked data in LIMS checked for accuracy and the corresponding hard copy data documented appropriately
10. Were proper data qualifiers applied to the data in LIMS
11. Was the hard copy package checked for completeness to include all data for the sequence such that the data reviewer could reconstruct sample analyses and validate / approve the data

Table 4, Data Reviewers Checklist (Prior to approving data)

1. Does the hard copy raw data (or electronic raw data) package look complete and include all data points
2. Were QA objectives met and for failures were the appropriate actions taken
3. For direct uploads to LIMS, did a subset cross check match the raw data
4. Did all the manual entries into LIMS match the raw data
5. Were there appropriate signatures and documentation on the raw data
6. Were appropriate LIMS flags used
7. Were manual integrations signed
8. Were manual integrations for calibration and QC samples approved by supervisor
9. Were manual calculations verified

ANALYST DATA REVIEW CHECKLIST

Sample Number(s):
Batch Number(s):
Method: 8260B/624/8270C/8270D/625 (Circle One)

QA/QC Item	Yes	No	NA	Second Review	Level
1. Is the BFB/DFTPP tune performed every 12 hours and is the tuning criteria met?					
Are the RRFs and % RSDs within QC limits for appropriate analytes for the initial calibration? Check the retention times for compounds with the same spectra. Check compounds with different conc.(e.g. m/p-xylene, ketones, etc.).					
3. Was the initial calibration curve verified by a second source calibration standard (ICV) and have criteria been met?					
4. Does the Continuing Calibration Standard (CCV) meet the criteria for the CCCs, SPCCs and/or 20%D for all analytes.					
5. Is the Method Blank run at the desired frequency and is its concentration for target analytes less than the MDLs?					
6. Are the LCS, MS, MSD within control limits and run at the desired frequency?					
7. Are all sample holding times met, analytes within calibration range, IS areas and surrogate recoveries within QC limits?					
8. Were the Method Blank, LCS, MS, MSD and samples uploaded to the LIMS and verified (at least one calculation per batch uploaded)?					

Comments on any "No" response:

Primary-Level Review: _____ Date: _____

Second-Level Review: _____ Date: _____

Table 5 - 625 QC limits

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONCENTRATION (ug/L)	LCS CONCENTRATION (ug/L)	LCS % REC #	QC. LIMITS REC.
Acenaphthene	100.00	0.0000	100.00	100	47-145
Acenaphthylene	100.00	0.0000	100.00	100	33-145
Anthracene	100.00	0.0000	100.00	100	27-133
Benzidine	100.00	0.0000	100.00	100	D-110
Benzo(a)anthracene	100.00	0.0000	100.00	100	33-143
Benzo(b)fluoranthene	100.00	0.0000	100.00	100	24-159
Benzo(k)fluoranthene	100.00	0.0000	100.00	100	11-162
Benzo(g,h,i)perylene	100.00	0.0000	100.00	100	D-219
Benzo(a)pyrene	100.00	0.0000	100.00	100	17-163
bis(2-Chloroethoxy)meth	100.00	0.0000	100.00	100	33-184
bis(2-Chloroethyl)ether	100.00	0.0000	100.00	100	12-158
bis(2-Chloroisopropyl)e	100.00	0.0000	100.00	100	36-166
Bis(2-ethylhexyl)phthal	100.00	0.0000	100.00	100	8-158
4-Bromophenyl-phenyleth	100.00	0.0000	100.00	100	53-127
Butylbenzylphthalate	100.00	0.0000	100.00	100	D-152
4-Chloro-3-methylphenol	100.00	0.0000	100.00	100	22-147
2-Chloronaphthalene	100.00	0.0000	100.00	100	60-118
2-Chlorophenol	100.00	0.0000	100.00	100	23-134
4-Chlorophenyl-phenylet	100.00	0.0000	100.00	100	25-158
Chrysene	100.00	0.0000	100.00	100	17-168
Dibenz(a,h)anthracene	100.00	0.0000	100.00	100	D-227
1,2-Dichlorobenzene	100.00	0.0000	100.00	100	32-129
1,3-Dichlorobenzene	100.00	0.0000	100.00	100	D-172
1,4-Dichlorobenzene	100.00	0.0000	100.00	100	20-124
3,3'-Dichlorobenzidine	100.00	0.0000	100.00	100	D-262
2,4-Dichlorophenol	100.00	0.0000	100.00	100	39-135
Diethylphthalate	100.00	0.0000	100.00	100	D-114
2,4-Dimethylphenol	100.00	0.0000	100.00	100	32-119
Dimethylphthalate	100.00	0.0000	100.00	100	D-112
Di-n-butylphthalate	100.00	0.0000	100.00	100	1-118
4,6-Dinitro-2-methylphe	100.00	0.0000	100.00	100	D-181
2,4-Dinitrophenol	100.00	0.0000	100.00	100	D-191
2,4-Dinitrotoluene	100.00	0.0000	100.00	100	39-139
2,6-Dinitrotoluene	100.00	0.0000	100.00	100	50-158
Di-n-octylphthalate	100.00	0.0000	100.00	100	4-146
Fluoranthene	100.00	0.0000	100.00	100	26-137
Fluorene	100.00	0.0000	100.00	100	59-121
Hexachlorobenzene	100.00	0.0000	100.00	100	D-152
Hexachlorobutadiene	100.00	0.0000	100.00	100	24-116
Hexachlorocyclopentadie	100.00	0.0000	100.00	100	15- 70
Hexachloroethane	100.00	0.0000	100.00	100	40-113
Indeno(1,2,3-cd)pyrene	100.00	0.0000	100.00	100	D-171
Isophorone	100.00	0.0000	100.00	100	21-196
Naphthalene	100.00	0.0000	100.00	100	21-133
Nitrobenzene	100.00	0.0000	100.00	100	35-180
2-Nitrophenol	100.00	0.0000	100.00	100	29-182
4-Nitrophenol	100.00	0.0000	100.00	100	D-132
N-Nitroso-di-methylamin	100.00	0.0000	100.00	100	29- 66
N-Nitrosodiphenylamine	100.00	0.0000	100.00	100	23-100
N-Nitroso-di-n-propylam	100.00	0.0000	100.00	100	D-230
Pentachlorophenol	100.00	0.0000	100.00	100	14-176
Phenanthrene	100.00	0.0000	100.00	100	54-120
Phenol	100.00	0.0000	100.00	100	5-112
Pyrene	100.00	0.0000	100.00	100	52-115
1,2,4-Trichlorobenzene	100.00	0.0000	100.00	100	44-142
2,4,6-Trichlorophenol	100.00	0.0000	100.00	100	37-144

Table 6 - BNA STANDARDS USED

<u>base/neutral mix (2000ppm)</u>	<u>acids mix (2000ppm)</u>
bis(2-Chloroethyl)ether	2,4-Dinitrophenol
bis(2-Chloroisopropyl)ether	2-Methylphenol
1,3-Dichlorobenzene	4-Methylphenol
1,2-Dichlorobenzene	Benzoic acid
1,4-Dichlorobenzene	4,6-Dinitro-2-methylphenol
Hexachloroethane	4-Nitrophenol
N-Nitroso-di-methylamine	2,4,5-Trichlorophenol
N-Nitroso-di-n-propylamine	2,4,6-Trichlorophenol
2,4-Dinitrotoluene	Phenol
2,6-Dinitrotoluene	Pentachlorophenol
Fluorene	2-Nitrophenol
Dimethylphthalate	4-Chloro-3-methylphenol
Hexachlorocyclopentadiene	2,4-Dichlorophenol
Anthracene	2,4-Dimethylphenol
4-Bromophenyl-phenylether	Benzoic acid
Di-n-butylphthalate	
bis(2-Chloroethoxy)methane	
1,2-Diphenylhydrazine	<u>semivoa misc. mix(2000ppm)</u>
Fluoranthene	Aniline
Hexachlorobenzene	Benzyl alcohol
N-Nitrosodiphenylamine	Carbazole
Phenanthrene	4-Chloroaniline
Hexachlorobutadiene	Dibenzofuran
Isophorone	2-Methylnaphthalene
Naphthalene	2-Nitroaniline
Nitrobenzene	3-Nitroaniline
1,2,4-Trichlorobenzene	4-Nitroaniline
Acenaphthene	Pyridine
Acenaphthylene	
2-Chloronaphthalene	<u>Benzidine mix (2000ppm)</u>
4-Chlorophenyl-phenylether	Benzidine
Diethylphthalate	3,3'-Dichlorobenzidine
Benzo(a)anthracene	
Bis(2-ethylhexyl)phthalate	
Butylbenzylphthalate	
Chrysene	<u>Individual or misc. mixes (2000/5000/20,000ppm)</u>
p-(Dimethylamino)azobenzene	Caprolactam
Pyrene	Benzaldehyde
Benzo(b)fluoranthene	Atrazine
Benzo(k)fluoranthene	1,1'-Biphenyl
Benzo(g,h,i)perylene	1,4-Dioxane
Benzo(a)pyrene	1-methylnaphthalene
Dibenz(a,h)anthracene	2,6-dichlorophenol
Di-n-octylphthalate	2,3,4,6-tetrachlorophenol
Indeno(1,2,3-cd)pyrene	

<u>BNA internals (2000ppm)</u>	<u>Acid surrogate (7500ppm)</u>
1,4-Dichlorobenzene-d4 (I.S)(1)	2-Fluorophenol (S)
Naphthalene-d8 (I.S)(35)	Phenol-d6 (S)
Acenaphthene-d10 (I.S) (59)	2,4,6-Tribromophenol (S)
Phenanthrene-d10 (I.S) (79)	2,-Chlorophenol-d4 (S)
Chrysene-d12 (I.S) (92))	<u>BN surrogate (5000ppm)</u>
Perylene-d12 (I.S) (101)	Nitrobenzene-d5 (S)
	Terphenyl-d14 (S)
	2-Fluorobiphenyl (S)
	1,2-Dichlorobenzene-d4 (S)

Table 7 INTERNAL STANDARD ASSOCIATION / QUANT MASS – Standard SVOC analysis					
COMPOUND	*I.S	Q.M	COMPOUND	*I.S	Q.M
1,4-Dichlorobenzene-d4 (I.S)(1)		152	Dimethylphthalate	59	163
Acetophenone	1	105	Hexachlorocyclopentadiene	59	237
Aniline	1	93	2,4-Dinitrophenol	59	184
Benzaldehyde	1	106	2,4-Dinitrotoluene	59	165
Benzyl alcohol	1	108	2,6-Dinitrotoluene	59	165
bis(2-Chloroethyl)ether	1	93	Fluorene	59	166
bis(2-Chloroisopropyl)ether	1	45	2-Nitroaniline	59	65
1,3-Dichlorobenzene	1	146	3-Nitroaniline	59	138
1,2-Dichlorobenzene	1	146	4-Nitroaniline	59	138
1,4-Dichlorobenzene	1	146	4-Nitrophenol	59	65
2-Methylphenol	1	108	2,4,5-Trichlorophenol	59	196
4-Methylphenol	1	108	2,4,6-Trichlorophenol	59	196
3-Methylphenol	1	108	2-Fluorobiphenyl (S)	59	172
Phenol	1	94	Phenanthrene-d10 (I.S) (79)		188
Pyridine	1	79	Anthracene	79	178
Hexachloroethane	1	117	Atrazine	79	200
N-Nitroso-di-methylamine	1	42	4-Bromophenyl-phenylether	79	248
N-Nitroso-di-n-propylamine	1	70	Carbazole	79	167
2-Fluorophenol (S)	1	112	Di-n-butylphthalate	79	149
Phenol-d6 (S)	1	99	4,6-Dinitro-2-methylphenol	79	198
Naphthalene-d8 (I.S)(35)		136	1,2-Diphenylhydrazine	79	77
Benzoic acid	35	105	Fluoranthene	79	202
bis(2-Chloroethoxy)methane	35	93	Hexachlorobenzene	79	284
Caprolactam	35	113	N-Nitrosodiphenylamine	79	169
4-Chloroaniline	35	127	Pentachlorophenol	79	266
4-Chloro-3-methylphenol	35	107	Phenanthrene	79	178
2,4-Dichlorophenol	35	162	2,4,6-Tribromophenol (S)	79	330
2,4-Dimethylphenol	35	107	Chrysene-d12 (I.S) (92)		240
Hexachlorobutadiene	35	225	Benzidine	92	184
Isophorone	35	82	Benzo(a)anthracene	92	228
2-Methylnaphthalene	35	141	Bis(2-ethylhexyl)phthalate	92	149
Naphthalene	35	128	Butylbenzylphthalate	92	149
Nitrobenzene	35	77	Chrysene	92	228
2-Nitrophenol	35	139	3,3'-Dichlorobenzidine	92	252
1,2,4-Trichlorobenzene	35	180	p-(Dimethylamino)azobenzene	92	225
Catechol	35	110	Pyrene	92	202
Nitrobenzene-d5 (S)	35	82	Terphenyl-d14 (S)	92	244
Acenaphthene-d10 (I.S) (59)		164	Perylene-d12 (I.S) (101)		264
Acenaphthene	59	153	Benzo(b)fluoranthene	101	252
Acenaphthylene	59	152	Benzo(k)fluoranthene	101	252
1,1'-Biphenyl	59	154	Benzo(g,h,i)perylene	101	276
2-Chloronaphthalene	59	162	Benzo(a)pyrene	101	252
4-Chlorophenyl-phenylether	59	204	Dibenz(a,h)anthracene	101	278
Dibenzofuran	59	168	Di-n-octylphthalate	101	149
Diethylphthalate	59	149	Indeno(1,2,3-cd)pyrene	101	276

I.S=internal standard, Q.M=quant mass, S=surrogate

**Table 7 INTERNAL STANDARD ASSOCIATION / QUANT MASS –
Standard SVOC analysis (contd)**

COMPOUND	*I.S	Q.M	COMPOUND	*I.S	Q.M
1,4-Dichlorobenzene-d4 (I.S)(1)		152	Diphenylamine	59	169
Pentachloroethane	1	167	Thionazin	59	107
2-Picoline	1	93		59	
N-Nitrosomethylethylamine	1	88		59	
Methyl methanesulfonate	1	80		59	
N-Nitrosodiethylamine	1	102		59	
Ethyl methanesulfonate	1	79		59	
N-Nitrosopyrrolidine	1	100		59	
N-Nitrosomorpholine	1	56		59	
O-Toluidine	1	106		59	
	1		Phenanthrene-d10 (I.S) (79)		188
	1		4-Nitroquinoline-1-oxide	79	190
	1		Phenacetin	79	108
	1		4-Aminobiphenyl	79	169
	1		Pentachloronitrobenzene	79	237
	1		Sulfotepp	79	97
	1		Phorate	79	75
Naphthalene-d8 (I.S)(35)		136	Diallate	79	86
1- Methylnaphthalene	35	141	Dimethoate	79	87
N-Nitrosopiperidine	35	114	Pronamide	79	173
a,a-Dimethylphenethylamine	35	58	Disulfoton	79	88
O,O,O-Triethylphosphorothioate	35	97	Dinoseb	79	211
Hexachloropropene	35	213		79	
2,6-Dichlorophenol	35	162		79	
p-Phenylenediamine	35	108	Chrysene-d12 (I.S) (92)		240
N-Nitrosodi-n-butylamine	35	84	Methapyrilene	92	97
Safrole	35	162	p-(Dimethylamino)azobenzene	92	225
1,2,4,5-Tetrachlorobenzene	35	216	Chlorobenzilate	92	251
	35		3,3'- Dimethylbenzidine	92	212
	35		2- Acetylaminofluorene	92	181
	35		7,12-Dimethylbenz[a]anthracene	92	256
	35		Aramite	92	185
	35		Methyl parathion	92	109
	35		Parathion	92	109
Acenaphthene-d10 (I.S) (59)		164	Isodrin	92	193
Isosafrole	59	162	Kepone	92	272
1,4-Naphthoquinone	59	158	Famphur	92	218
Pentachlorobenzene	59	250	Perylene-d12 (I.S) (101)	101	
2-Naphthylamine	59	143	3-Methylcholanthrene	101	268
1-Naphthylamine	59	143	Hexachlorophene	101	196
2,3,4,6-Tetrachlorophenol	59	232		101	
5-Nitro-o-toluidine	59	152		101	
I.S=internal standard, Q.M=quant mass, S=surrogate					

Table 8: LOW CONCENTRATION PAH INTERNAL STANDARD/SURROGATE SPECIFICATIONS

INTERNAL STD ASSOCIATION

Phenanthrene-d10 (IS)

Naphthalene
2-Methylnaphthalene
1-Methylnaphthalene

2-Fluorobiphenyl(SUR)

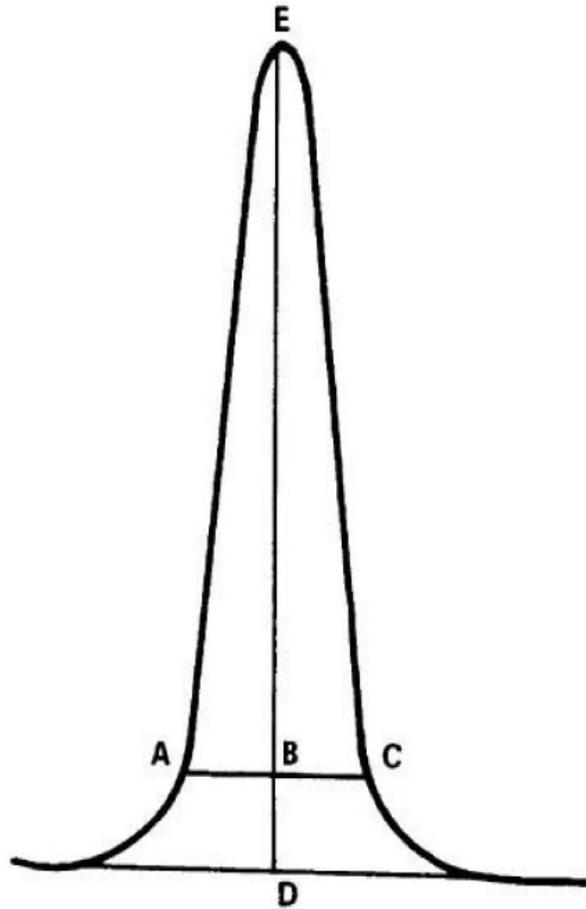
Acenaphthylene
Acenaphthene
Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene

Perylene-d12 (IS)

Terphenyl-d14(SUR)

Benzo(a)anthracene
Chrysene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

FIGURE 1
TAILING FACTOR CALCULATION



$$\text{TAILING FACTOR} = \frac{BC}{AB}$$

Example calculation: Peak Height = DE = 100 mm
10% Peak Height = BD = 10 mm
Peak Width at 10% Peak Height = AC = 23 mm
AB = 11 mm
BC = 12 mm

$$\text{Therefore: Tailing Factor} = \frac{12}{11} = 1.1$$

Table 9, DFTPP Tuning Criteria

Mass	Ion Abundance Criteria
51	30-60% of mass 198
68	<2% of mass 69
70	<2% of mass 69
127	40-60% of mass 198
197	<1% of mass 198
198	Base peak, 100% relative
199	5-9% of mass 198
275	10-30% of mass 198
365	>1% of mass 198
441	Present, but less than mass 443
442	>40% of mass 198
443	17-23% of mass 442

Note: While 8270D table 3 indicates different criteria, section 11.3.1.2 allows the use of alternate criteria.

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 202

REVISION #: 23

EFFECTIVE DATE: 20100909

**GC/MS VOLATILES BY EPA METHOD E624 & SW846 METHOD 8260B
INCLUDING APPENDIX IX COMPOUNDS**

APPROVALS:

Lab Director:  _____ Date: 9/9/10

Data Quality Manager:  _____ Date: 9/9/10

Section Supervisor:  _____ Date: 9/9/10

Changes Summary

Revision 23, 09/09/10

- This SOP is an update from Revision 22 dated 09/30/09.
- Tables 1 and 2 have been updated with appropriate reference updates.
- Tables 5-7 have been added.

Revision 22, 9/30/09

- The SOP is an update from Revision 21 dated 09/11/08
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

Table of Contents

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16. Method Performance
17. Pollution Prevention
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1. Identification of the Test Method

1.1 This SOP is compliant with methods – EPA Method 624 and SW-846 Method 8260B

2. Applicable Matrix or Matrices

2.1 This SOP is applicable to – The analysis of volatile organic compounds in a variety of matrices including but not limited to soils, sediments, ground and surface waters, aqueous sludge, oily wastes, etc.

3. Detection Limit: See **Table 1** of this SOP.

4. Scope of Application, Including components to be Analyzed

4.1 This SOP is based primarily on SW-846 Method 8260B. Methods SW-846 Method 8000B; *Federal Register* Method 624; and CLP Method for Volatiles have also been used in the development of this SOP. The analyses by these various methods are clearly defined in the respective regulatory manuals. A good understanding of these different methods is essential to the performance of each method. Each parameter that is analyzed and reported under the scope of this SOP is listed in **Table 1** of this SOP. When applicable, surrogate and Internal Standard Analytes are listed and indicated as such within this table.

5. Summary of the Test Method

5.1 After sample preparation, the sample is introduced into the GC/MS generally using purge and trap but sometimes using direct injection (see SW-846 Methods 5030B, 5035 and 3585 for preparation). In purge and trap, the analytes are stripped from the sample using helium and trapped on an adsorbent tube. The tube is heated while being backflushed with helium to carry the analytes to the GC/MS system. The analytes are separated in the gas chromatograph by a combination of the temperature program and the capillary column. The analytes are then detected by the mass spectrometer. Analytes are identified by comparing the mass spectra of known standards with the mass spectra of the sample. Analytes are quantitated relative to known standards using the internal standard method.

6. Definitions

6.1 Laboratory Quality System SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.

7. Interferences

7.1 Section 3.0 of SW-846 Method 8260B details interferences and potential problems which may be encountered when dealing with volatile analyses.

8. Safety

- 8.1 Laboratory SOP QS13 "Safety Program & Chemical Hygiene Plan" discusses the safety program that is to be followed labwide.

9. Equipment & Supplies

- 9.1 GC : HP 5890 or 6890, temperature programmable, suitable for split or splitless injection.
- 9.2 Column: DB-VRX 60 meter x 0.25 mm I.D. 1.4 μm film thickness or 20 meter x 0.18 mm ID 1.0 μm film thickness silicon coated fused silica capillary column or equivalent.
- 9.3 M.S.: HP 5971, 5972 or 5973 capable of scanning 35 to 500 amu every one second or less, using 70 volts electron energy in electron impact ionization mode. The MS is capable of producing a mass spectrum for p-Bromofluorobenzene, BFB, which meets all tuning criteria for EPA methods [when 1 μL (50 ng) of the GC/MS tuning standard is introduced to the GC.]
- 9.4 Purge and Trap Unit
 - 9.4.1 Concentrators: Tekmar LSC 2000 or Tekmar/Dohrmann 3000/3100 Sample Concentrator equipped with Supelco trap number 2-1066-U or 2-4920-U VOCARB 3000 providing good delivery for all target compounds.
 - 9.4.2 Autosamplers: Varian Archon 51 position programmable autosampler with 5ml to 25ml water and heated soil capability.
- 9.5 Acquisition Software: HP chemstation system interfaced to the GC/MS. The system acquires and stores data throughout the chromatographic programs.
- 9.6 Data Processing Software: TargetDB on Windows NT data system interfaced to the HP Chemstation. The system accepts and stores acquired data. It plots by extracted ion current profile (EICP). The system is also capable of integrating the abundances of any EICP between specified time or scan-number limits. NBS75K mass spectral library is installed.
- 9.7 Microsyringes – 1.0, 5.0, 10, 25, 100, 250, 500 and 1000 μL .
- 9.8 Syringes – 5, 25 and 50 mL, gas-tight with Luer end.
- 9.9 Balance - analytical, 0.0001 g; top-loading, 0.01 g.
- 9.10 Disposable pasteur pipets.
- 9.11 Volumetric flasks, Class A - 2 mL, 5 mL, 10 mL, 50 mL, 100 mL and 250 mL with ground-glass stoppers.
- 9.12 Spatula - stainless steel.
- 9.13 Glass scintillation vials - 20mL with screw caps.
- 9.14 Nitrile Gloves
- 9.15 pH paper (measures pH from 0-14).

10. Reagents and Standards

- 10.1 The laboratory's LIMS system allows for complete documentation and for the traceability of reagents and standards used within the laboratory. The following information relates to the specific reagents and standards used for the performance of the method:
- 10.2 Organic-free reagent water - obtained from the charcoal filter system in the VOA laboratory.
- 10.3 Methanol - Purge and trap grade (EM-Omnisolv EM-0482-6 or equivalent)
- 10.4 Methanol - suitable for use in gas chromatography (B&J Omnisolv MX0484- 1, or equivalent)
- 10.5 Sodium bisulfate, NaHSO₄ – ACS reagent grade, or equivalent. Available from Aldrich (Part No. 30,782-3).
- 10.6 Stock standards are purchased in mixtures from reputable vendors. The date they are received is noted on the label. The date they are opened is noted on the label and recorded in the LIMS system along with their lot number and vendor and given a sequential number. Each standard label is completed with the standard number, name, preparation date, expiration date, solvent and analyst initials. Stock standards, when opened, have an expiration date of 6 months, **except for gas standards for South Carolina samples which have a one week expiration date**. All stocks and standards are stored in the freezer at a temperature of $-15^{\circ}\text{C} \pm 5^{\circ}\text{C}$ or less from the date they are received/prepared. The freezer temperature is monitored daily with a calibrated thermometer (annual calibration for liquid in glass and quarterly calibration for digital) and recorded with calibration correction in the VOA refrigerator/freezer logbook. Makeup of common standards is detailed below. See standard ID in LIMS system for makeup of other standards.
- 10.6.1 The Bromofluorobenzene (BFB) tuning standard is prepared as follows: Using a 50 μL syringe, 40 μL of standard (BFB @ 2500ng/ μL) is injected into a 2mL volumetric flask containing approximately 1.0mL P&T methanol (Vendor, Lot) and diluted to volume with same making a 50ng/ μL standard. After capping and inverting 3 times, the solution is transferred to a labeled 2ml, teflon-lined, screw-capped vial and stored in the freezer at $-15^{\circ}\text{C} \pm 5^{\circ}\text{C}$ or less for up to 6 months (**1 week for South Carolina samples**). A direct injection of 1 μL (or equivalent purge) is used to tune the instrument.
- 10.6.2 The internal and surrogate standards are prepared as follows: Using the indicated syringe, the indicated amount of standard is injected into a 50 mL volumetric flask containing P&T methanol (Vendor, Lot) and diluted to volume with same making a 150ng/ μL standard. After capping and inverting 3 times, the solution is transferred to the Archon standard vial and stored under helium for 1 month or less. Each 8260/624 sample is automatically injected with 1 μL of this standard. (The internal standard/surrogate solution may be replaced if the -50% - 200% criteria fails in the CCV when calculated against the previous CCV.)

Standard	Conc. (ng/μL)	Syringe (μL)	Amount (μL)
8260 ISTD Mix	2500	1000	3000
Surr. Mix	2500	1000	3000

10.6.3 Calibration standards are prepared from the vendor stock standards at appropriate concentrations as follows. Occasionally unusual compounds are added to the mix so it is best to check the LIMS for exact standard makeup. Note: for laboratory control spikes (LCS), alternate sources or lot numbers from the main calibration standard are used to make the LCS standard.

10.6.3.1 Primary Standard: Using the indicated syringe, the indicated amount of standard is injected into a 2mL volumetric flask containing approximately 1.0mL P&T methanol (Vendor, Lot) and diluted to volume with same to make a 100-500ng/μL standard. After capping and inverting 3 times, the solution is transferred into 2ml amber vial w/mini-inert valve and stored in the freezer at $-15^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 1 week. A 100μg/L (5mL purge) standard is made using 50μL of this standard to 50mL of reagent water.

Stock Standard(CCV)	Conc (ng/μL)	Syringe(μL)	Amount(μL)	Final Conc (ng/μL)
2-CEVE (Cat#30265)	20000	25	20	200
Vinyl Acetate (#3766)	5000	100	80	200
Ketones (cat#30006)	5000	100	80	200
Liquid mix (C-349H-07)	2000	100	100	100
Custom mix (CCS-1037)	5000	50	40	100
Gases (cat#30042)	2000	100	100	100
Acrolein/Acrylonitrile (CC2098.10)	20,000	50	50	500

Additional compounds may be added such as Appendix IX. Refer to standard ID in LIMS system.

10.6.4 ICV/LCS/Matrix Spike Mix: A second source standard is used to check the validity of the gas and primary calibration standards used in analyzing the calibration curve. Using the indicated syringe, the indicated amount of standard is injected into a 2mL volumetric flask containing approximately 1.0mL P&T methanol (Vendor, Lot) and diluted to volume with same to make a 100-500ng/μL standard. After capping and inverting 3 times, the solution is transferred into 2ml amber vial w/mini-inert valve and stored in the freezer at $-15^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 1 week. A 50μg/L ICV/LCS/Matrix Spike is made using 25μL of this standard to 50mL of reagent water/Sample Matrix.

Stock Standard(ICV/LCS)	Conc (ng/μL)	Syringe(μL)	Amount(μL)	Final Conc (ng/μL)
2-CEVE	20,000	25	20	200
Vinyl Acetate	5000	100	80	200
Ketones	5000	100	80	200
Liquid mix	2000	100	100	100
Custom Mix	5000	50	40	100
Gases	2000	100	100	100
Acrolein/Acrylonitrile	50,000	50	50	500

11. Sample Collection, Preservation, Shipment, and Storage

- 11.1 Quality Systems SOP QS10 related to Sample Receipt, Handling, & Processing provides details for collection, preservation, shipment, and storage.
- 11.2 All water samples are stored in the “True” refrigerator in the VOA lab at a temperature of 4°C. All unpreserved soil samples in TerraCore or encores are stored in the freezer in the VOA lab. All soil samples in bulk jars or chemically preserved TerraCore are stored in the soil walk-in refrigerator at a temperature of 4°C. Non-preserved water volatile samples have a holding time of 7 days from date of sampling. Preserved water samples and soil volatile samples have a holding time of 14 days from date of sampling (unless otherwise specified for the project). The temperature is monitored daily with a calibrated thermometer (annual calibration for liquid in glass and quarterly calibration for digital) and recorded with calibration correction in the VOA refrigerator/freezer logbook. The weekend temperature is monitored with a Min/Max thermometer and recorded upon arrival next business day.

12. Quality Control

- 12.1 Quality Systems SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” outlines details related to laboratory wide protocols on quality control.
- 12.1 Internal Standards - All samples and QC are spiked with internals. See **Table 2** for acceptance criteria and corrective action.
- 12.2 Surrogates - All samples and QC are spiked with surrogates. See **Table 2** of this SOP for acceptance criteria and corrective action.
- 12.3 LCS Sample - An LCS is analyzed every 12 hour tune. To prepare the LCS, a blank is spiked with standards prepared from an alternate vendor or lot number from the calibration standards. Note: the concentration of the LCS will be 20 μg/L when analyzing 624 samples (QC Check Sample). See **Table 2** of this SOP for acceptance criteria and corrective action. **When analyzing samples for South Carolina the limits are 70-130% except for poor purgers which are 60-140%.**
- 12.4 Method Blanks - A method blank is analyzed every 12 hour tune. See **Table 2** of this SOP for acceptance criteria and corrective action..
- 12.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample - 1 in 20 samples are spiked for an MS/MSD with the LCS standard. See **Table 2** of this SOP for acceptance

criteria and corrective action. MS data evaluation must include the consideration of the following factors.

- 12.5.1 Sample matrix - If the sample is a soil, grab sample or sequentially collected water sample it may affect the %R and RPD of the MS/MSD. A water sample which was taken from the same VOA vial for the original sample and the MS/MSD should have very good RPDs unless there has been a method problem. Corrective action must be taken in the form of reanalysis if a method problem is indicated.
- 12.5.2 Original sample concentration - If a spiked compound has a problem and the concentration of that compound in the original sample was four or more times the concentration of the spike, no further corrective action may be necessary other than the generation of a corrective action report to document the problem.
- 12.5.3 MS vs. MSD - If a spiked compound has a problem in both the MS and MSD, review the LCS and if acceptable no further action may be necessary since it is attributable to matrix effect.
- 12.5.4 Non-target Interference - The presence of significant non-target interference should be brought to the immediate attention of your supervisor who should discuss the problem with the client/project manager to determine the action to be taken.

13. Calibration and Standardization

- 13.1 Quality Systems **SOP QS08** “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.
- 13.2 Chromatographic conditions – Refer to corresponding instrument maintenance log for current gas chromatograph, mass spectrometer, and concentrator conditions.
- 13.3 System Bakeout - Prior to analysis an instrument blank is analyzed.

NOTE: Further cleaning may be accomplished by backflushing the lines with methanol and then analyzing blanks overnight.

13.4 Tuning - Prior to any calibration or analysis, BFB tuning criteria must be met for a 1.0 μ L injection of the tuning standard. See **Table 5** of this SOP for acceptance criteria. Tune must be met every 12 hours sample analysis is to be performed (**every 24 hours for *Federal Register Method 624* except for South Carolina which only allows 12 hours**). The mass spectrum of BFB is acquired as follows: by using the BFB method in Target (which uses three scans with background subtraction) to process the BFB data file. If the BFB tune does not pass criteria corrective action should be taken

- 13.5 **Calibration:** Calibration standards are made up in water using the appropriate amount of the methanol standard. See the LIMS for preparation of standards. **Calibration for soils for South Carolina requires that 5mL of sodium bisulfate**

solution is added to each calibration standard made if the samples will be preserved with sodium bisulfate. All manual calibration integrations must be approved by the section manager or designated peer reviewer.

13.5.1 Initial Calibration - An initial calibration curve at no less than five (six if using a quadratic curve fit) concentration levels must be analyzed and shown to meet the initial calibration criteria before any sample analysis may be performed. **For Arizona samples the surrogates must also be calibrated at a minimum of five concentrations.** See **Table 2** of this SOP for acceptance criteria and corrective action. The lowest standard must be less than or equal to the reported quantitation limit and the highest standard must not exceed the linear range of the detector. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, dated, and reason with the quantitation report and chromatograms. All manual calibration integrations must be approved by the section manager or designated peer reviewer Any response factors less than 0.050 must be supported by the mass spectrum of the lowest standard. **No quadratic curves for South Carolina.**

CCCs:	1,1-Dichloroethene	Toluene
	Chloroform	Ethylbenzene
	1,2-Dichloropropane	Vinyl chloride
SPCCs:	Chloromethane	0.10
	1,1-Dichloroethane	0.10
	Bromoform	0.10
	Chlorobenzene	0.30
	1,1,2,2-Tetrachloroethane	0.30

13.5.2 Initial Calibration Verification (ICV) - A second source standard is prepared at or near the CCV concentration and calculated against the initial calibration curve, then shown to meet the calibration check criteria before any sample analysis may be performed. See **Table 2** of this SOP for acceptance criteria and corrective action. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, dated, and reason with the quantitation report and chromatograms. All manual ICV integrations must be approved by the section manager or designated peer reviewer.

13.5.3 Continuing Calibration Verification (CCV) - A CCV is analyzed every 12 hour tune and calculated against the initial calibration curve, then shown to meet the calibration check criteria before any sample analysis may be performed. See **Table 2** of this SOP for acceptance criteria and corrective action. Any manual integrations are documented by inclusion of the integrated signals (**before and after manual integration**) initialed, dated, and reason with the quantitation report and chromatograms. All manual CCV integrations must be approved by the section manager or designated peer reviewer. .

NOTE: Acceptance criteria for method 624 consists of meeting recovery limits found in table 5 of the method for a QC check sample. This QC check

sample is made from a separate source or lot number than the calibration standard at a concentration of 20 µg/L.

14. Procedure

14.1 LCS - An LCS is analyzed every 12 hour tune. Using standards prepared from an alternate vendor or lot number, blank water is spiked at the 50 µg/L (5mL/soil) or 10 µg/L (25mL) level. See **Table 2** of this SOP for acceptance criteria and corrective action. **Note: the concentration of the LCS will be 20 µg/L when analyzing 624 samples (QC Check Sample).**

14.2 Method Blank - Prior to sample analysis, the system must be shown to be free of contamination through analysis of a method blank. See **Table 2** of this SOP for acceptance criteria and corrective action.

14.3 Sample Analysis - Prior to analysis, the samples are prepared for chromatography using the appropriate sample preparation method (5mL water, 25mL water, low soil, high soil, etc.) See SOP 225 for preparation of a 5035 soil sample. For a 5mL/25mL water sample, use the following procedure:

14.3.1 Load the vial into the Archon autosampler in the expected position.

14.3.2 Program the Archon for the loaded vial range and necessary dilutions, making sure the programmed method is set for the same volume as the purge vessel on the front of the LSC 2000 or 3000/3100 and that the Chemstation sequence matches the Archon sequence. Note: TCLP samples are analyzed at a 10x dilution. One TCLP sample is spiked per batch at receipt of leachates.

14.3.3 After analysis of the sample has been completed, check the pH of the sample using pH paper and verify it to be less than a pH of 2 (recorded on the sequence log). If it is not, record the pH on the sequence log and generate a non-conformance report. The sample report will have to be qualified for preservation if the analysis is being performed more than 7 days after sampling. [Note: TCLP samples do not require a pH check.]

14.4 Instrument sequence

An example of a typical instrument sequence log follows:

1-BFB Tune (12:00 am)

2-CCV

3-LCS

4-Method Blank

5-Sample

6-Sample

7-Sample

8-Sample

9-Sample

10-Sample

11-Sample

12-Sample

13-Sample

14-Sample

- 15-Sample
- 16-Sample
- 17-Sample MS
- 18-Sample MSD
- 19-BFB (12:00pm - 12 hours since last BFB/CCV)
- 20-CCV
- 21-LCS
- 22-Method Blank
- 23-Sample
- 24-Sample

14.5 Data Reduction/Evaluation - Each sample analysis sequence is documented using the computer run log generated on the chemstation. This run log is signed, dated and paginated then placed in a 3 ring binder for that instrument. After the sample has been analyzed, the data is processed through the TargetDB on Windows NT data system. Quantitative measurements are performed using the calculations found in section 15.2 of this SOP. The following must be checked to determine if the sample will need any reanalysis or dilution. See **Table 2** of this SOP for acceptance criteria and corrective action. Formal data evaluation is detailed in SOP QS05. See **SOP QS07 for guidance on manual integrations.**

14.5.1 Internal Standards - Areas counts and retention times.

14.5.2 Surrogates – Recoveries and retention times.

Federal Register Method 624 contains no criteria for surrogate recovery.

Surrogate	WATER	SOIL
Dibromofluoromethane	85-120	80-125
1,2-Dichloroethane-d4	85-135	75-140
Toluene-d8	85-115	80-120
Bromofluorobenzene	80-120	80-125

14.5.3 Analyte concentration.

14.5.4 Qualitative identification based on spectrum and retention time.

15. Data Analysis and Calculations

15.1 Quality Systems SOP QS09 “General and Commonly used Laboratory Calculations” provides details on general calculations used throughout the laboratory.

15.2 Calculations:

15.2.1 The RF is calculated as follows:

$$RF = \frac{A_s \times C_{is}}{A_{is} \times C_s}$$

where:

A_s = Peak area (or height) of the analyte or surrogate.

A_{is} = Peak area (or height) of the internal standard.

C_s = Concentration of the analyte or surrogate.

C_{is} = Concentration of the internal standard.

- 15.2.2 Calibration verification involves the calculation of the percent drift (linear) or the percent difference (average) of the instrument response between the initial calibration and each subsequent analysis of the verification standard. Use the equations below to calculate % Drift or % Difference, depending on the calibration procedure used.

$$\% \text{ Drift} = \frac{(\text{Calculated concentration} - \text{Theoretical concentration}) * 100}{\text{Theoretical Concentration}}$$

where the calculated concentration is determined from the initial calibration and the theoretical concentration is the concentration at which the standard was prepared.

$$\% \text{ Difference} = \frac{(\text{CCV RF} - \text{Average RF}) * 100}{\text{Average RF}}$$

where CCV RF is the response factor from the analysis of the verification standard and Average RF is the average response factor from the initial calibration. The % difference or % drift calculated for the calibration verification standard must be within $\pm 20\%$ for each CCC analyte, or for all target analytes if the CCCs are not target analytes, before any sample analyses may take place.

- 15.2.3 Concentration in water samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to ug/L.]

$$\text{Concentration } (\mu\text{g/L}) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{\text{RF}})(V_s)(1000)}$$

where:

A_s = Area (or height) of the peak for the analyte in the sample.

A_{is} = Area (or height) of the peak for the internal standard.

C_{is} = Concentration of the internal standard in the volume purged in ug/L.

D = Dilution factor, if the sample was diluted prior to analysis. If no dilution was made, $D = 1$. The dilution factor is always dimensionless.

V_i = For purge-and-trap analysis, V_i is not applicable and is set at 1.

$\overline{\text{RF}}$ = Mean response factor from the initial calibration.

V_s = Volume of the aqueous sample purged (mL). If units of liters are used for this term, multiply the results by 1000.

- 15.2.4 Concentration in non-aqueous samples is calculated as follows: [Note: Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to ug/kg.]

$$\text{Concentration } (\mu\text{g/kg}) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{\text{RF}})(W_s)(1000)}$$

where: A_s , A_{is} , C_{is} , D , and \overline{RF} are the same as for aqueous samples.
 W_s = Weight of sample extracted (g). Either a dry weight or wet weight may be used, depending upon the specific application of the data. If units of kilograms are used for this term, multiply the results by 1000.

16. Method Performance

16.1 Demonstration of Capability (DOC): Each analyst must perform a DOC prior to reporting data. The analyst must prepare (for prep technicians) and analyze (analysts reviewing and reporting data) 4-LCS samples. The data is calculated for accuracy and precision requirements. The DOC form is completed by each analyst and then provided to the supervisor for further processing and approval. See [Table 2](#) for acceptance criteria.

17. Pollution Prevention

17.1 Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18. Data Assessment and Acceptance Criteria for Quality Control Measures

18.1 Quality Control SOP QS05, “Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results”, provides details on data assessment and acceptance criteria for Quality Control Measures. [Table 2](#) of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19. Contingencies for Handling out-of-control or unacceptable data

19.1 Quality Control SOP QS05, “Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results”, provides details on handling out of control data. [Table 2](#) within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

20. Waste Management.

20.1 Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

21. References

- 21.1 40 CFR, Part 136; Appendix A
- 21.2 Test Methods for Evaluating Solid Waste, SW-846, Third Edition and updates
- 21.3 National Environmental Laboratory Accreditation Conference; CH. 5, 2001
- 21.4 USACE, EM 200-1-3; Appendix 1; Shell, 2/2001
- 21.5 DOD Quality Systems Manual for Environmental Laboratories version 3, 3/2005

22. Tables, Diagrams, Flowcharts and Validation Data

- 22.1 Table 1, all applicable parameters with the applicable DL(MDL)/LOD/LOQ(MRL).
- 22.2 Table 2, QA/QC summary table
- 22.3 Table 3, Technical Completeness / Accuracy Checklist
- 22.4 Table 4, Data Reviewers Checklist(s)
- 22.5 Table 5, BFB Tuning Criteria
- 22.6 Table 6, Analyst Checklist
- 22.7 Table 7, INTERNAL STANDARD ASSOCIATION

Table 1 – DL/LOD/LOQ

Analyte	MDL/DL	LOD	MRL/LOQ	Units
1,1,1,2-Tetrachloroethane	1.25	2.50	5.00	ug/Kg
1,1,1-Trichloroethane (1,1,1-TCA)	1.25	2.50	5.00	ug/Kg
1,1,2,2-Tetrachloroethane	1.25	2.50	5.00	ug/Kg
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)	2.50	5.00	10.0	ug/Kg
1,1,2-Trichloroethane	1.25	2.50	5.00	ug/Kg
1,1-Dichloroethane (1,1-DCA)	1.25	2.50	5.00	ug/Kg
1,1-Dichloroethene (1,1-DCE)	1.25	2.50	5.00	ug/Kg
1,1-Dichloropropene	1.25	2.50	5.00	ug/Kg
1,2,3-Trichlorobenzene	1.25	2.50	5.00	ug/Kg
1,2,3-Trichloropropane	1.25	2.50	5.00	ug/Kg
1,2,4-Trichlorobenzene	1.25	2.50	5.00	ug/Kg
1,2,4-Trimethylbenzene	1.25	2.50	5.00	ug/Kg
1,2-Dibromo-3-chloropropane (DBCP)	2.50	5.00	10.0	ug/Kg
1,2-Dibromoethane (EDB)	1.25	2.50	5.00	ug/Kg
1,2-Dichlorobenzene	1.25	2.50	5.00	ug/Kg
1,2-Dichloroethane (EDC)	1.25	2.50	5.00	ug/Kg
1,2-Dichloropropane	1.25	2.50	5.00	ug/Kg
1,3,5-Trimethylbenzene	1.25	2.50	5.00	ug/Kg
1,3-Dichlorobenzene	1.25	2.50	5.00	ug/Kg
1,3-Dichloropropane	1.25	2.50	5.00	ug/Kg
1,4-Dichlorobenzene	1.25	2.50	5.00	ug/Kg
2,2-Dichloropropane	1.25	2.50	5.00	ug/Kg
2-Butanone (Methyl ethyl ketone; MEK)	2.50	5.00	10.0	ug/Kg
2-Chlorotoluene	1.25	2.50	5.00	ug/Kg
2-Hexanone (Methyl butyl ketone; MBK)	1.25	2.50	5.00	ug/Kg
4-Chlorotoluene	1.25	2.50	5.00	ug/Kg
4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)	1.25	2.50	5.00	ug/Kg
Acetone	5.00	10.0	20.0	ug/Kg
Acrolein	5.00	10.0	20.0	ug/Kg
Acrylonitrile	5.00	10.0	20.0	ug/Kg
Benzene	1.25	2.50	5.00	ug/Kg
Bromobenzene	1.25	2.50	5.00	ug/Kg
Bromochloromethane	1.25	2.50	5.00	ug/Kg
Bromodichloromethane	1.25	2.50	5.00	ug/Kg
Bromoform	1.25	2.50	5.00	ug/Kg
Bromomethane	2.50	5.00	10.0	ug/Kg
Carbon Disulfide	1.25	2.50	5.00	ug/Kg
Carbon Tetrachloride	1.25	2.50	5.00	ug/Kg
Chlorobenzene	1.25	2.50	5.00	ug/Kg
Chloroethane	2.50	5.00	10.0	ug/Kg
Chloroform	1.25	2.50	5.00	ug/Kg
Chloromethane	2.50	5.00	10.0	ug/Kg
cis-1,2-Dichloroethene (cis-1,2-DCE)	1.25	2.50	5.00	ug/Kg
cis-1,3-Dichloropropene	1.25	2.50	5.00	ug/Kg
Cyclohexane	1.25	2.50	5.00	ug/Kg
Dibromochloromethane	1.25	2.50	5.00	ug/Kg

Analyte	MDL/DL	LOD	MRL/LOQ	Units
Dibromomethane	1.25	2.50	5.00	ug/Kg
Dichlorodifluoromethane (CFC-12)	2.50	5.00	10.0	ug/Kg
Ethyl methacrylate	1.25	2.50	5.00	ug/Kg
Ethylbenzene	1.25	2.50	5.00	ug/Kg
Hexachlorobutadiene	1.25	2.50	5.00	ug/Kg
Iodomethane	5.00	10.0	20.0	ug/Kg
Isopropylbenzene (Cumene)	1.25	2.50	5.00	ug/Kg
Methyl Acetate	2.50	5.00	10.0	ug/Kg
Methyl methacrylate	1.25	2.50	5.00	ug/Kg
Methyl Tertiary Butyl Ether (MTBE)	1.25	2.50	5.00	ug/Kg
Methylcyclohexane	1.25	2.50	5.00	ug/Kg
Methylene Chloride, or Dichloromethane	2.50	5.00	10.0	ug/Kg
Naphthalene	1.25	2.50	5.00	ug/Kg
n-Butylbenzene	1.25	2.50	5.00	ug/Kg
n-Propylbenzene	1.25	2.50	5.00	ug/Kg
p-Isopropyltoluene	1.25	2.50	5.00	ug/Kg
sec-Butylbenzene	1.25	2.50	5.00	ug/Kg
Styrene	1.25	2.50	5.00	ug/Kg
tert-Butylbenzene	1.25	2.50	5.00	ug/Kg
Tetrachloroethene (PCE; PERC)	1.25	2.50	5.00	ug/Kg
Toluene	1.25	2.50	5.00	ug/Kg
trans-1,2-Dichloroethene (trans-1,2-DCE)	1.25	2.50	5.00	ug/Kg
trans-1,3-Dichloropropene	1.25	2.50	5.00	ug/Kg
Trichloroethene (TCE)	1.25	2.50	5.00	ug/Kg
Trichlorofluoromethane (CFC-11)	2.50	5.00	10.0	ug/Kg
Vinyl acetate	2.50	5.00	10.0	ug/Kg
Vinyl Chloride (VC)	2.50	5.00	10.0	ug/Kg
m,p-Xylene	2.50	5.00	10.0	ug/Kg
o-Xylene	1.25	2.50	5.00	ug/Kg
1,1,1,2-Tetrachloroethane	0.25	0.50	1.00	ug/L
1,1,1-Trichloroethane (1,1,1-TCA)	0.25	0.50	1.00	ug/L
1,1,2,2-Tetrachloroethane	0.25	0.50	1.00	ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)	0.50	1.00	2.00	ug/L
1,1,2-Trichloroethane	0.25	0.50	1.00	ug/L
1,1-Dichloroethane (1,1-DCA)	0.25	0.50	1.00	ug/L
1,1-Dichloroethene (1,1-DCE)	0.25	0.50	1.00	ug/L
1,1-Dichloropropene	0.25	0.50	1.00	ug/L
1,2,3-Trichlorobenzene	0.25	0.50	1.00	ug/L
1,2,3-Trichloropropane	0.50	1.00	2.00	ug/L
1,2,4-Trichlorobenzene	0.25	0.50	1.00	ug/L
1,2,4-Trimethylbenzene	0.25	0.50	1.00	ug/L
1,2-Dibromo-3-chloropropane (DBCP)	0.50	1.00	2.00	ug/L
1,2-Dibromoethane (EDB)	0.25	0.50	1.00	ug/L
1,2-Dichlorobenzene	0.25	0.50	1.00	ug/L
1,2-Dichloroethane (EDC)	0.25	0.50	1.00	ug/L
1,2-Dichloropropane	0.25	0.50	1.00	ug/L
1,3,5-Trimethylbenzene	0.25	0.50	1.00	ug/L
1,3-Dichlorobenzene	0.25	0.50	1.00	ug/L
1,3-Dichloropropane	0.25	0.50	1.00	ug/L

Analyte	MDL/DL	LOD	MRL/LOQ	Units
1,4-Dichlorobenzene	0.25	0.50	1.00	ug/L
1-Chlorohexane	0.50	1.00	2.00	ug/L
2,2-Dichloropropane	0.25	0.50	1.00	ug/L
2-Butanone (Methyl ethyl ketone; MEK)	2.50	5.00	10.0	ug/L
2-Chloroethyl vinyl ether	1.25	2.50	5.00	ug/L
2-Chlorotoluene	0.25	0.50	1.00	ug/L
2-Hexanone (Methyl butyl ketone; MBK)	1.25	2.50	5.00	ug/L
4-Chlorotoluene	0.25	0.50	1.00	ug/L
4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)	1.25	2.50	5.00	ug/L
Acetone	2.50	5.00	10.0	ug/L
Acrolein	1.25	2.50	5.00	ug/L
Acrylonitrile	2.50	5.00	10.0	ug/L
Benzene	0.25	0.50	1.00	ug/L
Bromobenzene	0.25	0.50	1.00	ug/L
Bromochloromethane	0.25	0.50	1.00	ug/L
Bromodichloromethane	0.25	0.50	1.00	ug/L
Bromoform	0.25	0.50	1.00	ug/L
Bromomethane	0.50	1.00	2.00	ug/L
Carbon Disulfide	0.25	0.50	1.00	ug/L
Carbon Tetrachloride	0.25	0.50	1.00	ug/L
Chlorobenzene	0.25	0.50	1.00	ug/L
Chloroethane	0.50	1.00	2.00	ug/L
Chloroform	0.25	0.50	1.00	ug/L
Chloromethane	0.25	0.50	1.00	ug/L
cis-1,2-Dichloroethene (cis-1,2-DCE)	0.25	0.50	1.00	ug/L
cis-1,3-Dichloropropene	0.25	0.50	1.00	ug/L
Cyclohexane	0.25	0.50	1.00	ug/L
Dibromochloromethane	0.25	0.50	1.00	ug/L
Dibromomethane	0.25	0.50	1.00	ug/L
Dichlorodifluoromethane (CFC-12)	0.50	1.00	2.00	ug/L
Di-isopropyl ether	0.25	0.50	1.00	ug/L
ETBE	0.25	0.50	1.00	ug/L
Ethyl methacrylate	0.25	0.50	1.00	ug/L
Ethylbenzene	0.25	0.50	1.00	ug/L
Hexachlorobutadiene	0.25	0.50	1.00	ug/L
Iodomethane	0.25	0.50	1.00	ug/L
Isopropylbenzene (Cumene)	0.25	0.50	1.00	ug/L
Methyl Acetate	0.50	1.00	2.00	ug/L
Methyl methacrylate	0.25	0.50	1.00	ug/L
Methyl Tertiary Butyl Ether (MTBE)	0.25	0.50	1.00	ug/L
Methylcyclohexane	0.25	0.50	1.00	ug/L
Methylene Chloride, or Dichloromethane	0.50	1.00	2.00	ug/L
Naphthalene	0.25	0.50	1.00	ug/L
n-Butylbenzene	0.25	0.50	1.00	ug/L
n-Propylbenzene	0.25	0.50	1.00	ug/L
p-Isopropyltoluene	0.25	0.50	1.00	ug/L
sec-Butylbenzene	0.25	0.50	1.00	ug/L
Styrene	0.25	0.50	1.00	ug/L
t-Butyl alcohol	1.25	2.50	5.00	ug/L

Analyte	MDL/DL	LOD	MRL/LOQ	Units
tert-Amyl methyl ether	2.50	5.00	10.0	ug/L
tert-Butylbenzene	0.25	0.50	1.00	ug/L
Tetrachloroethene (PCE; PERC)	0.25	0.50	1.00	ug/L
Tetrahydrofuran	1.25	2.50	5.00	ug/L
Toluene	0.25	0.50	1.00	ug/L
trans-1,2-Dichloroethene (trans-1,2-DCE)	0.25	0.50	1.00	ug/L
trans-1,3-Dichloropropene	0.25	0.50	1.00	ug/L
Trichloroethene (TCE)	0.25	0.50	1.00	ug/L
Trichlorofluoromethane (CFC-11)	0.50	1.00	2.00	ug/L
Vinyl acetate	1.25	2.50	5.00	ug/L
Vinyl Chloride (VC)	0.50	1.00	2.00	ug/L
m,p-Xylene	0.50	1.00	2.00	ug/L
o-Xylene	0.25	0.50	1.00	ug/L

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Method 8260B)					
QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Demonstrate acceptable analytical capability	Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix.	QC acceptance criteria published by DoD, if available; otherwise, method-specific criteria.	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f of DoD QSM 4.1).	NA.	This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete.
MDL determination	Initial method demonstration required for some states – not required for DoD	Refer to SOP QS09.			
LOD determination and verification	Prior to initial analysis then quarterly verification.	See Box D-13 of DoD QSM 4.1			
LOQ establishment and verification	Prior to initial analysis then quarterly verification.	See Box D-14 of DoD QSM 4.1			
Tuning	Prior to ICAL and at the beginning of each 12-hour period.	Refer to table 5 of this SOP.	Retune instrument and verify. Rerun affected samples.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be accepted without a valid tune.
Minimum five-point initial calibration (ICAL) for all analytes	ICAL prior to sample analysis.	<p>1. Average response factor (RF) for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane.</p> <p>2. RSD for RFs for CCCs: VOCs $\leq 30\%$ and one option below: Option 1: RSD for each analyte $\leq 15\%$; Option 2: linear least squares regression $r \geq 0.995$; Option 3: non-linear regression–coefficient of determination (COD) $r^2 \geq 0.99$ (6 points shall be used for second order, 7 points shall be used for third order).</p>	Correct problem then repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin for DoD projects.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260B) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Second source calibration verification (ICV)	Once after each ICAL.	All project analytes within $\pm 20\%$ of true value. [$\pm 25\%$ for non-DoD 8260B;]	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be run until calibration has been verified.
Retention time window position establishment for each analyte and surrogate	Once per ICAL.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the sequence CCV is used.	NA.	NA.	
Evaluation of relative retention times (RRT)	With each sample.	RRT of each target analyte within ± 0.06 RRT units. Note - retention times may be updated based on the CCV to account for minor performance fluctuations or after routine system maintenance (such as column clipping).	Correct problem, then rerun ICAL.	Flagging criteria are not appropriate.	With each sample, the RRT shall be compared with the most recently updated RRT. If the RRT has changed by more than ± 0.06 RRT units since the last update, this indicates a significant change in system performance and the laboratory must take appropriate corrective actions as required by the method and rerun the ICAL to reestablish the retention times.
Continuing calibration verification (CCV)	Daily before sample analysis and every 12 hours of analysis time.	1. Average RF for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane. 2. %Difference/Drift for all target compounds and surrogates: VOCs $\leq 20\%D$ (Note: D = difference when using RFs or drift when using least squares regression or non-linear calibration). [$\pm 20\%$ for CCCs only non-DoD 8260B]	DoD project level approval must be obtained for each of the failed analytes or corrective action must be taken. Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since last acceptable CCV.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply qualifier to all results for the specific analyte(s) in all samples since last acceptable CCV. [For non-DoD 8260B, if CCCs exceed, evaluate all analytes for 20%D and qualify as above]	Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed, holding time has been exceeded or client has approved reporting.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260B) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Internal standards verification	Every field sample, standard, and QC sample.	Retention time \pm 30 seconds from retention time of the midpoint standard in the ICAL or daily CCV; EICP area within -50% to +100% of ICAL midpoint standard or daily CCV.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	If corrective action fails in field samples, apply qualifier to analytes associated with the non-compliant IS. Flagging criteria are not appropriate for failed standards.	Sample results are not acceptable without a valid IS verification.
Method blank	One per preparatory batch.	No analytes detected $> \frac{1}{2}$ RL and $> 1/10$ the amount measured in any sample or $1/10$ the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected $>RL/LOQ$	Correct problem. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
LCS containing all analytes to be reported, including surrogates	One per preparatory batch.	QC acceptance criteria specified by client or DoD (appendix G), if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Matrix Spike (MS)	One per preparatory batch per matrix (see Box D-7).	Use LCS criteria, above.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.
Matrix spike duplicate (MSD) or sample duplicate	One per preparatory batch per matrix (see Box D-7).	MSD: For matrix evaluation, use LCS acceptance criteria above. MSD or sample duplicate: $RPD \leq 30\%$ or client specified limit (between MS and MSD or sample and sample duplicate).	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	The data shall be evaluated to determine the source of difference.

Table 2. Organic Analysis by Gas Chromatography/Mass Spectrometry (Methods 8260B) (continued)

QC Check	Minimum Frequency	Acceptance Criteria			Corrective Action	Flagging Criteria	Comments
Surrogate spike	All field and QC samples.	Surrogate	WATER	SOIL	For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Apply qualifier to all associated analytes if acceptance criteria are not met.	Alternative surrogates are recommended when there is obvious chromatographic interference.
		Dibromofluoromethane	85-120	80-125			
		1,2-Dichloroethane-d4	85-135	75-140			
		Toluene-d8	85-115	80-120			
		Bromofluorobenzene	80-120	80-125			
		QC acceptance criteria specified by DoD (above) or Client. Otherwise, in-house control limits may be used. No limits specified for Method 624.					
Results reported between DL and LOQ	NA.	NA.			NA.	Apply J-flag to all results between DL and LOQ.	

Table 3, Technical Completeness / Accuracy Checklist

1. Were all the QC check elements analyzed – refer to Table 2 of the SOP
2. Were the QC criteria met
3. In cases of failures, was there an NCR written
4. Were all manual integrations signed
5. Were dilution factors applied correctly
6. Was there supervisory approval for manual integrations on standards and QC samples
7. Was the data uploaded into LIMS via direct upload – if yes, then was a cross check subset of the uploaded values performed
8. If the data was entered into LIMS manually, was a check of all entered values performed
9. Was the red marked data in LIMS checked for accuracy and the corresponding hard copy data documented appropriately
10. Were proper data qualifiers applied to the data in LIMS
11. Was the hard copy package checked for completeness to include all data for the sequence such that the data reviewer could reconstruct sample analyses and validate / approve the data

Table 4, Data Reviewers Checklist (Prior to approving data)

1. Does the hard copy raw data (or electronic raw data) package look complete and include all data points
2. Were QA objectives met and for failures were the appropriate actions taken
3. For direct uploads to LIMS, did a subset cross check match the raw data
4. Did all the manual entries into LIMS match the raw data
5. Were there appropriate signatures and documentation on the raw data
6. Were appropriate LIMS flags used
7. Were manual integrations signed
8. Were manual integrations for calibration and QC samples approved by supervisor
9. Were manual calculations verified

Table 5, Tuning Criteria

m/z	Required Intensity (relative abundance)
50	15 to 40% of m/z 95
75	30 to 60% of m/z 95
95	Base peak, 100% relative abundance
96	5 to 9% of m/z 95
173	Less than 2% of m/z 174
174	Greater than 50% of m/z 95
175	5 to 9% of m/z 174
176	Greater than 95% but less than 101% of m/z 174
177	5 to 9% of m/z 176

Table 6, ANALYST DATA REVIEW CHECKLIST

Sample Number(s):
Batch Number(s):
Method: 8260B/624/8270C/8270D/625 (Circle One)

QA/QC Item	Yes	No	NA	Second Review	Level
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1. Is the BFB/DFTPP tune performed every 12 hours and is the tuning criteria met?

Are the RRFs and % RSDs within QC limits for appropriate analytes for the initial calibration? Check the retention times for compounds with the same spectra. Check compounds with different conc.(e.g. m/p-xylene, ketones, etc.).

3. Was the initial calibration curve verified by a second source calibration standard (ICV) and have criteria been met?

4. Does the Continuing Calibration Standard (CCV) meet the criteria for the CCCs, SPCCs and/or 20%D for all analytes.

5. Is the Method Blank run at the desired frequency and is its concentration for target analytes less than the MDLs?

6. Are the LCS, MS, MSD within control limits and run at the desired frequency?

7. Are all sample holding times met, analytes within calibration range, IS areas and surrogate recoveries within QC limits?

8. Were the Method Blank, LCS, MS, MSD and samples uploaded to the LIMS and verified (at least one calculation per batch uploaded)?

Comments on any "No" response:

Primary-Level Review: _____ Date: _____

Second-Level Review: _____ Date: _____

Table 7, Internal Standard Association

Analyte	Internal Standard	Analyte	Internal Standard
1,1,1-Trichloroethane	Fluorobenzene	1,1,1,2-Tetrachloroethane	d5-Chlorobenzene
1,1,2-Trichloro-1,2,2-trifluoroethane	Fluorobenzene	1,1,2-Trichloroethane	d5-Chlorobenzene
1,1-Dichloroethane	Fluorobenzene	1,2,3-Trichloropropane	d5-Chlorobenzene
1,1-Dichloroethane	Fluorobenzene	1,2-Dibromoethane (EDB)	d5-Chlorobenzene
1,1-Dichloropropene	Fluorobenzene	1,3-Dichloropropane	d5-Chlorobenzene
1,2-Dichloroethane	Fluorobenzene	1-Chlorohexane	d5-Chlorobenzene
1,2-Dichloroethane-d4	Fluorobenzene	2-Hexanone	d5-Chlorobenzene
1,2-Dichloroethane (total)	Fluorobenzene	Bromofluorobenzene	d5-Chlorobenzene
1,2-Dichloropropane	Fluorobenzene	Bromoform	d5-Chlorobenzene
1,4-Dioxane	Fluorobenzene	Chlorobenzene	d5-Chlorobenzene
2,2-Dichloropropane	Fluorobenzene	Chlorobenzene-d5	d5-Chlorobenzene
2-Butanone	Fluorobenzene	Dibromochloromethane	d5-Chlorobenzene
2-Chloroethyl vinyl ether	Fluorobenzene	Ethyl Methacrylate	d5-Chlorobenzene
4-Methyl-2-pentanone	Fluorobenzene	Ethylbenzene	d5-Chlorobenzene
Acetaldehyde	Fluorobenzene	m,p-Xylene	d5-Chlorobenzene
Acetone	Fluorobenzene	Methacrylonitrile	d5-Chlorobenzene
Acetonitrile	Fluorobenzene	o-Xylene	d5-Chlorobenzene
Acrolein	Fluorobenzene	Styrene	d5-Chlorobenzene
Acrylonitrile	Fluorobenzene	Tetrachloroethane	d5-Chlorobenzene
Allyl chloride	Fluorobenzene	Toluene	d5-Chlorobenzene
Benzene	Fluorobenzene	Toluene-d8	d5-Chlorobenzene
Bromochloromethane	Fluorobenzene	trans-1,3-Dichloropropene	d5-Chlorobenzene
Bromodichloromethane	Fluorobenzene	Xylenes (total)	d5-Chlorobenzene
Bromomethane	Fluorobenzene	1,1,2,2-Tetrachloroethane	1,4-dichlorobenzene-d4
Carbon disulfide	Fluorobenzene	1,2,3-Trichlorobenzene	1,4-dichlorobenzene-d4
Carbon tetrachloride	Fluorobenzene	1,2,4-Trichlorobenzene	1,4-dichlorobenzene-d4
Chloroethane	Fluorobenzene	1,2,4-Trimethylbenzene	1,4-dichlorobenzene-d4
Chloroform	Fluorobenzene	1,2-Dibromo-3-chloropropane	1,4-dichlorobenzene-d4
Chloromethane	Fluorobenzene	1,2-Dichlorobenzene	1,4-dichlorobenzene-d4
Chloroprene	Fluorobenzene	1,3,5-Trimethylbenzene	1,4-dichlorobenzene-d4
cis-1,2-Dichloroethane	Fluorobenzene	1,3-Dichlorobenzene	1,4-dichlorobenzene-d4
cis-1,3-Dichloropropene	Fluorobenzene	1,4-Dichlorobenzene	1,4-dichlorobenzene-d4
Cyclohexane	Fluorobenzene	1,4-Dichlorobenzene-d4	1,4-dichlorobenzene-d4
Dibromofluoromethane	Fluorobenzene	2-Chlorotoluene	1,4-dichlorobenzene-d4
Dibromomethane	Fluorobenzene	4-Chlorotoluene	1,4-dichlorobenzene-d4
Dichlorodifluoromethane	Fluorobenzene	Bromobenzene	1,4-dichlorobenzene-d4
Diisopropyl Ether	Fluorobenzene	cis-1,4-Dichloro-2-butene	1,4-dichlorobenzene-d4
Ethyl tert-Butyl Ether	Fluorobenzene	Hexachlorobutadiene	1,4-dichlorobenzene-d4
Fluorobenzene	Fluorobenzene	Naphthalene	1,4-dichlorobenzene-d4
Hexane	Fluorobenzene	n-Butylbenzene	1,4-dichlorobenzene-d4
Iodomethane	Fluorobenzene	n-Propylbenzene	1,4-dichlorobenzene-d4
Isobutyl alcohol	Fluorobenzene	p-Isopropyltoluene	1,4-dichlorobenzene-d4
Isopropylbenzene	Fluorobenzene	sec-Butylbenzene	1,4-dichlorobenzene-d4
Methyl Acetate	Fluorobenzene	tert-Butylbenzene	1,4-dichlorobenzene-d4
Methyl Methacrylate	Fluorobenzene	trans-1,4-Dichloro-2-butene	1,4-dichlorobenzene-d4
Methyl t-Butyl Ether	Fluorobenzene		
Methylcyclohexane	Fluorobenzene		
Methylene chloride	Fluorobenzene		
Propionitrile	Fluorobenzene		
t-Butyl alcohol	Fluorobenzene		
Tert-Amyl Methyl Ether	Fluorobenzene		
Tetrahydrofuran	Fluorobenzene		
trans-1,2-Dichloroethane	Fluorobenzene		
Trichloroethene	Fluorobenzene		
Trichlorofluoromethane	Fluorobenzene		
Vinyl acetate	Fluorobenzene		
Vinyl chloride	Fluorobenzene		

EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE

ORGANICS: SOP 211

REVISION #: 23

EFFECTIVE DATE: 20100920

GAS CHROMATOGRAPHY/ELECTRON CAPTURE DETECTOR (GC/ECD)
ORGANOCHLORINE PESTICIDES/POLYCHLORINATED BIPHENYLS (PCB)
BY EPA METHOD 608/608.2 or
SW846 METHOD 8081A/8082 or 8081B/8082A

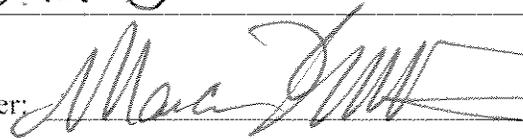
APPROVALS:

Lab Director:



Date: 9/22/10

Data Quality Manager:



Date: 9/22/10

Section Supervisor:



Date: 9/22/10

Changes Summary

Revision 23, 20100920

- The SOP is an update from Revision 22 dated 070710.
- All temperature references of 1°C-4.4°C were revised to reflect 0°C-6°C.

Revision 22, 07/07/10

- The SOP is an update from Revision 21 dated 04/11/10.
- The SOP has been updated to move specific requirements to tables at the back of the SOP and add Mirex, PCB-1262, PCB-1268 as analytes.

Revision 21, 04/11/10

- The SOP is an update from Revision 20 dated 04/27/09
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

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17. Pollution Prevention
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1.0 Identification of the Test Method

This SOP is compliant with SW-846 Methods 8000B/8081A/8082 and 8000C/8081B/8082A. *Federal Register* Method 608/608.2 and CLP Method for Pesticides have also been used in the development of this SOP.

2.0 Applicable Matrix or Matrices

This Standard Operating Procedure, SOP, is used for the analysis of Pesticide/PCB organic compounds in a variety of matrices (soils, sediments, waters, etc.).

3.0 Detection Limits

See Table1.

4.0 Scope of Application, Including Components to Be Analyzed

4.1 Each parameter that is analyzed and reported under the scope of this SOP is listed in **Table 1** of this SOP. This table also lists the associated Detection Limit/Method Detection Limit, Limit of Detection and Reporting Limit/Limit of Quantitation for each analyte.

4.3 Extreme care should be taken when working with pure standard and stock standard solutions of these compounds. These compounds have been classified as known or suspected human or mammalian carcinogens.

5.0 Summary of the Test Method

After sample preparation using the appropriate extraction technique, the sample is introduced into the GC using direct injection. The analytes are separated in the gas chromatograph by a combination of the temperature program and the capillary column. The analytes are then detected by the ECD. Pesticide analytes are identified and confirmed based on the retention time of known standards. PCB and multi-component pesticide analytes are identified based on pattern recognition. Analytes are quantitated relative to known standards using the external standard method.

6.0 Definitions

Laboratory Quality System SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.

7.0 Interferences

Section 3.0 of SW-846 Methods 8081A/8082 and Section 4.0 of Methods 8081B/8082A details interferences and potential problems which may be encountered when dealing with pesticide/PCB analyses. Please see sample clean-up SOPs (307, 308, 309 and 330) to evaluate possible clean-up options for any encountered interferences.

8.0 Safety

8.1 Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed labwide.

8.2 Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of latex gloves and lab coats is highly recommended.

- 8.3 Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples that need special consideration have applicable notes on the sample logs.
- 8.4 MSDS sheets are available for all reagents and standards that have been purchased. These are located on the bookshelves in the Quality Assurance Officer's office.

9.0 Equipment & Supplies

- 9.1 GC's:
 - 9.1.1 Agilent 6890N- complete with temperature programmable gas chromatograph suitable for split/splitless injection.
- 9.2 Columns:
 - 9.2.1 Restek Siltek Guard Column (or equivalent): 10 meter x 0.32 mm ID
 - 9.2.2 RTX-CLP or ZB-MR1 (or equivalent): 30 meter x 0.32 mm ID x 0.5 µm film thickness fused silica column.
 - 9.2.3 RTX-CLP II or ZB-MR2 (or equivalent): 30 meters x 0.32 mm ID x 0.5 µm film thickness fused silica column.
- 9.3 Autosamplers:
 - 9.3.1 Agilent 7683 autosamplers capable of reproducibility from one injection to another, proven by meeting QC and calibration criteria.
- 9.4 Acquisition Software: HP Chemstation system is interfaced to the GC. The system acquires and stores data throughout the chromatographic program.
- 9.5 Data Processing Software: Target DB Windows data system is interfaced to the HP Chemstation. The system accepts, processes and stores acquired data.

10.0 Reagents and Standards

- 10.1 The laboratory's LIMS system allows for complete documentation and for the traceability of reagents and standards used within the laboratory. The following information relates to the reagents and standards used for the performance of the method. See **Table 5** for information on standard sources/calibration concentrations.
- 10.2 Stock standards are purchased in mixtures from reputable vendors. The date they are received is noted on the COA and recorded in the LIMS. The date they are opened is recorded in the LIMS along with their lot number and vendor and given a sequential number. Each standard that is prepared is recorded in the LIMS and given a sequential number. The following are noted in the LIMS: standard makeup, solvent used, date received, date opened, date prepared, expiration date and analyst. Each standard label is completed with the standard number, name, concentration, expiration date, and analyst initials. All stocks and standards are stored in the refrigerator at a temperature of 0°C-6°C from the date they are received/prepared. The refrigerator and freezer temperature is monitored daily with an annually calibrated thermometer and recorded with calibration correction in the GC refrigerator temperature logbook.
- 10.3 List of Reagents:
 - Hexane - pesticide quality or equivalent.

11.0 Sample Collection, Preservation, Shipment, and Storage

Section 3.0 and table 3-1 of the Empirical Laboratories' Quality Assurance Manual include details concerning sample preservation, containers and handling of semi-volatile samples and extracts. All water and soil samples are stored in the appropriate walk-in coolers at a temperature of 4°C. All extracts are stored in the Hobart in the Extraction lab at a temperature of 4°C. Water samples have a holding time of 7 days from date of sampling while soil samples

have a holding time of 14 days from date of sampling (unless otherwise specified for the project). Extracts have 40 days from date of extraction to be analyzed.

12.0 Quality Control

- 12.1 Quality Systems SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” outlines details related to laboratory wide protocols on quality control.
- 12.2 Surrogates - All samples and QC are spiked with surrogates prior to extraction. See **Table 2** for criteria and corrective action.
- 12.3 LCS Sample - The LCS is extracted 1 per extraction batch of up to 20 samples to provide accuracy results. It is spiked using an alternate source or lot number than the calibration standards. See **Table 2** for criteria and corrective action.
- 12.4 Method Blanks - The Method Blank is extracted 1 per extraction batch of up to 20 samples. See **Table 2** for criteria and corrective action.
- 12.5 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Sample - 1 in 20 samples are spiked for a MS/MSD, if sample is available. If no sample is available, an LCSD must be extracted to provide precision results. See **Table 2** for criteria and corrective action. Some factors that may affect MS/MSD results are:
 - 12.5.1 Sample matrix - If the sample is a soil, grab sample or sequentially collected water sample it may affect the %R and RPD of the MS/MSD. Corrective action must be taken in the form of reanalysis if a method problem is indicated.
 - 12.5.2 Original sample concentration - If a spiked compound has a problem and the concentration of that compound in the original sample was four or more times the concentration of the spike, no further corrective action may be necessary other than the generation of a corrective action report to document the problem.
 - 12.5.3 MS vs. MSD - If a spiked compound has a similar problem in both the MS and MSD and is not traced to a method problem, no further action may be necessary other than the generation of a non-conformance report to document the problem.
 - 12.5.4 Non-target Interference - The presence of significant non-target interference should be brought to the immediate attention of your supervisor who should discuss the problem with the client/project manager to determine the action to be taken.
- 12.6 Demonstration of Capability (DOC) – Each new analyst must complete a demonstration of capability by analyzing four LCSs with acceptable precision and accuracy. This also must be done when a new instrument is installed or a significant change to the method has been made.

13.0 Calibration and Standardization

- 13.1 Quality Systems **SOP QS08** “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.
- 13.2 See Section 14.4 for Calibration details.

14.0 Procedure

- 14.1 The GC/ECD should be primed by injecting a pesticide standard at 200-500 µg/L and/or PCB standard at 2,500 µg/L, 10 times more concentrated than the mid-level standard. Inject this prior to beginning initial or daily calibration.
- 14.2 Chromatographic conditions:

14.2.1	ZB MR1/MR2 columns:	
	GC	ECD3
	Purge on	60ml/min at 0.50 min.
	Injector/Detector temperature	250/340°C
	Column flow	3.0 mL/min
	Initial column temperature	100°C for 1.0 minutes
	Temperature ramp	35°C/min
	Intermediate column temperature	220°C for 0.0 minutes
	Second Temperature Ramp	15°C/min
	Final Column Temperature	340°C for 2.0 minutes
14.2.2	ZB MR1/MR2 columns:	
	GC	ECD4
	Purge on	60ml/min at 0.50 min.
	Injector/Detector temperature	250/350°C
	Column flow	3.0 mL/min
	Initial column temperature	100°C for 1.0 minutes
	Temperature ramp	35°C/min
	Intermediate column temperature	220°C for 0.0 minutes
	Second Temperature Ramp	15°C/min
	Final Column Temperature	340°C for 2.0 minutes

Note: Current gas chromatograph conditions can be confirmed in the corresponding maintenance log.

14.3 Eval Mix – Before pesticide calibration and/or sample analysis, a degradation check standard (evaluation mix) of endrin and 4,4'-DDT must be injected. Degradation of either compound must not exceed 15 percent. See **Table 2** for criteria and corrective action.

14.4 Calibration - (See SW-846 Method 8000B Section 7.4 or Method 8000C Section 9.3).

14.4.1 Initial Calibration - An initial multi-point calibration curve must be prepared in hexane, analyzed and shown to meet the initial calibration criteria before any sample analyses may be performed. See **Table 2** for criteria and corrective action. See **Table 5** for standard concentrations/sources and below for makeup of the intermediates. The lowest standard must be less than or equal to the reported quantitation limit and the highest standard must not exceed the linear range of the detector. For single component pesticides and surrogates, a seven point calibration is injected and analyzed for each analyte of interest. For Toxaphene and Technical Chlordane a single low calibration point standard is analyzed unless they are expected/detected then a six-point calibration is injected and analyzed. Initial calibration for Aroclors may be accomplished by using a six-point curve that contains Aroclors 1016 and 1260. The mixture of these two Aroclors contains many of the peaks represented in the other Aroclor mixtures (1221, 1232, 1242, 1248, 1254, 1262 & 1268). Full calibration is required if they are expected/detected. Any manual integrations are documented by inclusion of the integrated chromatograms (**before and after manual integration**) initialed, reason indicated and dated with the quantitation report and chromatogram. All integrations are second-checked for acceptability by a senior analyst. Refer to SOP-QS07 for guidance.

Mix A/B (and Surrogate) Calibration Intermediate Solution: Using a 500µL syringe, 500µL of A/B Mix and 500µL Surrogate are injected into a 10mL volumetric flask containing approximately 9.5mL hexane and diluted to volume with same to make a 10 µg/mL standard.*

Mirex (and Surrogate) Calibration Intermediate Solution: Using a 500µL syringe, 100µL of Mirex and 50µL Surrogate are injected into a 10mL volumetric flask

containing approximately 9.5mL hexane and diluted to volume with same to make a 1 µg/mL standard.*

Technical Chlordane (and Surrogate) Calibration Intermediate Solution: Using a 500µL syringe, 100µL of Technical Chlordane and 500µL Surrogate are injected into a 10mL volumetric flask containing approximately 9.5mL hexane and diluted to volume with same to make a 10 µg/mL standard.

Toxaphene (and Surrogate) Calibration Intermediate Solution: Using a 500µL syringe, 500µL of Toxaphene and 250µL Surrogate are injected into a 10mL volumetric flask containing approximately 9.5mL hexane and diluted to volume with same to make a 50 µg/mL and 5ug/ml standard.*

Aroclor 1016/1260 (and Surrogate) Calibration Intermediate Solution: Using a 500µL syringe, 500µL of Aroclor 1016/1260 and 250µL Surrogate are injected into a 10mL volumetric flask containing approximately 9.5mL hexane and diluted to volume with same to make a 50 µg/mL and 5ug/ml standard.*

*After capping and inverting several times, all solutions are transferred into labeled, 12ml, teflon-lined, screw-capped vials and stored in the refrigerator at 4°C or less for up to 6 months. These standards are used to make the calibration curve standards in hexane at the concentrations found in table 5.

- 14.4.2 Initial Calibration Verification - A second source standard must be prepared in hexane, analyzed and calculated against the initial calibration curve, then shown to meet the ICV criteria before any sample analyses may be performed. See **Table 2** for criteria and corrective action. See **Table 5** for standard concentrations/sources. Any manual integrations are documented by inclusion of the integrated chromatograms (**before and after manual integration**) initialed, reason indicated and dated with the quantitation report and chromatogram. All integrations are second-checked for acceptability by a senior analyst. Refer to SOP-QS07 for guidance.
- 14.4.3 Continuing Calibration Verification (CCV) - Every 12 hours (and at the end of the analysis sequence), a CCV must be analyzed and calculated against the initial calibration curve, then shown to meet the calibration check criteria before any sample analyses may be performed. See **Table 2** for criteria and corrective action. See **Table 5** for standard concentrations/sources. Any manual integrations are documented by inclusion of the integrated chromatograms (**before and after manual integration**) initialed, reason indicated and dated with the quantitation report and chromatogram. All integrations are second-checked for acceptability by a senior analyst. Refer to SOP-QS07 for guidance.
- 14.4.4 RT Windows - Retention time criteria set forth in SW-846 method 8000B Section 7.6 are used to set retention time windows. New in-house retention time windows are established after every major change to the system (new column or temperature program) and at initial calibration using the midpoint standard RTs. If the established retention time window is less than +/-0.03 minutes, the window defaults to +/-0.03 minutes. Retention times are updated with the first CCV of the day or the mid-level standard of the curve if samples are analyzed directly after a curve.
- 14.5 Samples - Prior to using Method 608, SW-846 8081A, 8081B, 8082, 8082A or CLP (pesticide method) the samples are prepared for chromatography using the appropriate sample preparation and clean up methods (generally SW-846 methods 3510, 3541, 3546, 3640, 3550, 3580, EPA method 608 or CLP).

14.5.1 Example of a sequence run log:

1-Primer A/B Mix-1000 or Primer PCB-10,000
2- EVAL Mix (Pest only)
3- CCV A/B Mix
4- CCV Toxaphene (single point)
5-CCV Chlordane (single point)
6- CCV PCB 1660
7- Method Blank
8-LCS A/B Mix
9-LCS PCB
10-Sample
11-Sample
12-Sample
13-Sample
14-Sample
15-Sample
16-Sample
17-Sample
18-Sample
19-Sample
20-Sample
21-Sample-MS
22-Sample-MSD
23-Sample
24-Sample
25-Sample
26-Sample
27-Sample
28-Sample
29- CCV A/B Mix
30-CCV PCB

14.6 Data Reduction/Evaluation - Each sample analysis sequence is documented in the run logbook for the instrument. After the sample has been analyzed, the data is processed through the Target DB Windows data system. Quantitative measurements are performed as described in SW-846 8081A Section 7.5.6, and SW-846 8081B Section 11.5.6.1. The following must be checked to determine if the sample will need any reanalysis, cleaning or dilution. Criteria and corrective action are found in Table 2. Formal data evaluation is detailed in SOP QS05 and documented using the Analyst Data Review Checklist (see Appendix). Manual integration guidance is found in SOP QS07.

14.6.1 Analyte concentration after rounding to 3 significant figures must be within the range of the calibration curve. If an analyte exceeds the curve, a dilution must be performed and the next sample must be checked for carryover. Any dilution should keep the concentration of the analyte in question within the mid-range to the top half of the curve.

14.6.2 If the sample shows signs of sulfur contamination in the time range where sulfur compounds elute a sulfur cleanup is required [see SOP-307].

- 14.6.3 If the sample has extraneous peaks eluting in the chromatogram an acid cleanup is required for PCB samples and may be applicable for certain pesticides, (acid clean-up may be required for all PCB samples, check with your supervisor), [see SOP-308].
- 14.6.4 Analyte quantitation verification.
- 14.7 Identification/Quantitation [See SW-846 method 8081A Section 7.6 or method 8082 Sections 7.7-7.9].
- 14.10.1 Single peak components are identified by retention time on a primary column with confirmation by retention time on a secondary or confirmation column. Which column is used for primary/confirmation is determined by the chromatography in the region of the compound.
- 14.10.1.1 Due to coelution of certain compounds confirmation for all analytes may not be achieved. The analyst must use experience and judgment to decide if the compound is there. If a call is made, the data should be qualified appropriately.
- 14.10.1.2 If a compound is outside of its window on one column but in the window on the other column, the analyst will need to use their judgment or seek guidance from the organic lab manager or another experienced analyst to determine if the analyte is present.
- 14.10.2 Multi-peak components (PCB's, Toxaphene and Technical Chlordane) are identified by pattern recognition using an on scale standard chromatogram to compare to an on scale sample chromatogram enabling the analyst to judge whether the sample pattern matches a standard pattern. Confirmation of multi-peak components is required by the method and may be accomplished in several ways. If the sample is from a source known to contain specific Aroclors then this information may be used as a confirmation. Documentation of this approach must meet the requirements outlined in Sec. 7.7.3 of SW-846 Method 8082. Another approach is to use a column of dissimilar stationary phase and compare the pattern to a known Aroclor standard. Finally if the concentration is high enough GC/MS may be used as confirmation.
- A. Generally, five unique peaks representing the full range of the multi-peak component are used in the quantitation of the multi-peak components.
- B. Multi-peak components that still have matrix interference after appropriate sample cleanup steps have been taken may need to be hand calculated using peaks that do not have interference. This should be brought to the organic lab manager's attention.
- C. Multi-peak components that exhibit a weathered pattern may need to be hand calculated by the analyst. The analyst will need to use peaks that exhibit the full range of weathering. The number of peaks used to quantitate the multi-peak component will depend on the analyst's judgment of what it will take to achieve the truest concentration of the component. This should be brought to the organic lab manager's attention.
- 14.10.3 Quantitation – Once a compound has been identified qualitatively, the concentration must then be quantitated. Calculations follow in Section 15.0.

15.0 Data Analysis and Calculations

15.1 Quality Systems SOP QS09 “General and Commonly used Laboratory Calculations” provides details on general calculations used throughout the laboratory.

15.2 Calculate the calibration factor (CF) for each analyte at each concentration as:

$$CF = \frac{\text{Peak Area (or Height) of the Compound in the Standard}}{\text{Mass of the Compound Injected (in nanograms)}}$$

15.3 The mean CF is calculated as follows:

$$\overline{CF} = \frac{\sum_{i=1}^n CF_i}{n}$$

$$\text{AvgCF} = \frac{\sum \text{CF for each standard}}{N}$$

15.4 The standard deviation (SD) and the relative standard deviation (RSD) of the calibration factors for each analyte are calculated as follows:

$$SD = \sqrt{\frac{\sum_{i=1}^n (CF_i - \overline{CF})^2}{n - 1}}$$

$$RSD = \frac{SD}{CF} \times 100$$

15.5 Calibration verification involves the calculation of the percent drift (linear or quadratic) or the percent difference (average) of the instrument response between the initial calibration and each subsequent analysis of the verification standard. Use the equations below to calculate % Drift or % Difference, depending on the calibration procedure used.

$$\% \text{ Drift} = \frac{(\text{Calculated concentration} - \text{Theoretical concentration}) * 100}{\text{Theoretical Concentration}}$$

where the calculated concentration is determined from the initial calibration and the theoretical concentration is the concentration at which the standard was prepared.

$$\% \text{ Difference} = \frac{(\text{CCV CF} - \text{Average CF}) * 100}{\text{Average CF}}$$

where CCV CF is the calibration factor from the analysis of the verification standard and mean CF is the average calibration factor from the initial calibration.

15.6 Concentration in water samples is calculated as follows:

[Note: Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to µg/L.]

$$\text{Concentration } (\mu\text{g/L}) = \frac{(A_x)(V_t)(D)}{(CF)(V_i)(V_s)}$$

where:

A_x = Area (or height) of the peak for the analyte in the sample.

V_t = Total volume of the concentrated extract (µL).

D = Dilution factor, if the sample was diluted prior to analysis.

If no dilution was made, $D = 1$. The dilution factor is always dimensionless.

V_i = Volume of the extract injected (µL). The nominal injection volume for samples and calibration standards must be the same.

CF = Mean response factor from the initial calibration.

V_s = Volume of the aqueous sample extracted (mL). If units of liters are used for this term, multiply the results by 1000.

The 1000 in the denominator represents the number of µL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

15.7 Concentration in non-aqueous samples is calculated as follows:

[Note: Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to µg/kg.]

$$\text{Concentration } (\mu\text{g/kg}) = \frac{(A_x)(V_t)(D)}{(CF)(V_i)(W_s)}$$

where:

A_x , V_t , D , and CF are the same as for aqueous samples, and

W_s = Weight of sample extracted (g). Either a dry weight or wet weight may be used, depending upon the specific application of the data. If units of kilograms are used for this term multiply the results by 1000.

The 1000 in the denominator represents the number of µL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

16.0 Method Performance

See SOP QS08 and Table 2 for criteria and corrective actions associated to the following method performance items:

16.1 Method Detection Limit Study or Detection Limit Determination

16.2 Limit of Detection Verification

16.3 Limit of Quantitation or Reporting Limit Verification

16.4 Demonstration of Capability (DOC)

16.5 PT Studies

17.0 Pollution Prevention

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

Quality Control SOP QS05, “Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results”, provides details on data assessment and acceptance criteria for Quality Control Measures. **Table 2** of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19.0 Contingencies for Handling out-of-control or unacceptable data

Quality Control SOP QS05, “Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results”, provides details on handling out of control data. **Table 2** within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

20.0 Waste Management

Please see Waste Disposal, SOP QS14 for proper disposal of waste coming from this area within our laboratory. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

21.0 References

- 21.1 *Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Method 8081A, 8081B, 8082, 8082A*
- 21.2 *USEPA Code of Federal Regulations, 40, CH 1, PT 136; Method 608, 608.2; APX-B*
- 21.3 *USEPA Contract Laboratory Program (CLP) for Organics ILM04.2; ILM04.3*
- 21.4 *DOD Quality Systems Manual, Ver. 3/4.1*

22.0 Tables, Diagrams, Flowcharts and Validation Data

- 22.1 Table 1, all applicable parameters, including the surrogates and internals with the applicable RL and lowest calibration standard.
- 22.2 Table 2, for all technical methods, should always be the QA/QC summary table and I am including a format for this at the end.
- 22.3 Table 3, Technical Completeness / Accuracy Checklist
- 22.4 Table 4, Data Reviewers Checklist
- 22.5 Table 5, Calibration Standards

Table1- Detection limits

Analyte (water)	MDL/DL	LOD	LOQ/RL	Units
4,4'-DDD	0.00500	0.0100	0.0200	ug/L
4,4'-DDE	0.00500	0.0100	0.0200	ug/L
4,4'-DDT	0.00500	0.0100	0.0200	ug/L
Aldrin	0.00330	0.0100	0.0200	ug/L
alpha-BHC	0.00330	0.0100	0.0200	ug/L
alpha-Chlordane	0.00330	0.0100	0.0200	ug/L
beta-BHC	0.00330	0.0100	0.0200	ug/L
Chlordane (tech)	0.0170	0.0250	0.0500	ug/L
delta-BHC	0.00330	0.0100	0.0200	ug/L
Dieldrin	0.00500	0.0100	0.0200	ug/L
Endosulfan I	0.00330	0.0100	0.0200	ug/L
Endosulfan II	0.00500	0.0100	0.0200	ug/L
Endosulfan sulfate	0.00500	0.0100	0.0200	ug/L
Endrin	0.00500	0.0100	0.0200	ug/L
Endrin aldehyde	0.00500	0.0100	0.0200	ug/L
Endrin ketone	0.00500	0.0100	0.0200	ug/L
gamma-BHC (Lindane)	0.00330	0.0100	0.0200	ug/L
gamma-Chlordane	0.00330	0.0100	0.0200	ug/L
Heptachlor	0.00330	0.0100	0.0200	ug/L
Heptachlor epoxide	0.00330	0.0100	0.0200	ug/L
Methoxychlor	0.00330	0.0100	0.0200	ug/L
Mirex	0.00330	0.0100	0.0200	ug/L
Toxaphene	0.330	0.667	1.00	ug/L
Aroclor-1016	0.125	0.250	0.500	ug/L
Aroclor-1221	0.125	0.250	0.500	ug/L
Aroclor-1232	0.125	0.250	0.500	ug/L
Aroclor-1242	0.125	0.250	0.500	ug/L
Aroclor-1248	0.125	0.250	0.500	ug/L
Aroclor-1254	0.125	0.250	0.500	ug/L
Aroclor-1260	0.125	0.250	0.500	ug/L
Aroclor-1262	0.125	0.250	0.500	ug/L
Aroclor-1268	0.125	0.250	0.500	ug/L
Analyte (Soil)	MDL/DL	LOD	LOQ/RL	Units
4,4'-DDD	0.170	0.340	0.670	ug/Kg
4,4'-DDE	0.170	0.340	0.670	ug/Kg
4,4'-DDT	0.170	0.340	0.670	ug/Kg
Aldrin	0.110	0.340	0.670	ug/Kg
alpha-BHC	0.110	0.340	0.670	ug/Kg
alpha-Chlordane	0.110	0.340	0.670	ug/Kg
beta-BHC	0.110	0.340	0.670	ug/Kg
Chlordane (tech)	0.570	0.850	1.70	ug/Kg
delta-BHC	0.110	0.340	0.670	ug/Kg
Dieldrin	0.170	0.340	0.670	ug/Kg
Endosulfan I	0.110	0.340	0.670	ug/Kg
Endosulfan II	0.170	0.340	0.670	ug/Kg
Endosulfan sulfate	0.170	0.340	0.670	ug/Kg
Endrin	0.170	0.340	0.670	ug/Kg
Endrin aldehyde	0.170	0.340	0.670	ug/Kg

Analyte (Soil)	MDL/DL	LOD	LOQ/RL	Units
Endrin ketone	0.170	0.340	0.670	ug/Kg
gamma-BHC (Lindane)	0.110	0.340	0.670	ug/Kg
gamma-Chlordane	0.110	0.340	0.670	ug/Kg
Heptachlor	0.110	0.340	0.670	ug/Kg
Heptachlor epoxide	0.110	0.340	0.670	ug/Kg
Methoxychlor	0.110	0.340	0.670	ug/Kg
Toxaphene	11.0	22.0	33.0	ug/Kg
Aroclor-1016	4.17	8.33	16.7	ug/Kg
Aroclor-1221	4.17	8.33	16.7	ug/Kg
Aroclor-1232	4.17	8.33	16.7	ug/Kg
Aroclor-1242	4.17	8.33	16.7	ug/Kg
Aroclor-1248	4.17	8.33	16.7	ug/Kg
Aroclor-1254	4.17	8.33	16.7	ug/Kg
Aroclor-1260	4.17	8.33	16.7	ug/Kg
Aroclor-1262	4.17	8.33	16.7	ug/Kg
Aroclor-1268	4.17	8.33	16.7	ug/Kg
Analyte (TCLP)	MDL/DL	LOD	LOQ/RL	Units
Chlordane (tech)	0.000170	0.000250	0.000500	mg/L
Endrin	0.0000500	0.000100	0.000200	mg/L
gamma-BHC (Lindane)	0.0000330	0.000100	0.000200	mg/L
Heptachlor	0.0000330	0.000100	0.000200	mg/L
Heptachlor epoxide	0.0000330	0.000100	0.000200	mg/L
Methoxychlor	0.0000330	0.000100	0.000200	mg/L
Toxaphene	0.00330	0.00670	0.0100	mg/L

Table 1. Organic Analysis by Gas Chromatography (Methods 8081, 8082)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Demonstrate acceptable analytical capability	Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix.	QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria.	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f).	Not Applicable (NA).	This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete.
MDL determination	Initial method demonstration required for some states – not required for DoD	Refer to SOP QS09.			
LOD determination and verification	Prior to initial analysis then quarterly verification.	See Box D-13 of DoD QSM 4.1			
LOQ establishment and verification	Prior to initial analysis then quarterly verification.	See Box D-14 of DoD QSM 4.1			
Retention time (RT) window width calculated for each analyte and surrogate	At method set-up and after major maintenance (e.g., column change).	RT width is ± 3 times standard deviation for each analyte RT from a 72-hour study. Minimum ± 0.030 min.	NA.	NA.	
Breakdown check (Endrin / DDT Method 8081 only)	At the beginning of each 12-hour period, prior to analysis of samples.	Degradation $\leq 15\%$ for both DDT and Endrin.	Correct problem then repeat breakdown check.	Flagging criteria are not appropriate.	No samples shall be run until degradation $\leq 15\%$ for both DDT and Endrin.
Minimum five-point initial calibration (ICAL) for all analytes	ICAL prior to sample analysis.	One of the options below: Option 1: RSD for each analyte $\leq 20\%$; Option 2: linear least squares regression: $r \geq 0.995$; Option 3: non-linear regression: coefficient of determination (COD) $r^2 \geq 0.99$ (6 points shall be used for second order, 7 points shall be used for third order).	Correct problem then repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin for DoD analyses. Quantitation for multicomponent analytes such as chlordane, toxaphene, and Aroclors must be performed using a 5-point calibration, if detected. Results may not be quantitated using a single point.

Table 2. Organic Analysis by Gas Chromatography (Methods 8081, 8082) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Retention time window position establishment for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA.	NA.	
Second source calibration verification (ICV)	Immediately following ICAL.	All project analytes within established retention time windows. All project analytes within $\pm 20\%$ of expected value from the ICAL;	Correct problem, rerun ICV. If that fails, repeat ICAL.	Flagging criteria are not appropriate for DoD analyses.	Problem must be corrected. No samples may be run until calibration has been verified.
Continuing calibration verification (CCV)	Prior to sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All project analytes within established retention time windows. All project analytes within $\pm 20\%$ of expected value from the ICAL;	Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply qualifier to all results for the specific analyte(s) in all samples since the last acceptable calibration verification.	Problem must be corrected. Results may not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. Retention time windows are updated per the method.
Method blank	One per preparatory batch.	No analytes detected $> \frac{1}{2}$ RL and $> \frac{1}{10}$ the amount measured in any sample or $\frac{1}{10}$ the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Correct problem, then see SOP QS05. If required, reprep and reanalyze method blank and all samples processed with the contaminated blank.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Laboratory control sample (LCS) containing all analytes to be reported, including surrogates	One per preparatory batch.	QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available (see full explanation in Appendix G).	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply qualifier to specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.

Table 2. Organic Analysis by Gas Chromatography (Methods 8081, 8082) (continued)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Matrix spike (MS)	One per preparatory batch per matrix.	For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.
Matrix spike duplicate (MSD) or sample duplicate	One per preparatory batch per matrix.	MSD: For matrix evaluation, use LCS acceptance criteria specified by DoD, if available. Otherwise, use in-house LCS control limits. MSD or sample duplicate: RPD \leq 30% (between MS and MSD or sample and sample duplicate).	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	The data shall be evaluated to determine the source of difference.
Surrogate spike	All field and QC samples.	QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits.	For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Qualify surrogate results on form I.	Alternative surrogates are recommended when there is obvious chromatographic interference.
Confirmation of positive results (second column or second detector)	All positive results must be confirmed.	Calibration and QC criteria same as for initial or primary column analysis. Results between primary and second column RPD \leq 40%.	NA.	Apply qualifier if RPD > 40%. Discuss in the case narrative.	Use project-specific reporting requirements if available; otherwise, use method reporting requirements; otherwise, report the result from the primary column.
Results reported between DL and LOQ	NA.	NA.	NA.	Apply J-flag to all results between DL and LOQ.	

Table 4, Data Reviewers Checklist (Prior to approving data)

ANALYST DATA REVIEW CHECKLIST

Sample Number(s):
Batch Number(s):
Method: 8081/8082

	Yes	No	NA	Second Level Review
A. Initial Calibration				
1. Did the evaluation mix pass criteria?	_____	_____	_____	_____
2. Does the curve consist of at least five Calibration Standards (six for quadratic curve)?	_____	_____	_____	_____
3. Is the low standard equal to or below the MRL/LOQ?	_____	_____	_____	_____
4. Are the %RSD or fit criteria within QC limits for all analytes?	_____	_____	_____	_____
B. Second Source Verification				
1. Was the initial calibration curve verified by a second source calibration standard (ICV) and have criteria been met?	_____	_____	_____	_____
C. Continuing Calibration				
1. Are the Continuing Calibration Verification (CCV) standards analyzed every 20 samples or every 12 hours and at the end of the sequence?	_____	_____	_____	_____
2. Are the % differences within QC limits for all analytes?	_____	_____	_____	_____
D. Sample Analysis				
1. Did the evaluation mix pass criteria?	_____	_____	_____	_____
2. Are all sample holding times met?	_____	_____	_____	_____
3. Are all samples with concentrations > the highest standard used for initial calibration diluted and reanalyzed?	_____	_____	_____	_____
4. For single peak analytes - are all compounds identified on the primary column confirmed on the secondary column?	_____	_____	_____	_____
5. For multi-peak analytes - does the pattern of the analyte in the sample match the pattern of the standard?	_____	_____	_____	_____
6. Are surrogate recoveries within QC limits? (one surrogate both columns)	_____	_____	_____	_____

ANALYST DATA REVIEW CHECKLIST, cont.

E. QC Samples

- 1. Is the Method Blank extracted at the desired frequency and is its concentration for target analytes less than the MDLs? _____
- 2. Is the Laboratory Control Sample and its percent recovery within QC limits? _____
- 3. Is the Matrix Spike/Matrix Spike Duplicate extracted at the desired frequency and is the percent recovery/RPD within QC limits? _____

F. Others

- 1. Are all nonconformances included and noted? _____
- 2. Are all calculations checked at the minimum frequency with one example worked out in the space below? _____
- 3. Did analyst initial/date the appropriate printouts and report sheets? _____
- 4. Are all sample IDs and units checked for transcription errors? _____
- 5. Are all manual integrations checked by a second reviewer to verify they were performed correctly? _____

Calculation – one complete calculation from raw area/height to final concentration:

Comments on any "No" response:

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

Table 5 – Standard concentrations/sources
NOTE: All standards are fully documented within the LIMS

	Level 1 (ppb)	Level 2 (ppb)	Level 3 (ppb)	Level 4 (ppb)	Level 5 (ppb)	Level 6 (ppb) MIDPOINT	Level 7 (ppb)	Primary Source (Concentration-ppm)	Secondary Source** (Concentration-ppm)
Single Component Pesticides	1	5	10	25	50	100	200	Restek (200)	Accustandard (1000)
Mirex	1	5	10	25	50	100	200	Accustandard (100)	ChemService (100)
DCB/TCMX	1	5	10	25	50	100	200	Restek (200)	NA
Technical Chlordane*	-	5	10	25	50	100	200	Restek (1000)	Ultra Scientific (5000)
Toxaphene*	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (100)
PCB-1016/PCB-1260	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (1000)
PCB-1221*	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (1000)
PCB-1242*	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (1000)
PCB-1248*	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (1000)
PCB-1254*	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (1000)
PCB-1262*	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (100)
PCB-1268*	-	50	100	500	750	1000	2500	Restek (1000)	Accustandard (500)

* - Toxaphene and Technical Chlordane single point at low standard unless detected. PCB calibration 1016/1260 unless other pattern detected.

** - Secondary Source may be from any vendor other than the primary source.

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 219

REVISION #: 14

EFFECTIVE DATE: 20101201

**GAS CHROMATOGRAPHY/FLAME IONIZATION DETECTOR
(GC/FID) NONHALOGENATED VOLATILE ORGANICS
AND TOTAL PETROLEUM HYDROCARBONS (TPH)
BY METHOD 8015B/8015C/TN EPH/GRO**

APPROVALS:

Lab Director:



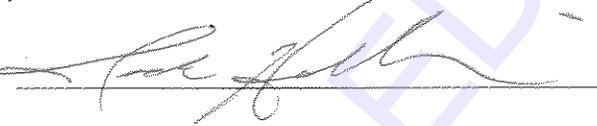
Date: 12/1/10

Data Quality Manager:



Date: 12/1/10

Section Supervisor:



Date: 12/1/10

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Changes Summary

Revision 14, 20101201

- The SOP is an update from Revision 13 dated 09/20/10.
- Updated current temperature programs used.
- Added surrogates and gasoline (instead of individual components) to calibration requirement.
- Added a note clarifying how to prep GRO water samples.

Revision 13, 20100920

- The SOP is an update from Revision 12 dated 09/09/10.
- All temperature references of 1°C-4.4°C were revised to reflect 0°C-6°C.

Revision 12, 09/09/10

- The SOP is an update from Revision 11 dated 04/27/09
- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory's revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.
- References to alcohol or glycol analysis have been removed.
- SOP references have been updated.
- Tables 1 and 2 have been added.

Table of Contents

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3. Detection Limit
4. Scope of Application, Including components to be Analyzed
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6. Definitions
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8. Safety
9. Equipment & Supplies
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11. Sample Collection, Preservation, Shipment, and Storage
12. Quality Control
13. Calibration and Standardization
14. Procedure
15. Data Analysis and Calculations
16. Method Performance
17. Pollution Prevention
18. Data Assessment and Acceptance Criteria for Quality Control Measures
19. Contingencies for Handling out-of-control or unacceptable data
20. Waste Management
21. References
22. Tables, Diagrams, Flowcharts and Validation Data

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**GAS CHROMATOGRAPHY/FLAME IONIZATION DETECTOR
(GC/FID) NONHALOGENATED VOLATILE ORGANICS
AND TOTAL PETROLEUM HYDROCARBONS (TPH)
BY METHOD 8015B/8015C/TN EPH/GRO**

1.0 Identification of the Test Method

The GC/FID system is used to analyze nonhalogenated Volatile Organics (VO), TPH and gasoline range organics/diesel range organics (GRO/DRO) compounds.

2.0 Applicable Matrix or Matrices

This Standard Operating Procedure, SOP, is used for the analysis of Gasoline range organic and Diesel range organic compounds in a variety of matrices including Solids: Soil, Sediments, etc. and Waters.

3.0 Detection Limit

See **Table 1** of this SOP.

4.0 Scope of Application, Including Components to Be Analyzed

Each parameter that is analyzed and reported under the scope of this SOP is listed in **Table 1** of this SOP. When applicable, surrogate and Internal Standard Analytes are listed and indicated as such within this table. We presently use this method to analyze ethylene glycol, methanol, GRO/DRO and TPH. This SOP will describe the different analyses performed using a temperature programmable gas chromatograph configured with a flame ionization detector (FID).

5.0 Summary of the Test Methods

- 5.1 GRO: Are Purged using a purge and trap method. Samples are then injected onto a GC. The analytes are run in the gas chromatograph by a combination of the temperature program and the capillary column. The analytes are then detected by the FID.
- 5.2 DRO: After sample preparation using the appropriate extraction technique, the sample is introduced into the GC using direct injection. The analytes are run in the gas chromatograph by a combination of the temperature program and the capillary column. The analytes are then detected by the FID.
- 5.3 DROs/GROs are multi-component ranges. They are identified based on Retention time windows set by the first CCV. Ranges are quantitated relative to known standards using the external standard method.

6.0 Definitions

Laboratory Quality System SOP QS08 "Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures" provides information on the commonly used definitions.

Acronyms

°C	-	degrees centigrade
CF	-	calibration factor
CRDL	-	contract required detection limit
%D	-	percent difference
DOD	-	Department of Defense
DRO	-	diesel range organics
EPH	-	extractable petroleum hydrocarbons
FID	-	flame ionization detector
GC	-	gas chromatograph
GRO	-	gasoline range organics
LCS	-	laboratory control sample
LCSD	-	laboratory control sample duplicate
MDL	-	method detection limit
mg/KG	-	milligrams per kilogram
mg/L	-	milligrams per liter
µL	-	microliter
µm	-	micrometer
ml	-	milliliter
mm	-	millimeter
MS	-	matrix spike
MSD	-	matrix spike duplicate
%RSD	-	percent relative standard deviation
RT	-	retention time
SOP	-	standard operating procedure
TPH	-	total petroleum hydrocarbons
VPH	-	volatile petroleum hydrocarbons

7.0 Interferences

Section 3.0 of SW-846 Method 8015B and Section 4.0 of Method 8015C details interferences and potential problems which may be encountered when dealing with non-halogenated organic analyses by this method.

8.0 Safety

Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed lab wide. Extreme care should be taken when working with pure standard and stock standard solutions of these compounds and all handling of standards should be done in a hood. These compounds have been classified as known or suspected human or mammalian carcinogens.

- 8.1 Care should be used in handling all samples.
- 8.2 Safety glasses must be worn in the lab at all times. The use of gloves and lab coats is highly recommended.
- 8.3 Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples that need special consideration have applicable notes on the sample logs.
- 8.4 MSDS sheets are available for all reagents and standards that have been purchased. These are located in the Data Quality Managers office.

9.0 Equipment & Supplies

- 9.1 Gas Chromatograph
 - 9.1.1 HP 5890 Series II (temperature programmable). – DRO/GRO
- 9.2 Autosampler and Concentrator
 - 9.2.1 HP-7673 injector - DRO
 - 9.2.2 OI 4560 Concentrator - GRO
 - 9.3.3 Tekmar 3000 Concentrator - GRO
 - 9.3.4 ARCHON 5100 Autosampler - GRO
- 9.3 Columns-Capillary columns.
 - 9.3.1 RTX-5 - 30 meter x 0.32 mm ID 0.25 μ m film thickness fused silica - used for DRO analyses.
 - 9.3.2 RTX-502.2 - 105 meter x 0.53 mm ID, 3.0 μ m film thickness fused silica - used for TN GRO analyses used for other volatile analyses.
- 9.4 Data Acquisition and Processing Software
 - 9.4.1 HP Chemstation system is interfaced to the HP-GC for data acquisition and storage.
 - 9.4.2 TARGET data system is interfaced to the acquisition systems. The system accepts, processes and stores acquired data.

10.0 Reagents and Standards

- 10.1 The laboratory's LIMS system allows for complete documentation and for the traceability of reagents and standards used within the laboratory. The following information relates to the specific reagents and standards used for the performance of the method:
 - 10.1.1 Reagent grade chemicals shall be used in all tests. All reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. Certified stock standards are purchased from Restek, Protocol, Ultra and other vendors depending on their availability. The date they are received is noted on the label or container they are received in and in the LIMS system. The date the standards are opened they are recorded and given a sequential number in the LIMS system.
 - 10.1.2 Stock standards are purchased from Restek, Protocol, Ultra and other vendors depending on their availability. GRO standard mixtures contain analytes from C6-C10, and are purchased from the vendors mentioned above. DRO standard mixtures contain analytes from C10-C28 and are also purchased from the vendors mentioned above. The source is dependent on method and client requirements. Make certain to verify the state for which the samples are to be analyzed so the appropriate calibration standards are used. The date they are received is noted on the label or container they are received in and in the LIMS system. The date the standards are opened they are recorded and given a sequential number in the LIMS system. All stock standards are stored at 4° C.

10.2 Intermediate standards are prepared from the stock standards. Intermediate and working standards are made up using the appropriate solvent or laboratory reagent blank water and noted using the LIMS system, detailing how they were made, solvent used (reagent water, methylene chloride, methanol), date made, expiration date (six months or sooner from date of preparation) and given a sequential number.

10.3 TPH-GRO/DRO

10.3.1 GRO

A ten component standard, (C6-C10), from Restek (Wisconsin PVOC mix or equivalent) is used for setting the retention time range. 4-bromofluorobenzene from Restek or equivalent is used as the surrogate and should be calibrated in the same manner as target analytes. Calibration standards must be prepared at a minimum of five concentration levels for each parameter of interest through dilution of the intermediate stock standard in appropriate solvent or laboratory reagent blank water. Use a gasoline standard for Method 8015 for calibration and quantitation. One of the concentration levels should be near but above the method detection limit (MDL). The remaining concentration levels should correspond to the expected range of concentrations found in the real samples or defines the working range of the GC-FID system.

10.3.2 DRO

A solution containing even numbered alkanes from C8 to C40 is run to determine the retention times for the appropriate analyses. Ortho-Terphenyl from Restek or equivalent is used as the surrogate and should be calibrated in the same manner as target analytes. Calibration standards must be prepared at a minimum of five concentration levels for each parameter of interest through dilution of the intermediate stock standard in the appropriate solvent or laboratory reagent blank water. Use a diesel standard for Method 8015 for calibration and quantitation. One of the concentration levels should be near but above the method detection limit (MDL). The remaining concentration levels should correspond to the expected range of concentrations found in real samples or defines the working range of the GC-FID system.

10.3.3 Surrogate Standards

For GRO (BFB) and DRO (OTP) analysis are used to monitor the performance of the analytical system, and the effectiveness of the method in dealing with each sample matrix. Corrective action is taken when surrogates are out of recovery limits. An NCR form is filled out within 24 hours and the supervisor is notified immediately. The supervisor will then make suggestions as to what action needs to be taken such as the sample may require re-extraction, re analysis, or the report flagged for a QC problem.

11.0 Sample Collection, Preservation, Shipment, and Storage

Section 3.0 and tables 3-1 and 3-2 of the Empirical Laboratories, LLC Quality Assurance Manual include details concerning sample preservation, containers and handling of volatile samples. All water volatile samples are stored in the water walk-in cooler and soils in the soil walk-in cooler at a temperature of 0°C – 6°C. Water and soil volatile samples have holding times of 14 days from date of sampling if preserved (unless otherwise specified for the project). All

organic extractable water and soil samples are stored in their respective walk in coolers at a temperature of 0°C – 6°C. All extracts are stored in the Hobart in the Extraction lab at a temperature of 0°C – 6°C. Soil samples have a holding time of 14 days, waters 7 days from date of sampling for extraction (unless otherwise specified for the project). Extracts have a holding time of 40 days for analysis.

12.0 Quality Control

Quality control for this method can be referenced in SW-846 Method 8000B Section 8.0.

- 12.1 A method blank is required every 20 samples or at the frequency required by the client or regulatory agency (1/matrix/batch/20 which ever is at the determined frequency). **See table 2** for acceptance criteria and corrective action.
- 12.2 An MS/MSD pair are required every 20 samples per matrix. **See table 2** for acceptance criteria and corrective action.
- 12.3 A Laboratory Control Sample (LCS) is required every 20 samples or at the frequency required by the client or regulatory agency. **See table 2** for acceptance criteria and corrective action.
 - 12.3.1 TPH TN Method criteria require LCS/LCSD for GRO and DRO. The recommended control spike for GRO is API PS-6 or other gasoline of similar composition and the DRO control standard spike is a commercial diesel #2. In both cases (GRO and DRO) the required recovery for the LCS is 50-150%. GRO or DRO sample analyses can not proceed until this criteria is met.
 - 12.3.2 The other analytes measured by this method do not specify an exact recovery range, but these ranges are developed in-house by charting LCS recoveries. Default limits of 50%-150% are used until in-house limits are generated.
 - 12.3.3 Calculate surrogate recovery on all samples, blanks, and spikes. The surrogate recovery is checked to see if it is within the recovery limits. **See table 2** for acceptance criteria and corrective action.
- 12.4 Demonstration of Capability (DOC) – Each analyst must perform a DOC to demonstrate proficiency with these methods. See SOP QS08 for guidance.

13.0 Calibration and Standardization

- 13.1 Quality Systems SOP QS08 “Technical / Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” related to Calibration Procedures provides laboratory wide protocols for calibration and standardization.

Refer to SW-846 Method 8000B/8000C for proper calibration techniques.

 - 13.1.1 Five point calibration curve must be introduced into the GC and analyzed for each analyte of interest using the appropriate instrument parameters.

13.1.2 The area for GRO and DRO in each calibration point is determined by using a baseline to baseline integration over the appropriate retention time range. Refer to SOP QS07 for guidance on manual integration. The calibration factor (CF) for each point is determined by dividing the total area by the concentration of the solution. The percent relative standard deviation of the calibration factor (CF) should be less than 20 percent (25 percent for TN-TPH) over the working range for each analyte of interest. If the percent relative standard deviation (% RSD) of the calibration factor is less than 20 percent over the working range, linearity through the origin can be assumed and the average calibration factor can be used in place of a calibration curve (linear curve corr. >0.995, quadratic >0.99 with six points). The curve is then verified using a second source standard (80-120% criteria).

13.1.3 The calibration curve must be verified every day through the analysis of a mid-level standard at the beginning and end of the sequence and after every 10 field samples. The percent difference back to the curve must not exceed 20 percent (25 percent for TN-TPH) for any analyte of interest. If this criteria is not met corrective action must be taken before sample analyses continues. This might include maintenance of the analytical system (see 14.1.3) and/or recalibration of each analyte that exceeded this criteria. Mid-level checks must be analyzed every 10 samples for TN-TPH and 10 field samples for DOD.

14.0 Procedure

The following information describes the instrument and QC requirements to analyze the compounds that we do by this method.

14.1 The Volatile Petroleum compounds VPH/GRO, are introduced into the temperature programmable gas chromatograph by transfer from a purge-and-trap concentrator (Method 5030B), boiling point ranges from 60°C-170°C.

Note: When preparing waters for GRO analysis, measure a 5mL aliquot of the sample by removing the plunger of a 5.0mL syringe and **pouring** the sample into the barrel of the syringe. Replace the plunger, invert the syringe, force out any air bubble, and measure 5ml (discarding any excess). Place in a VOA vial and cap tightly.

14.2 TPH extractable petroleum hydrocarbons EPH/DRO, boiling point range >170°C, require extraction (see SOP-320, and 322) into methylene chloride followed by direct injection.

14.3 Instrumentation

14.3.1 Purge and trap conditions - GRO

- a. Purge: 11 minutes at 40° C.
- b. Desorb: 2.0 minutes at 240° C.
- c. Bake: 10 minutes at 260° C.

14.3.2 GC and GC oven conditions (all temperature programs can be adjusted to better fit the range of analytes requested).

14.3.2.1 GRO (5ml purge and trap)

- a. Initial Temperature: 35° C hold for 5.0 minutes.
- b. Ramp1: 10° C/min to 200° C

- c. Ramp2: 5° C/min to 220° C.
- d. Final Temperature: 220° C hold for 1.5 minutes.

- 14.3.2.2 DRO (1.0 µL direct injection of extract)
- a. Initial Temperature: 45° C hold for 2.0 minutes.
 - b. Ramp1: 40° C/minute to 340° C
 - c. Final Temperature 340° C hold for 16.0 minutes

- 14.3.2.3 Alcohol (Direct aqueous injection)
- a. Flow: Between 8.0 - 10.0 mL / minute.
 - b. Initial Temperature: 40° C hold for 8.0 minutes.
 - c. Ramp: 10°C / minute to 200° C.
 - d. Final Temperature 200° C hold for 1.0 minute.

- 14.3.2.4 Ethylene Glycol (Direct aqueous injection)
- a. Flow: 8.0 - 10.0 mL / minute.
 - b. Initial Temperature: 110° C hold for 1.0 minute
 - c. Ramp: 8.0° C / minute to 220° C.
 - d. Final Temperature: 220° C hold for 1.0 minute.

14.4.3 Maintenance

14.4.3.1 Purge and Trap.

- a. Bake out the transfer line at 125° C and bake out the trap.
- b. Flush out the sample and/or transfer lines with methanol.
- c. Change the trap.

14.4.3.2 Gas Chromatograph.

- a. Clean or deactivate glass injection port insert or replace with a cleaned and deactivated insert.
- b. Trim the first few inches of the injection port side of the column.
- c. Remove the column and back-flush according to the manufacture instructions.
- d. If all else fails to correct the problem, the metal injector body may need to be deactivated or the column replaced.

14.5 Sample analysis will begin after the system performs the various checks outlined in Section 12.

14.5.1. A mid-level standard must be run at the beginning and end of the sequence and after every 10 field samples (every 10 samples for TPH) and cannot exceed 20 percent (25 percent for TN-TPH) difference from the initial calibration. A mid-level standard must also be analyzed at the end of the analysis sequence. If the mid-level check at the end fails, it is an indicator that GC maintenance is required (see 14.1.3).

14.5.2 The retention times are updated with the first midpoint check of the day or from the midpoint of the calibration curve if analyzed before the samples. Retention times for the range GRO C6-C10 is set by subtracting 0.03min. from the RT of 2-Methyl Pentane and adding 0.13min. to the RT of 1,2,4-Trimethylbenzene.

Retention times for the range DRO C10-C28 is set by subtracting 0.05min. from the RT of C10 and adding 0.05min. to the RT of C28.

- 14.6 Following sample analysis, the data is reduced using the instrument data system. The following must be checked to see if the samples will require re-analyses or dilution.
- 14.6.1 The analyte concentration must be within the range of the calibration curve. If an analyte exceeds the curve, a dilution must be performed and the next sample must be checked for carryover. Any dilution should keep the concentration of the analyte in question within the top half of the curve.
- 14.6.2 Surrogate standard recovery must be checked to determine if it is within control limits (see 12.3.3 sec. A).
- 14.7 Any questions left by this SOP should be answered by reading the referenced methods, paying close attention to SW-846 Method 8015B/8015C or the State specific TPH Method. If questions still remain unanswered, check with the Organic Lab Manager, Technical Director or Data Quality Manager.

15.0 Data Analysis and Calculations

15.1 Quality Systems SOP QS09 "General and Commonly used Laboratory Calculations" provides details on general calculations used throughout the laboratory.

15.2. Calculations:

Calibration Factor (CF) = $\frac{\text{Total Area within Retention Time Range}}{\text{Mass Injected (in ng)}}$

15.2.1 Aqueous Sample:

$$\text{Concentration} = \frac{(A_x) (V_t) (D)}{(CF) (V_i) (V_s)}$$

where:

A_x = Area of the appropriate carbon range of analyte in the sample.

V_t = Total volume of the concentrated extract (µL).

D = Dilution Factor if the sample were diluted prior to analysis. If no dilution was made, D = 1.

CF = Mean calibration factor from the initial calibration (area/ng).

V_i = Volume of extract injected (µL). The injection volume for samples and calibration standards must be the same. For purge and trap analyses V_i, is not applicable and therefore set to 1.

V_s = Volume of the aqueous sample extracted in mL.

Using the units specified here for these terms will result in a concentration in units of ng/mL which is equivalent to µg/L.

15.2.2 Non-aqueous sample

$$\text{Concentration} = \frac{(A_x) (V_t) (D)}{(CF) (V_i) (W_s)}$$

where:

A_x , V_t , D , CF , and V_i are the same as for aqueous samples and W_s = Weight of the sample extracted (g). The wet weight or dry weight may be used, depending upon the specific application of the data. *Using the units specified here for these terms will result in a concentration in units of ng/g which is equivalent to ug/kg.*

16.0 Method Performance

Demonstration of Capability (DOC): Each analyst must perform a DOC prior to reporting data. The analyst must prepare (for prep technicians) and analyze (analysts reviewing and reporting data) 4-LCS samples. The data is calculated for accuracy and precision requirements. The DOC form, as listed within section 2.5 of the Quality is completed by each analyst and then provided to the supervisor for further processing and approval. See **Table 2** for acceptance criteria.

17.0 Pollution Prevention

Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on data assessment and acceptance criteria for Quality Control Measures. **Table 2** of this SOP provides information on QC samples, frequency, and the associated criteria specific to the performance of this method.

19.0 Contingencies for Handling out-of-control or unacceptable data

Quality Control SOP QS05, "Data Deviations / Interpretations / Exceptions: Laboratory Non-Conformance / Corrective Action Procedures, Decision Making Guidelines for Evaluating Laboratory Analytical Sample and Quality Control Results", provides details on handling out of control data. **Table 2** within this SOP also lists corrective actions associated with the failure of the various QC samples employed for the performance of this method.

20.0 Waste Management

Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management. Please see Waste Disposal, SOP-210 and SOP-405 for proper disposal of waste coming from this area within our laboratory.

21.0 References

- 21.1 *Test Methods for Evaluating Solid Waste*, SW-846.
- 21.2 *Tennessee Method for Determination of Extractable Petroleum Hydrocarbons by GC/FID*.

21.3 *Tennessee Method for Determination of Gasoline Range Organics.*

22.0 Tables, Diagrams, Flowcharts and Validation Data

- 22.1 Table 1, all applicable parameters with the applicable MDL/DL, LOD, LOQ/RL and Units.
- 22.2 Table 2, for all technical methods, should always be the QA/QC summary table.
- 22.3 Table 4, Data Reviewers Checklist

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TABLE 1

Analyte	MDL/DL	LOD	MRL/LOQ	Units
TPH DRO	6.67	6.67	6.67	mg/Kg
TPH GRO	2.50	5.00	7.50	mg/Kg
TPH DRO	0.100	0.100	0.100	mg/L
TPH GRO	0.0500	0.100	0.150	mg/L

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Table 2. Organic Analysis by Gas Chromatography (Method 8015)

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Flagging Criteria	Comments
Demonstrate acceptable analytical capability	Prior to using any test method and at any time there is a significant change in instrument type, personnel, test method, or sample matrix.	QC acceptance criteria published by DoD, if available; otherwise, method-specified criteria.	Recalculate results; locate and fix problem, then rerun demonstration for those analytes that did not meet criteria (see Section C.1.f).	Not Applicable (NA).	This is a demonstration of analytical ability to generate acceptable precision and bias per the procedure in Appendix C. No analysis shall be allowed by analyst until successful demonstration of capability is complete.
MDL determination	Initial method demonstration required for some states – not required for DoD	Refer to SOP QS09.			
LOD determination and verification	Prior to initial analysis then quarterly verification.	See Box D-13 of DoD QSM 4.1			
LOQ establishment and verification	Prior to initial analysis then quarterly verification.	See Box D-14 of DoD QSM 4.1			
Retention time (RT) window width calculated for each analyte and surrogate	At method set-up and after major maintenance (e.g., column change).	RT width is ± 3 times standard deviation for each analyte RT from a 72-hour study or 0.03min., whichever is greater.	NA.	NA.	
Minimum five-point initial calibration (ICAL) for all analytes	ICAL prior to sample analysis.	One of the options below: Option 1: RSD for each analyte $\leq 20\%$ Option 2: linear least squares regression: $r \geq 0.995$ Option 3: non-linear regression: coefficient of determination (COD) $r^2 \geq 0.99$ (6 points shall be used for second order, 7 points shall be used for third order).	Correct problem then repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples may be run until ICAL has passed. Calibration may not be forced through the origin for DoD projects.
Retention time window position establishment for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA.	NA.	

Table 2. Organic Analysis by Gas Chromatography (Method 8015)

Second source calibration verification (ICV)	Immediately following ICAL.	All project analytes within established retention time windows. <u>GC methods:</u> All project analytes within $\pm 20\%$ of expected value from the ICAL	Correct problem, rerun ICV. If that fails, repeat ICAL.	Flagging criteria are not appropriate.	Problem must be corrected. No samples should be run until calibration has been verified.
Continuing calibration verification (CCV)	Prior to sample analysis, after every 10 field samples (maximum of 20 for non-DoD projects) , and at the end of the analysis sequence.	All project analytes within established retention time windows. <u>GC methods:</u> All project analytes within $\pm 20\%$ of expected value from the ICAL;	DoD project level approval must be obtained for each of the failed analytes or corrective action must be taken. Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply qualifier to all results for the specific analyte(s) in all samples since the last acceptable calibration verification.	Problem must be corrected. Results should not be reported without a valid CCV. Flagging is only appropriate in cases where the samples cannot be reanalyzed. Retention time windows are updated per the method.
Method blank	One per preparatory batch.	No analytes detected $> \frac{1}{2}$ RL and $> \frac{1}{10}$ the amount measured in any sample or $\frac{1}{10}$ the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Correct problem, If required, reprep and reanalyze method blank and all samples processed with the contaminated blank.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid method blank. Flagging is only appropriate in cases where the samples cannot be reanalyzed.
Laboratory control sample (LCS) containing all analytes to be reported, including surrogates	One per preparatory batch.	QC acceptance criteria specified by client or DoD (appendix G), if available. Otherwise, use in-house control limits. In-house control limits may not be greater than ± 3 times the standard deviation of the mean LCS recovery.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	If reanalysis cannot be performed, data must be qualified and explained in the case narrative. Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch.	Problem must be corrected. Results may not be reported without a valid LCS. Flagging is only appropriate in cases where the samples cannot be reanalyzed.

Table 2. Organic Analysis by Gas Chromatography (Method 8015)

Matrix spike (MS)	One per preparatory batch per matrix (see Box D-7).	For matrix evaluation, use LCS acceptance criteria above.	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	For matrix evaluation only. If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error.
Matrix spike duplicate (MSD) or sample duplicate	One per preparatory batch per matrix (see Box D-7).	MSD: For matrix evaluation, use LCS acceptance criteria above. MSD or sample duplicate: RPD ≤ 30% (between MS and MSD or sample and sample duplicate).	Examine the project-specific DQOs. Contact the client as to additional measures to be taken.	For the specific analyte(s) in the parent sample, apply qualifier if acceptance criteria are not met.	The data shall be evaluated to determine the source of difference.
Surrogate spike	All field and QC samples.	QC acceptance criteria specified by DoD, if available. Otherwise, use in-house control limits.	For QC and field samples, correct problem then reprep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Apply qualifier to all associated analytes if acceptance criteria are not met.	Alternative surrogates are recommended when there is obvious chromatographic interference.
Results reported between DL and LOQ	NA.	NA.	NA.	Apply J-flag to all results between DL and LOQ.	

ANALYST DATA REVIEW CHECKLIST

Instrument: _____

Run Date: _____

Sample Number(s):
Batch Number(s):
Method: 8015DRO/TNEPH/FLPRO

	Yes	No	NA	Second Level Review
A. Initial Calibration				
1. Does the curve consist of five Calibration Standards?	_____	_____	_____	_____
2. Is the low standard at or below the LOQ/RL?	_____	_____	_____	_____
3. Are the % RSDs within QC limits for all analytes?	_____	_____	_____	_____
B. Second Source Verification				
1. Was the initial calibration curve verified by a second source calibration standard (ICV) and have criteria been met?	_____	_____	_____	_____
C. Continuing Calibration				
1. Are the Continuing Calibration Verification (CCV) standards analyzed every 20 samples (10 for DoD) and at the end of the sequence?	_____	_____	_____	_____
2. Are the % differences within QC limits for all analytes?	_____	_____	_____	_____
3. Are Surrogate recoveries within QC limits?	_____	_____	_____	_____
D. Sample Analysis				
1. Are all sample holding times met?	_____	_____	_____	_____
2. Are all samples with concentrations > the highest standard used for initial calibration diluted and reanalyzed?	_____	_____	_____	_____
3. Are all compounds identified on the primary column confirmed on the secondary column?	_____	_____	_____	_____
E. QC Samples				
1. Is the Method Blank extracted at the desired frequency and is its concentration for target analytes less than 1/2 the LOQ/RL?	_____	_____	_____	_____
2. Is the LCS extracted at the desired frequency and are the percent recoveries within QC limits?	_____	_____	_____	_____
3. Is the Matrix Spike/Matrix Spike Duplicate extracted at the desired frequency and are the percent recoveries/RPDs within QC limits?	_____	_____	_____	_____
F. Others				
1. Are all nonconformances included and noted?	_____	_____	_____	_____
2. Are all calculations checked at the minimum frequency with an example calculation included each batch?	_____	_____	_____	_____
3. Did analyst initial/date the appropriate printouts and report sheets?	_____	_____	_____	_____
4. Are all sample ID and units checked for transcription errors?	_____	_____	_____	_____
5. Do all manual integrations have before/after intialed/dated/coded and checked by a second reviewer to verify why they were performed?	_____	_____	_____	_____

Comments on any "No" response: _____

Analyst: _____ Date: _____

Second-Level Review: _____ Date: _____

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 225

REVISION #: 09

EFFECTIVE DATE: 20100907

**GC/MS VOLATILE NON-AQUEOUS MATRIX EXTRACTION USING
SW-846 METHOD 5035/5035A FOR 8260B ANALYSIS**

APPROVALS:

Lab Director:  Date: 9/8/10

Data Quality Manager:  Date: 9/8/10

Section Supervisor:  Date: 9/8/10

Changes Summary

Revision 09, 09/07/10

- The SOP is an update from Revision 08 dated 09/24/08
- The SOP has been updated to include reference to 5035A and preservation by freezing for unpreserved Terracores and Encores.

**GC/MS - VOLATILE
NON - AQUEOUS MATRIX EXTRACTION
USING SW-846 METHOD 5035/A**

1.0 SCOPE AND APPLICATION

The purpose of this SOP is to detail soil sample preparation for EPA method SW-846 5035 and 5035A. Soil samples should be sampled in the field using the EnCore™ sampler or prepared VOA vials (sometimes referred to as Terracore samplers) then shipped to the lab within 24 hours for preservation, storage and analysis. This SOP should be used in conjunction SOP-202, which details the analytical technique.

2.0 SUMMARY

Samples are collected in EnCores or prepared VOA vials and submitted to the laboratory for preparation/analysis.. EnCore samplers have to be frozen or prepared within 48 hrs of collection. Prepared VOA vials (sometimes referred to as Terracores) are shipped already prepared in water, methanol or preservative solution. If prepared in water, freezing is required within 48 hours. If preservative is used, refrigeration is the only requirement.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

EnCores are prepped within 48 hrs of collection or frozen until preparation can be completed. Preparation can be in sodium bisulfate with refrigeration at 4°C or in reagent water with freezing. Prepared VOA vials are received already prepared in water, methanol or sodium bisulfate solution. If prepared in water, freezing is required within 48 hours of collection. If preservative is used, refrigeration at 4°C is the only requirement. Holding Time is 14 days from collection once preserved.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Sample vials can be a source of contamination. Vials should be checked for contamination before use. Samples can be contaminated during sample prep. Prep blanks should be prepared at the same time as the samples to check for contamination.

5.0 EQUIPMENT AND MATERIALS

- Sample Containers – 40mL VOA vials with low bleed septa. Available from ESS (Part No. PC0040-0300 pack of 72), alternate sources are possible but must be checked for contaminants before use. ESS also supplies pre-prepped vials with the preservative and stirbar (Part No. PC4039-5035 pack of 72).
- Varian Archon 51 position programmable autosampler, or equiv.
- Top-loading balance – capable of accurately weighing to 0.01g.

- 1-10 mL Adjustable Dispenser, Model 400 Series, Oxford pipettor. Available from Oxford (Part No. 8885-040009).
- Spatula, stainless steel – narrow enough to fit into a sample vial.
- Magnetic stirring bars – PTFE- or glass-coated, of the appropriate size to fit the sample vials. Available from A. Daigger (Part No. WX22782A, case of 50).
- EnCore™ sampler – (En Chem, Inc., 1795 Industrial Drive, Green Bay, WI 54302), or equivalent. Necessary for field sampling crew.
- Terracore Vials- Available from QEC.
- Balance weights – used to calibrate the balance.
- Labels.

6.0 REAGENTS

- Reagent Water - Reagent water is NANO PURE WATER from source in the instrument lab, which is then purged with helium before use.
- Methanol, CH₃OH – purge-and-trap quality, or equivalent. Store away from other solvents.
- Sodium bisulfate, NaHSO₄ – ACS reagent grade, or equivalent. Available from Aldrich (Part No. 30,782-3).
- Sodium bisulfate solution – Prepare by adding 200 grams of NaHSO₄ (ACS reagent grade, or equivalent) to 1000 milliliters of helium-purged reagent water. Record the vendor and lot number of the NaHSO₄ in the Standards and Reagents Logbook. Each standard/reagent that is prepared is recorded in the logbook and given a sequential number. The label is completed with the standard/reagent number, name, preparation date, expiration date, solvent and analyst initials. The solution should be discarded after six months or sooner if it shows signs of contamination.

7.0 SAMPLE COLLECTION

As with any sampling procedure for volatiles, care must be taken to minimize the disturbance of the sample in order to minimize the loss of volatile compounds. Always wear gloves whenever handling the tared sample vials. Several techniques may be used to perform the transfer of the sample to the relatively narrow opening of the low concentration soil vial such as the EnCore™ sampler, a cut off disposable plastic syringe, or a stainless steel spatula. We prefer to use the EnCore™ sampler.

7.1 The EnCore™ sampler is both a sampler and a container for low-level and high level soils. It is designed to collect an average weight with the exact weight to be determined in the lab. It is disposable and is also designed to have zero headspace. The EnCore™ sampler will require the field personnel to get the sample to the laboratory within 24-36 hours of collection. The laboratory needs to be contacted prior to sample collection to ensure that all necessary containers (with or without preservative) are available and that the proper sampling technique is used.

7.2 All low-level soil samples must be collected in duplicate to allow the laboratory an additional sample for reanalysis. A third sample should be collected for preparation of a high-level sample. This sample would be prepared at the same time as the “low-level” sample. (Some projects may not require the “low-level” detection limits, in this case only the high level sample preparation would be required.). A fourth sample may be collected to enable the laboratory to perform a pretest on the soil to determine if the soil sample contains carbonate minerals that will effervesce upon contact with the acidic sodium bisulfate preservative solution in the low concentration sample vial. The additional soil samples must be collected from the same soil stratum or the same section of solid waste being sampled and within close proximity to the location from which the original sample was collected. **Additional bulk samples should be collected for screening and dry weight determination without the preservative.** Note: If the low-level sample cannot be preserved with sodium bisulfate, the remaining low-level sample aliquot(s) is(are) transferred to a pre-weighed vial containing 5 mL of reagent water. The sample in the unpreserved vial must either be analyzed immediately (within 48 hours of collection) or frozen within the 48 hour time frame and then analyzed within the 14 day holding time.

8.0 PROCEDURE

- 8.1** Log-in personnel will log the samples in, place them in the Soil walk-in cooler assigned for volatile sample storage and notify the Organic Lab Manager that samples are in-house for 5035 preparation.
- 8.2** The Organic Lab Manager or designee will determine the amount of time remaining on the 48 hour EnCore™ holding time and assign the task of preserving the samples.
- 8.3** Samples received from the field should be designated for low-level, high-level or % solids/screening (this fraction should be in a regular soil jar, if it is not, it will require transfer to a VOA vial). Each low-level and high-level sample must be preserved appropriately as follows:
 - 8.3.1** Organize the VOA vials required and label them with the sample number, date and LOW or HIGH for either low-level or high-level preservation. The LOW level VOA vials should have gray caps and septa if using the ESS brand.
 - 8.3.2** Get the samples from the Hobart assigned for volatile sample storage and log them out.
 - 8.3.3** Enter the sample numbers in the soil sample preparation logbook and add a sample preparation/storage blank to the book for each level being prepared (HIGH/LOW). There must be a line in the logbook for each sample vial being prepared (i.e. if there are 2 low-level samples and 1 high-level sample, the sample number should be listed in the logbook 3 times- use a,b,c to designate each vial associated with the same sample).
 - 8.3.4** Using an adjustable Oxford pipettor, add 5 mL P&T methanol to each of the vials marked HIGH. Then record the vendor & lot number of methanol and the exact volume of methanol added to each sample in the sample preparation logbook. If the vial is not to be used immediately, weigh the vial

to the nearest 0.01g and record the weight on the vial. The vial weight must be verified to be within ± 0.01 g of this value before using for sample preparation.

- 8.3.5** For each of the vials marked LOW, add 5 mL of sodium bisulfate or reagent water if frozen and record the reagent number in the sample preparation logbook. Add a magnetic stir bar to each vial. If pre-prepped vials from ESS (or equivalent) are used, this step is unnecessary but the lot number and the pre-prepped status must be recorded in the preparation log.

NOTE: Soil samples that contain carbonate minerals (either from natural sources or applied as an amendment) may effervesce upon contact with the acidic preservative solution in the low concentration sample vial. If the amount of gas generated is very small (i.e., several mL), any loss of volatiles as a result of such effervescence may be minimal if the vial is sealed quickly. However, if larger amounts of gas are generated, not only may the sample lose a significant amount of analyte, but the gas pressure may shatter the vial if the sample vial is sealed. Therefore, when samples are known or suspected to contain high levels of carbonates, a test sample should be collected, added to a vial, and checked for effervescence. If a rapid or vigorous reaction occurs, discard the sample and place low concentration samples in vials that contain 5ml water and a stir bar. This sample must be frozen in a slanted position until analysis or analyzed within 48 hours of sampling. Notify the Organic Lab Manager if this occurs, note this in the sample preparation logbook and generate an NCR to document the problem.

- 8.3.6** Place the vial (LOW/HIGH) on the top-loading balance, tare the vial then extrude the sample into the vial and record the weight of the sample in the sample preparation logbook. Make sure the lip of the vial does not have any soil on it, which might cause a leak, cap the vial tightly and mark the weight on the sample label.
- 8.3.7** Place the preserved samples in a box, return them to the Hobart assigned for volatile sample storage and log them back in.

9.0 ANALYSIS

- 9.1** Samples are analyzed by USEPA SW-846 methods 5035/8260B (low-level) using the Archon 51 position autosampler in conjunction with the GC/MS or 5030B/8260B (high-level) using any purge and trap instrument in conjunction with the GC/MS. For method 5035, the prepared low-level vials are placed in the Archon autosampler. The autosampler is programmed to add the appropriate internals and surrogates to each sample. Use of the autosampler is covered in the owners manual. Calibration of the analytical instrument with subsequent analysis of the samples is covered under SOP-202.
- 9.2** Determination of % Dry Weight – Weigh 5-10 grams of the sample from the bulk jar used for dry weight analysis in a tared crucible or aluminum pan. Dry overnight at 105°C. Allow to cool in a dessicator before weighing. Calculate % dry weight as follows:

$$\% \text{ dry weight} = \frac{\text{g of dry sample}}{\text{g of sample}} \times 100$$

9.2 If an extra bulk jar was not received for percent moisture determination, an alternate procedure using the methanol vial can be used with advance notice:

- Weigh the sample in the VOA vial to the necessary degree of accuracy for % solids (recommend a tare weight on the vial to the same degree of accuracy).
- Preserve the vial as normal.
- After we know the methanol extract is not needed or has been analyzed successfully, allow the methanol to evaporate and dry as necessary for % solids determination.
- Weigh the sample in the VOA vial to the necessary degree of accuracy for % solids.

10. HEALTH, SAFETY, WASTE MANAGEMENT AND POLLUTION PREVENTION

10.1 Care should be used in handling all samples. Safety glasses must be worn in the lab at all times. The use of blue nitrile gloves and lab coats is highly recommended.

10.2 Research into expected sample content and concentration should be done in order to be prepared for additional safety considerations. Generally, any samples that need special consideration have applicable notes on the sample logs.

10.3 MSDS sheets are available for all reagents and standards that have been purchased. These are located in the Quality Assurance Officers office.

10.4 Please see Waste Disposal SOP QS14 for proper disposal of waste coming from this area within our laboratory. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

REFERENCES

1. Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Third Edition (Update III); Method 5035, December 1996.

1. Test Methods for Evaluating Solid Waste Physical/Chemical Methods, SW-846; Other Methods; Method 5035A, July 2002.

DEFINITIONS

Refer to SOP QS08 for common environmental laboratory definitions.

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 300

REVISION #: 19

EFFECTIVE DATE: 20101117

**GC/MS SEMI-VOLATILE
BNA-AQUEOUS MATRIX
EXTRACTION USING
SW-846 METHOD 3510C
FOR 8270/625 ANALYSIS**

APPROVALS:

Lab Director:



Date:

11/19/10

Data Quality Manager:



Date:

11/19/10

Section Supervisor:



Date:

11/19/10

Changes Summary

Revision 19, 11/17/2010

- SOP has been updated to reflect current procedure used to prepare the “Baked Sodium Sulfate” and 10N NaOH solution.
- Redundant statement concerning holding time under sec. 14.0 has been removed.
- Volume correction for MeCl₂ added.
- Size and labeling of containers used as well as drying procedure prior to concentration of extracts updated.
- The requirement for a matrix spike duplicate for TCLP extracts has been added.

Revision 18, 04/26/10

- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory’s revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

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2. Applicable Matrix or Matrices
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19. Contingencies for Handling out-of-control or unacceptable data
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1.0 Identification of the Test Method

1.1 This SOP is compliant with SW-846 Method 3510C and Method 625.

2.0 Applicable Matrix or Matrices

2.1 This SOP is applicable to aqueous samples.

3.0 Detection Limit

Not Applicable to this SOP

4.0 Scope of Application, including components to be analyzed

Not Applicable to this SOP

5.0 Summary of the Test Method

5.1 Aqueous samples are extracted with methylene chloride. The extracts are dried through sodium sulfate and concentrated to an appropriate final volume.

6.0 Definitions

6.1 Laboratory Quality System SOP QS08 “Technical/Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.

7.0 Interferences

7.1 Solvents, reagents, glassware, and other sample processing apparatus can add interferences to sample analysis. Method blanks must be extracted under the same conditions as samples to demonstrate freedom from interferences.

7.2 Phthalate esters commonly found in plastics can interfere with the analysis. Plastics should be avoided.

7.3 Soap residue can degrade certain analytes such as aldrin and heptachlor. Glassware should be solvent rinsed to avoid this problem.

8.0 Safety

8.1 Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed labwide.

9.0 Equipment and Supplies

9.1 Separatory Funnel – 2L with Teflon stopcock

9.2 Beaker – 250mL or 400mL

9.3 Drying/Chromatographic column – 20mm I.D. x 300mm

9.4 Filter funnel

9.5 Turbo-Vap evaporation tube – 200mL tube made by Zymark or equivalent

9.6 Metal rack – capable of holding six glass evaporation tubes

9.7 Turbo-Vap Evaporator – heated and capable of temperature control (+5°C); the bath should be vented into a hood

9.8 Vials, 2.0 mL glass with Teflon-lined screw cap

9.9 pH indicator paper – wide range (1.0-12.0)

9.10 Syringe – 1mL

- 9.11 Graduated cylinder – 1000mL, 500mL, and 100mL, glass, Class A
- 9.12 Pasteur pipette – length 9”
- 9.13 Pasteur pipette bulb
- 9.14 Labels – DYMO
- 9.15 Teflon Bottles – 500mL
- 9.16 Volumetric Flasks – 500mL, 100mL, 50mL, and 10mL, glass, Class A
- 9.17 Ring Stand – 3-prong
- 9.18 Burette clamp – double
- 9.19 Aluminum foil – heavy duty
- 9.20 Nitrogen tank – equipped with pressure regulator
- 9.21 Boiling chips – Teflon
- 9.22 Glass Wool – Roving, 9989 purchased from Fisher #11-388 or equivalent

10.0 Reagents and Standards

- 10.1 Reagent Water - Reagent water is gathered in a carboy from source in the instrument lab as needed.
- 10.2 Sodium Hydroxide Solution - (10N). Weigh 800g NaOH (purchased in a fiber drum from Tennessee Reagents # 2-31825-25lb or equivalent) into a glass or plastic container. Add approximately 1000mL of reagent water to a 2000mL volumetric flask, add a stir bar, place on stir plate, and stir. Add pellets slowly and swirl until pellets are mostly dissolved. This mixture will get very hot. Continue to add reagent water while mixture is being stirred to keep volume at approximately 1000mL. Let stand until cool. Bring to final volume. Transfer to 1000mL Teflon containers.
- 10.3 Sodium Sulfate – Granular, anhydrous, trace pure 10-60 mesh (purchased in 200lb bulk fiber drum from Fisher #S415-200lb or equivalent). For low level tests, place an aliquot in a 1500mL heavy duty Pyrex beaker and bake in muffle furnace at 400°C for a minimum of 8 hours. Remove and cool in open air and place in designated “Baked Sodium Sulfate” container at room temperature
- 10.4 Glass Wool – Roving , 9989 Glass (purchased from Fisher #11-388 or equivalent).
- 10.5 Sulfuric Acid Solution - (1:1), slowly add 500mL of H₂SO₄ (Fisher, suitable for trace metal analysis #A300C-212 or equivalent) to 500mL of reagent water in a 1000mL Teflon container. This mixture will get very warm. Allow to cool before use.
- 10.6 Extraction Solvent - Methylene Chloride (purchased from Fisher #D151-4 or equivalent) Please read SOP-336 before handling this solvent in our laboratory.
- 10.7 The extraction analyst makes up surrogates and spikes. Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes.
 - 10.7.1 **BNA Surrogate** – The base neutral and acid surrogate are mixed together in one solution (purchased from NSI #WL-371-C at concentrations of 100-200ug/mL). The expiration for this standard is 6 months from the date opened. Use 0.5mL of this solution per 1000mL of aqueous sample.
 - 10.7.2 **BNA Spiking Solution** – The base neutral and acid spiking solutions are mixed together in one solution called BNA LCS#1 (This spiking solution contains all the compounds that are normally calibrated by GC/MS). This solution, with a final concentration of 100ug/mL, is prepared in Methanol by

making a dilution of stock purchased from reputable vendors (BNA LCS #1 spike kit #K-943 and 1-methylnapthalene #1288-01-08 are purchased from NSI, 2,6 Dichlorophenol #95591 is purchased from Absolute Standards and 1,4 Dioxane #30287 is purchased from Restek). Use 0.5mL of this solution per 1000mL of aqueous sample. Another spiking solution is also used, called BNA LCS#2. This solution contains short or matrix spike list base extractable compounds. This solution, with a final concentration of 100ug/mL, is prepared in Methanol by making a dilution of stock purchased from NSI #Q-6104-0. Use 0.5mL of this solution in combination with BNA LCS#1 for all full list BNA requirements. BNA LCS #2 may be omitted from samples requiring PAH analysis. (For low level PAHs, use 1.0mL of a 1.0ug/mL solution made from BNA LCS #1, called “LLPAH spiking solution.”) All standards expire 6 months from the date they are made.

10.7.3 BNA TCLP Spike – 0.5mL of BNA LCS#1 and BNA LCS#2 is added per 100mL volume. This volume is provided by Wet Chemistry in a 1L glass amber bottle. 100mL is removed from this container and measured using a graduated cylinder.

11.0 Sample Collection, Preservation, Shipment, and Storage

- 11.1 Quality Systems SOP QS10 related to Sample Receipt, Handling, & Processing provides details for collection, preservation, shipment, and storage.
- 11.2 Aqueous samples have a hold time of 7 days from the date of sampling.

12.0 Quality Control

- 12.1 Quality Systems SOP QS08 “Technical/ Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” outlines details related to laboratory wide protocols on quality control.

13.0 Calibration and Standardization

Not Applicable to this SOP

14.0 Procedure

- 14.1 Determine the samples necessary to extract from the following sources (Note: never extract samples of unknown origin without discussion with supervisor):
 - 14.1.1 Each day the extractions group leader will generate a sample backlog using LIMS.
 - 14.1.2 This backlog is used to determine extraction priorities based on hold times and due dates.
 - 14.1.3 Samples requiring RUSH turn around time may be logged in throughout the day, which will require immediate attention. Sample receiving personnel will generally communicate this need.
 - 14.1.4 Samples are placed in LIMS “batches” based on parameter and extracted accordingly.
- 14.2 Wearing lab coat, gloves and safety glasses, get samples from refrigerator. Samples must be signed out of the walk-in refrigerator. Enter the sample numbers, your initials and the date and time removed on the log provided. Inspect as to whether

they are in glass amber jar and have a Teflon lid. Find out if any special dilutions need to be made for this client. Routine procedures for difficult matrices are listed below:

14.2.1 SLUDGE - use only 100mL and dilute to 1000mL with reagent water.

14.2.2 TCLP EXTRACT - use only 100mL and dilute to 1000mL with reagent water. A separate matrix spike and matrix spike duplicate of 100mLs should be set up at the same time. Dilute to 1000mL with reagent water.

14.2.3 BAD MATRIX – for example a liquid that is partially sediment, see your supervisor to find out what dilution, if any should be made. SPLP extract-use 1 liter.

14.2.4 NPDES client - a special list of compounds is required including benzidine. Method 625 requires that there be a spike every ten samples. The sample must be extracted and concentrated in the same day. A GC/MS screen is recommended; therefore this extraction should be coordinated with the GC/MS operator. 1mL of the BNA spiking solution is added to the LCS and the matrix spike.

14.2.5 ACID EXTRACT WITH BAD MATRIX - a cleanup step is added. Samples are taken to a high pH, extracted with 60mL methylene chloride one time as explained below in the BASE NEUTRAL EXTRACTION section. This extract is discarded. The samples are then taken to a low pH and extracted as an acid extraction. Acid extractions may be concentrated in the TurboVap.

14.3 LOW LEVEL POLYAROMATIC HYDROCARBONS (PAHs) – Samples require a BNA extraction. Use the surrogate and spiking solution specified.

14.4 Mark the amber glass container of each sample at the water meniscus with "white out" for later determination of sample volume. Check the pH by inverting the sample and touching the wide range pH paper to the portion that remains on the lid. Record this pH on the LIMS bench sheet and, later, in LIMS.

14.5 Get out enough separatory funnels and 250mL beakers to extract the number of samples you have plus any additional spikes and a method blank. A method blank and an LCS must be processed with each set of samples. If the sample is a TCLP, blank fluid may be provided along with the extracted TCLP sample(s). Use only 100mL and dilute to 1000mL with reagent water. Process a matrix spike and matrix spike duplicate on aqueous samples if requested by client. If not, a LCSD must be processed. Rinse separatory funnels with methanol. Place label from sample bottle onto separatory funnel as samples are poured into funnels to ensure proper identification. Use Avery labels to properly identify method blank, LCS, and LCSD as well as each beaker for each sample.

14.6 Using the 1000mL glass graduated cylinder marked NANO PURE WATER ONLY, measure 1000mL of reagent water from the carboy and transfer it to a separatory funnel for the method blank and LCS. Transfer sample to separatory funnel that corresponds to the lab # on the sample bottle.

14.7 Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes. Set out the surrogate/spike at least ten minutes before use to allow it to warm to room temperature.

- 14.8 Generally 0.5mL of BNA surrogate is added to each sample, spike, and blank with a syringe designated for BNA surrogate. Someone must verify that the surrogate has been added by initialing LIMS bench sheet.
- 14.8.1 NOTE: Be sure to invert syringe and eliminate air bubble when obtaining surrogate solution and spiking solution.
- 14.9 For the sample in each analytical batch selected for spiking, use the 0.5mL glass syringe designated for BNA spike, to add 0.5mL of BNA spiking solution. **For low level PAHs use 1.0mL of the 1.0ppm LLP AHs spiking solution.** Someone must verify that the spike has been added by initialing the LIMS bench sheet. For DOD QSM projects, all target compounds will be spiked into the LCS and MS/MSD.
- 14.10 Enter the ID# of the surrogate/spike used on the LIMS bench sheet and, later, in LIMS.
- 14.11 ACID EXTRACTION: Adjust the pH to between 1.0 and 2.0, using 2mL of 1:1 H₂SO₄. Add to each sample, spike and method blank. Stopper and shake to insure that pH throughout the sample is changed. Check the drop of liquid hanging from the lid with short-range pH paper. Compare the color to the chart on the pH paper. If the color is not within range add more H₂SO₄ solution in small increments, as required to attain the proper pH.
- 14.12 Add 60mL of Methylene Chloride to each empty sample bottle and to the LCS, method blank and MS/MSD funnels. Swirl the 60mL of methylene chloride that you added to the empty sample bottle and transfer to the corresponding separatory funnel.
- 14.13 Seal and shake the separatory funnel vigorously for 2 minutes with periodic venting to release excess pressure. Alternatively, Teflon funnels may be used and placed in the shaker apparatus with the stopcocks slightly open. When this apparatus is used, the shake should be for 3 minutes.
- 14.13.1 NOTE: Methylene chloride creates excessive pressure very rapidly; therefore, initial venting should be done immediately after the separatory funnel has been sealed and shaken once.
- 14.14 Allow the sample to sit for 10 minutes, if necessary, after it has been shaken. It will separate into two layers with the solvent layer on the bottom. If it forms an emulsion (thick, cloudy, viscous, mixture that you cannot see through), drain what you believe to be 60mL into a labeled (w/Avery label) 250mL centrifuge bottle. If the layers are clearly separated, drain the solvent layer into a labeled (w/Avery label) 250mL glass beaker.
- 14.15 Following Steps 14.12 through 14.14, extract two more times with 40mL of methylene chloride. Combine the two solvent extracts into the same 250mL beaker.
- 14.16 BASE NEUTRAL EXTRACTION: Adjust the pH to 11 or slightly greater, using 10N NaOH. Start by adding 7.0mL to each sample, spike, and method blank. Stopper and shake to insure that pH throughout the sample is changed. Check the drop of liquid hanging from the lid with short-range pH paper. Compare the color to the chart on the pH paper. If the color is not within range add more 10N NaOH in small increments, as required to attain the proper pH. BNA extraction is necessary when doing low level PAHs.
- 14.16.1 NOTE: This step is critical to the extraction procedure. Too much NaOH solution could cause you to lose certain Base Neutral compounds. Be careful on this step.

- 14.17 FOR 8270 extraction: Extract one more time with 20mL of methylene chloride following Step 14.16. Do not combine BN and Acid extracts in a same 250mL beaker. However, you may filter BN and Acid extracts through the same sodium sulfate filter and combine into the same turbo in order to concentrate BN and acid extracts for one final extract.
- 14.17.1 NOTE: It has been demonstrated that two acid and one BN extraction can be used for normal 8270 samples. This procedure cannot be used for DOD or 625 samples.
- 14.18 For 625 extractions: extract 2 more times with 40 mL methylene chloride following steps 14.12 through 14.14. Combine BN extracts in the empty 250mL sample beaker as the acid portion concentrates in the turbo vap. Following step 14.24, concentrate the acid extract to ~5mL and then filter the BN extract into the same turbo.
- 14.19 Prepare to dry the sample by either of the following methods:
- 14.19.1 Set up a ring stand with funnels. Place a small amount of glass wool in the bottom of the funnels, add ~2" sodium sulfate to the funnel and rinse with 20-30 mL methylene chloride. Discard this rinse into the Chlorinated Waste container in the hood.
- 14.20 If the extract was drained into a centrifuge bottle, at this point you will need to take it to the centrifuge. Push the "ON" button to turn the centrifuge on. Be sure that the large holders are available for the 250-mL centrifuge bottles. The sample must always be balanced. If necessary use a dummy bottle making it similar weight using reagent water. Set the rpm at 2500 and the temperature at 0°C. Close the lid and be sure to press it down until you hear it click. Move the lever at the front of the lid to the "LOCK" position. Turn the time to approximately 15 minutes and bring it back to 10 minutes. As the rotor begins to move, you will be able to see the rpm's in the digital readout. Stay with the centrifuge until it has come up to the rpm's set to insure that it does not become unbalanced. This looks like 8888 on the digital readout. Should this occur, refer to the manual. When the cycle is complete, the digital readout will read 0000. Push the "OPEN" button and the lid will pop up. Move the lever at the front of the lid to the "UNLOCK" position. Open lid and remove sample. The sample will usually be in two layers with the extract on the bottom.
- 14.21 Remove any water layer from the extract in the beaker or centrifuge bottle, by one of two methods. Remove with a Pasteur pipette by carefully pulling up the water layer, on top, and not the solvent. Discard this layer in the sink. Use the smallest amount possible of Na₂SO₄ by sprinkling the top layer with Na₂SO₄ until it hardens, separates, and drops to the bottom.
- 14.22 Determine the original sample volume by refilling the sample bottle to the mark made with "white out." Transfer the liquid to a plastic 1000-mL graduated cylinder and record the sample volume on the LIMS bench sheet to the nearest 10-mL and record, later, in LIMS.
- 14.23 Prepare sample vial tray using labels printed off from LIMS that identify sample numbers, initial/final volumes, client, parameter, and date extracted.
- 14.24 TURBO-VAP CONCENTRATION
- 14.24.1 Rinse a Turbo-Vap tube with methylene chloride and arrange it underneath a rinsed, funnel. Pour the extract through the funnel so that it will collect in the

tube. Rinse the 400-mL beaker, which contained the solvent extract twice with 10 to 15 mL of methylene chloride and add each rinse to the funnel to complete the quantitative transfer. After all the extract has passed through the funnel, rinse the funnel with 10 to 15 mL of methylene chloride. Total volume in the glass evaporator tube should not exceed 200 mLs to avoid splattering on the lid of the Turbo-Vap.

- 14.24.2 Record the numbers of the Turbo-Vap tube on the LIMS bench sheet and place the tube in a metal holder.
- 14.24.3 Turbo-Vap Operation: Adjust the pressure of nitrogen gas tank to >30 psi. Make sure the tank has 200 psi or more on the main valve. The temperature of the bath should be approximately 40°C -50°C.
- 14.24.4 Place the glass evaporator tube in the Turbo-Vap. Be sure to push tube down so the tip slides into the sensor well. Close the lid to start concentration. Check that each position with a tube has an orange light showing. If the orange light is not steady, bubbles may be in the sensor and need removal. (See Turbo-Vap manual). Note which TV position was used for each sample on bench sheet.
- 14.24.5 When the beep sounds indicating the end of concentration, the extract will be at approximately one half mL (half way up tip of tube). Remove the tube from the bath. Use a 9" Pasteur pipette to draw up the sample and transfer it to the 2-mL vial. **THIS IS THE MOST CRITICAL PART OF THE ENTIRE OPERATION!!!** A single drop represents about 10 percent of the total sample. Before you move the tip of the pipette from the tube to the vial, be sure that a drop will not form on the end and fall off.
- 14.24.6 Draw ~0.25 mL of methylene chloride into a 9" Pasteur pipette and add this aliquot to the turbo-vap. Draw the methylene chloride into a pipette and rinse the sides of the tube several times. Transfer this rinse to the appropriately labeled 2-mL vial. Add methylene chloride from the designated clean pipette and repeat the rinsing process until you have ~ 1 mL in the sample extract vial. Compare this volume to a 2-mL dummy vial containing 1 mL of solvent to insure that you have not exceeded 1 mL. The methylene chloride rinse volume must be adjusted to achieve this final volume. Cover the extract with a Teflon-sealed screw cap.
- 14.25 The extract is now ready to be analyzed. Refrigerate at 4°C or carry directly to the instrument operator. Samples must be signed into the Sample Extract refrigerator. On log provided, enter the sample numbers, the analyst initials, and the date and time the samples were placed into the refrigerator.
- 14.26 Transfer handwritten extraction details from bench sheet to LIMS and archive bench sheet for future reference.

15.0 Data Analysis and Calculations

Not Applicable to this SOP

16.0 Method Performance

16.1 Demonstration of Capability (DOC): Each analyst must perform a DOC prior to independently extracting samples and yearly thereafter. The analyst must prepare 4 LCS samples. The data is calculated for accuracy and precision requirements.

17.0 Pollution Prevention

17.1 Quantity of chemicals purchased should be based on expected usage during its shelf life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

Not Applicable to this SOP

19.0 Contingencies for Handling out of control or unacceptable data

Not Applicable to this SOP

20.0 Waste Management

20.1 Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

21.0 References

21.1 Test Methods for Evaluating Solid Waste, SW-846, Third Edition

21.2 40 CFR, Method 625.

22.0 Tables, Diagrams, Flowcharts, and Validation Data

Not Applicable to this SOP

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 302

REVISION #: 18

EFFECTIVE DATE: 20101117

**PESTICIDE/PCBs
AQUEOUS MATRIX EXTRACTION
FOR EPA METHOD 608/608.2 AND
SW846 METHOD 8081/8082
USING SW846 METHOD 3510C**

APPROVALS:

Lab Director:



Date: 11/19/10

Data Quality Manager:



Date: 11/19/10

Section Supervisor:



Date: 11/19/10

Changes Summary

Revision 18, 11/17/2010

- SOP has been updated to reflect current procedure used to prepare the “Baked Sodium Sulfate” and 10N NaOH solution
- removed a redundant statement concerning holding time under sec. 14.0
- added volume corrections for MeCl₂ and hexane
- clarified size and labeling of containers used as well as drying procedure prior to concentration of extracts
- added the requirement of a matrix spike duplicate for TCLP extracts

Revision 17, 04/26/2010

- The SOP is formatted to include all 22-elements required per the NELAC standards
- The laboratory’s revision of all technical SOPs now includes a Table of Contents that provides the map of the technical information contained within the SOP.
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

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1.0 Identification of the Test Method

- 1.1 This SOP is compliant with SW-846 Method 3510C and Method 608/608.2

2.0 Applicable Matrix or Matrices

2.1 This SOP is applicable to aqueous samples

3.0 Detection Limit

Not Applicable to this SOP

4.0 Scope of Application, including components to be analyzed

Not Applicable to this SOP

5.0 Summary of the Test Method

5.1 Aqueous samples are extracted with methylene chloride. The extracts are dried through sodium sulfate and concentrated and exchanged to hexane.

6.0 Definitions

6.1 Laboratory Quality System SOP QS08 “Technical/Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” provides information on the commonly used definitions.

6.2 Additional definitions specific to this SOP are listed below:

6.2.1 PCBs- polychlorinated biphenyls

6.2.2 Pest- pesticides

6.2.3 TCMX- tetrachloro-m-xylene

7.0 Interferences

7.1 Solvents, reagents, glassware, and other sample processing apparatus can add interferences to sample analysis. Method blanks must be extracted under the same conditions as samples to demonstrate freedom from interferences.

7.2 Phthalate esters commonly found in plastics can interfere with the analysis. Plastics should be avoided.

7.3 Soap residue can degrade certain analytes such as aldrin and heptachlor. Glassware should be solvent rinsed to avoid this problem.

8.0 Safety

8.1 Laboratory SOP QS13 “Safety Program & Chemical Hygiene Plan” discusses the safety program that is to be followed labwide.

9.0 Equipment and Supplies

- 9.1 Separatory Funnel – 2L with Teflon stopcock
- 9.2 Beaker – 250mL or 400mL
- 9.3 Drying/Chromatographic column – 20mm I.D. x 300mm
- 9.4 Filter funnel
- 9.5 Turbo-Vap evaporation tube – 200mL tube made by Zymark or equivalent
- 9.6 Metal rack – capable of holding six glass evaporation tubes
- 9.7 Turbo-Vap Evaporator – heated and capable of temperature control ($\pm 5^{\circ}\text{C}$); the bath should be vented into a hood
- 9.8 Vials, 10mL glass with Teflon-lined screw cap
- 9.9 pH indicator paper – wide range (1.0-12.0)
- 9.10 Syringe – 1mL
- 9.11 Graduated cylinder – 1000mL, 500mL, and 100mL, glass, Class A
- 9.12 Pasteur pipette – length 9”
- 9.13 Pasteur pipette bulb
- 9.14 Labels – Avery
- 9.15 Teflon Bottles – 500mL
- 9.16 Volumetric Flasks – 500mL, 100mL, 50mL, and 10mL, glass, Class A
- 9.17 Ring Stand – 3-prong
- 9.18 Burette clamp – double
- 9.19 Aluminum foil – heavy duty
- 9.20 Nitrogen tank – equipped with pressure regulator
- 9.21 Boiling chips – Teflon
- 9.22 Glass Wool – Roving, 9989 purchased from Fisher #11-388 or equivalent

10.0 Reagents and Standards

- 10.1 Reagents
 - 10.1.1 Reagent water – Reagent water is gathered in a carboy from source in the instrument lab daily.
 - 10.1.2 Sodium Sulfate – Granular, anhydrous, trace pure 10-60 mesh purchased in 200lb bulk fiber drum from Fisher #S415-200lb or equivalent. Place an aliquot in a 1500mL heavy-duty Pyrex beaker and bake in muffle furnace at 400°C for a minimum of 8 hours. Remove and cool in open air and place in designated “Baked Sodium Sulfate” container at room temperature.
 - 10.1.3 Sulfuric Acid Solution (1:1) – Slowly add 500mL concentrated Sulfuric Acid, purchased from Fisher #A300C-212 or equivalent, to 500mL of reagent water in a 1000mL Teflon container. This mixture will get very warm. Let stand until cool. Bring to final volume.
 - 10.1.4 Sodium Hydroxide Solution - (10N). Weigh 800g NaOH (purchased in a fiber drum from Tennessee Reagents # 2-31825-25lb or equivalent) into a glass or plastic container. Add approximately 1000mL of reagent water to a 2000mL volumetric flask, add a stir bar, place on stir plate, and stir. Add pellets slowly and swirl until pellets are mostly dissolved. This mixture will get very hot. Continue to add reagent water while mixture is being stirred to keep volume at approximately 1000mL. Let stand until cool. Bring to final volume. Transfer to 1000mL Teflon containers.

- 10.1.5 Methylene Chloride - purchased from Fisher #D151-4 or equivalent. **Please see SOP 336 before handling this solvent in our laboratory.**
- 10.1.6 Hexane – suitable for gas chromatography, purchased from Fisher #H303-4
- 10.2 Standards – The extraction analyst makes up surrogates and spikes. Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes.
- 10.2.1 TCMX/DCB (2,4,5,6-Tetrachloro-meta-xylene/Decachlorobiphenyl) – Surrogate solution is prepared, with a final concentration of 0.5ug/mL, by diluting a stock solution (purchased from Restek #32000) in acetone. This solution is named “Pesticide Surrogate for Extractions 500ppb” and expires 6 months after the date it is made. Use 1.0mL of this solution per 1000mL of aqueous sample.
- 10.2.2 PCB Spiking Solution – For all standard extractions, a mixture of 1016/1260 is prepared and used. The stock standards (purchased by Accustandard 1016 #APP-9-158-10X and 1260 #C260S-H-10X) are diluted in acetone to a final concentration of 5ug/mL. This solution is named “PCB 1660 LCS for Extractions 5ppm” and expires 6 months after the date it is made. Use 1.0mL of this solution per 1000mL of aqueous sample. The Laboratory Director and/or Organic Manager will determine if another PCB mixture is necessary, such as 1242, 1258, or 1254.
- 10.2.3 Pesticide Spiking Solution – A spiking solution, with a final concentration of 1ug/mL, is prepared by making a dilution of the Pesticide AB ICV Intermediate (this is made in-house by GC operators) in acetone. This solution is named “Pesticide AB LCS for Extractions 1.0ppm” and expires 2 weeks after the date it is made. Use 1.0mL of this solution per 1000mL of aqueous sample. For 608 samples, 1 out of every 10 samples must be spiked
- 10.2.4 TCLP- When it is necessary to set up a TCLP, in addition to setting up the sample, two matrix spikes and matrix spike duplicates must be set up and should include the following:
- A. TCLP Spike 1 – This matrix spike must include a solution containing Chlordane at a concentration of 100ug/mL and Toxaphene at a concentration 10ug/mL. Both compounds are diluted in acetone from stock standards purchased from reputable vendors (Chlordane from Ultra Scientific #EPA-1086, Toxaphene from AccuStandard #P-0935-H). This solution is named “Tox/Chlor LCS for Extractions 10-100ppm” and expires 6 months from the date it is made. Add 1.0mL of leachate.
 - B. TCLP Spike 2 – This matrix spike must include the Pesticide Spiking Solution known as “Pesticide AB LCS for Extractions 10ppm.” Add 1.0mL of this solution per 100mL of leachate.

11.0 Sample Collection, Preservation, Shipment, and Storage

- 11.1 Quality Systems SOP QS10 related to Sample Receipt, Handling, & Processing provides details for collection, preservation, shipment, and storage.
- 11.2 Aqueous samples have a hold time of 7 days from the date of sampling.

12.0 Quality Control

- 12.1 Quality Systems SOP QS08 “Technical/ Operational Definitions, Minimum Essential Quality Control Elements, and Laboratory Calibration Procedures” outlines details related to laboratory wide protocols on quality control.

13.0 Calibration and Standardization

Not applicable to this SOP

14.0 Procedure

- 14.1 Determine the samples necessary to extract from the following (Note: never extract samples of unknown origin without discussion with supervisor):
 - 14.1.1 Each day the extractions group leader will generate a sample backlog using LIMS
 - 14.1.2 This backlog is used to determine extraction priorities based on hold times and due dates.
 - 14.1.3 Samples requiring RUSH turn around time may be logged in throughout the day, which will require immediate attention. Sample receiving personnel will generally communicate this need.
 - 14.1.4 Samples are placed in LIMS “batches” based on parameter and extracted accordingly.
- 14.2 Wearing lab coat, gloves, and safety glasses, get samples from cooler. Samples must be signed out of the walk-in refrigerator. Enter the sample numbers, your initials, and the date and time removed on the log provided. Inspect as to whether they are in glass amber jars and have a Teflon lid.
- 14.3 Find out if any special dilutions need to be made for client. Routine procedures for difficult matrices are listed below:
 - 14.3.1 Sludge – use only 100mL and dilute to 1000mL with reagent water
 - 14.3.2 TCLP Extract – use only 100mL for the sample and dilute to 1000mL with reagent water. There must be two matrix spikes of 100mL as well that are also diluted to 1000mL with reagent water.
 - 14.3.3 Bad Matrix – e.g. a liquid that is partially sediment. See Organics Supervisor to find out what dilution, if any, should be made.
 - 14.3.4 NPDES client – Samples for method 608/608.2 are checked by login to make sure the pH of the sample is in the range of 5.0-9.0. If the sample is not in this range, extraction personnel will be notified. At that time, it is the responsibility of the extraction lab to adjust the pH of the sample to the appropriate range (pH of 5-9 using NaOH solution or Sulfuric Acid, as necessary) or to extract the sample within 72 hours of sampling. If a pH adjustment is made, the details of the adjustment must be recorded on the sample COC and in LIMS. Set up one full list matrix spike for every ten samples.
- 14.4 Mark the amber glass container of each sample at the water meniscus with “white out” (or equivalent) for later determination of sample volume.

- 14.5 Check the pH by inverting the sample and touching the wide range pH paper to the portion that remains on the lid. Record this pH on the bench sheet and later, in LIMS.
- 14.6 Get out enough separatory funnels to extract the number of samples you have plus any additional spikes and a method blank. A method blank and a LCS must be processed with each set of samples. If the sample is a TCLP, blank fluid may be provided along with the extracted TCLP sample(s). Follow instructions for TCLP in section 14.3.2 of this SOP. Process a matrix spike and matrix spike duplicate on aqueous samples if requested by client. If not, a LCSD must be processed.
- 14.7 Rinse separatory funnels with methanol and discard of waste according to SOP QS14.
- 14.8 Pour samples into separatory funnel, placing the label from the sample bottle on the designated separatory to ensure proper identification. Use Avery labels to properly identify method blank, LCS, LCSD, any TCLPs, and TCLP spikes. If a sample requires both Pesticide and PCB analysis, a Pesticide LCS/MS/MSD (if client specified) or LCS/LCSD and a PCB LCS/MS/MSD (if client specified) or LCS/LCSD must be processed to satisfy QC requirements for the batch.
 - 14.8.1 Due to limited volume received, it is usually necessary to use 500mL of sample to do a matrix spike so that a matrix spike duplicate can also be extracted. If only one sample container is provided for spiking purposes, use a 500mL glass cylinder to measure out half of the sample for extraction. Add half of the normal amount of spiking solution and half of the normal amount of surrogate.
- 14.9 Add 60mL of methylene chloride to the empty sample container, swirl, and pour into the designated separatory funnel.
- 14.10 Using the 1L glass graduated cylinder marked "DIH20 WATER ONLY" measure 1L of reagent water from the carboy and transfer it to the designated separatory funnels for method blank, LCS, and LCSD.
- 14.11 Add 60mL of methylene chloride to the method blank, LCS, and LCSD.
- 14.12 Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes. Set the surrogate/spike out at least ten minutes before use to allow it to warm to room temperature.
- 14.13 Using the 1.0mL glass syringe marked "TCMX/DCB" surrogate, add 1.0mL of TCMX/DCB surrogate to each sample, method blank, and spike.

Note: Invert, 1-2 times, the spike solution for surrogate and LCS prior to drawing into syringe.

A second analyst must verify that the surrogate has been added. Enter the ID# of the standard, amount, and the initials of the analysts on the LIMS generated bench sheet and later in LIMS.
- 14.14 Determine if the sample will require a Pesticide spike, PCB spike, or both and proceed as follows:
 - 14.14.1 Pesticide and PCB – Refer to 14.8 for instructions on how to determine QC requirements. To all Pesticide QC, add 1.0mL of Pesticide AB LCS with a glass syringe dedicated for that particular spike. To all PCB QC, add 1.0mL of PCB 1660 LCS using a glass syringe dedicated for that particular spike.

- 14.14.2 Pesticide only – To all Pesticide QC, add 1.0mL of Pesticide AB LCS with a glass syringe dedicated for that particular spike.
- 14.14.3 PCB only – To all PCB QC, add 1.0mL of PCB 1660 LCS with a glass syringe dedicated for that particular spike. 1660 is the standard PCB that we analyze for, if client specifies another PCB the extraction analyst will need to prepare another spike mix accordingly.
- 14.14.4 Enter the LIMS generated spike mix ID#, amount added, and the initials of the extraction and verifying analysts on the bench sheet and, later, in LIMS.
- 14.15 If the pH is not within 5.0-9.0 range, it must be adjusted using either the NaOH solution or Sulfuric Acid solution. If a pH adjustment is made, the details of the adjustment must be recorded in LIMS.
- 14.16 Seal and shake the separatory funnel vigorously for 3 minutes in the shaker apparatus with the stopcock open.
 - 14.16.1 Methylene chloride creates excessive pressure very rapidly; therefore, initial venting should be done immediately after the separatory funnel has been sealed and shaken once.
- 14.17 Allow the sample to set for a few minutes, if needed, after it has been shaken. It will separate into two layers with the solvent layer on the bottom.
 - 14.17.1 If it forms an emulsion (thick, cloudy, viscous mixture that you cannot see through), drain what you believe to be 50mL into a 250mL centrifuge bottle.
 - 14.17.2 Save and drain into this centrifuge bottle until the extraction is complete.
 - 14.17.3 The emulsion must be centrifuged at 2500rpm for a good separation of the water from solvent.
- 14.18 Drain solvent layer into an appropriately labeled 250mL beaker.
- 14.19 Following steps 14.16 through 14.18, extract one more time with 60mL of methylene chloride combining all solvent extracts into the same appropriately labeled 250mL beaker.
- 14.20 Prepare a sample vial tray with 12mL vials and vial labels (transferred from the beakers) or use a permanent marker. These labels contain the sample number, client name, initial/final volume, parameter, and date extracted.
- 14.21 Remove any water layer from the extract in the beaker or centrifuge bottle, by either or both of the following two methods.
 - 14.21.1 Remove with a Pasteur pipette by carefully pulling up the water layer, on top, and not solvent. Discard this layer.
 - 14.21.2 Use the smallest amount possible of Sodium Sulfate by sprinkling the top layer until it hardens, separates, and drops to the bottom.
- 14.22 Turbo-Vap Concentration
 - 14.22.1 Rinse a Turbo-Vap tube and arrange it underneath hexane rinsed sodium sulfate filled filter funnel.
 - 14.22.2 Using a permanent marker (or transferred Avery labels), label the Turbo-Vap with the sample IDs
 - 14.22.3 Pour the extract through the filter funnel into the appropriately labeled Turbo-Vap tube.
 - 14.22.4 Rinse the beaker three times with hexane and pour through funnel.
 - 14.22.5 Rinse the filter funnel with hexane once more and allow the funnels to sit until there is no more solvent dripping.

- 14.22.6 For solvent exchange purposes, add 30mL of hexane to each tube. Total volume in the Turbo-Vap tube should not exceed 200mL to avoid splattering on the lid of the Turbo-Vap. If there is a large volume of methylene chloride extract, allow the sample to condense in Turbo-Vap until 75mL-100mL are left in the turbo tube.
- 14.22.7 Adjust pressure of nitrogen gas tank to >30psi, making sure that the tank has 200psi or more on the main valve.
- 14.22.8 Record the water bath temperature in the logbook located beside the TurboVap, making sure that it is 40°C-50°C.
- 14.22.9 Place turbo-vap tube in the Turbo-Vap. Be sure to push the tube down so the tip slides into the sensor well.
- 14.22.10 Close the lid and push corresponding well light to start concentration.
- 14.23 For PCBs Only – Some wastewater samples will form a gel like substance when the hexane is concentrated. Proceed with these samples as follows:
 - 14.23.1 Add just enough methylene chloride to make the gel go back into solution
 - 14.23.2 Acid clean the extract and reconcentrate.
 - 14.23.3 Exchange with hexane again
 - 14.23.4 If gel forms again, add enough methylene chloride to get gel back into solution
 - 14.23.5 Transfer to a suitable container and record the final volume on the label and on bench sheet. Make sure to note the percentage of methylene chloride in sample.
- 14.24 When the samples reach a volume of 3mL-5mL, remove the tube from the batch
- 14.25 Hold the sample vial and tube in one hand at ~45° angle and 9” Pasteur pipette equipped with a latex bulb in the other.
- 14.26 Draw up sample and transfer into appropriately labeled 12mL sample vial. Be careful not to spill a drop during transfer.
- 14.27 Add 2-3mL of hexane to the tube and rinse several times using the pipette. Transfer this rinsate to sample vial and bring sample up to 10mL with hexane (using volume verification vial) and cover the extract with a Teflon-sealed screw cap.
- 14.28 Take sample batch to GC Hobart sample refrigerator and log the sample numbers, analyst initials, and the date and time the samples were placed into the Hobart in the sample logbook located beside the refrigerator.
- 14.29 Transfer handwritten extraction details from bench sheet to LIMS and archive bench sheet for future reference.

15.0 Data Analysis and Calculations

Not applicable to this SOP

16.0 Method Performance

- 16.1 Demonstration of Capability (DOC): Each analyst must perform a DOC prior to independently extracting samples and yearly thereafter. The analyst must prepare 4 LCS samples. The data is calculated for accuracy and precision requirements.

17.0 Pollution Prevention

17.1 Quantity of chemicals purchased should be based on expected usage during its shelf life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

Not applicable to this SOP

19.0 Contingencies for Handling out-of-control or unacceptable data

Not applicable to this SOP

20.0 Waste Management

20.1 Laboratory SOP QS14 on Waste Handling discusses general guidelines for the appropriate handling of wastes and the laboratory program on waste management.

21.0 References

21.1 *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition

21.2 40 CFR, Method 608

22.0 Tables, Diagrams, Flowcharts, and Validation Data

Not applicable to this SOP.

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 322

REVISION #: 10

EFFECTIVE DATE: 20100909

**TOTAL PETROLEUM HYDROCARBONS (TPH) AQUEOUS
MATRIX by USEPA SW846 METHOD 8015B**

APPROVALS:

Lab Director:  Date: 09/09/10

Data Quality Manager:  Date: 09/09/10

Section Supervisor:  Date: 09/09/10

Changes Summary

Revision 10, 09/09/10

- The SOP was updated to reflect references to LIMS, current SOPs, and reagents.

Revision 09, 08/29/10

- The SOP is an update from Revision 08 dated 09/24/09.

**Total Petroleum Hydrocarbons (TPH) AQUEOUS MATRIX by
USEPA SW-846 Method 8015B
Method from the Tennessee Division of Underground Storage Tanks,
Effective April 1, 1992**

I. SCOPE AND APPLICATION

1. This SOP describes the extraction of total petroleum hydrocarbons from water by separatory funnel extraction using SW846 Method 3510C.

II. SUMMARY

1. The samples are extracted with methylene chloride, dried with sodium sulfate, and concentrated.

III. INTERFERENCES

1. Solvents, reagents, glassware, and other sample processing apparatus can add interferences to sample analysis. Method blanks must be extracted under the same conditions as samples to demonstrate freedom from interferences.
2. Phthalate esters commonly found in plastics can interfere with the analysis. Plastics should be avoided.
3. Soap residue can degrade certain analytes. Glassware should be solvent rinsed to avoid this problem.

IV. APPARATUS AND MATERIALS

- Separatory Funnel - 2 Liter with Teflon stopcock
- Beaker - 400 mL
- Drying Column (Chromatographic column) - 20 mm I.D. x 300 mm
- Turbo-Vap evaporation tube - 200 mL tube made by Zymark to fit into Turbo-Vap evaporator.
- Metal rack - capable of holding six glass evaporation tubes.
- Turbo-Vap Evaporator - heated and capable of temperature control (+5°C); the bath should be vented into a hood.
- Vials 10 mL glass, with Teflon-lined screw cap
- pH indicator paper - wide range (1.0 and 12.0)
- Syringe - 1 mL, 500 µL
- Graduated cylinder - Glass, Class A, 1000 mL, 500 mL and 100 mL
- Pasteur pipette - length 9"
- Pasteur pipette bulb
- Labels - Avery
- Teflon Bottles - 250 mL and 1000 mL
- Volumetrics - Class A, glass, 1000 mL and 500 mL
- Ring stand - 3 prong
- Burette clamp - double
- Aluminum foil - heavy duty
- 10 mL disposable pipette
- Nitrogen tank - equipped with pressure regulator

V. REAGENTS

- Reagent water - Reagent water is Modulab water gathered in a carboy from source in the wet chemistry lab.
- Sodium Sulfate (Na_2SO_4) - Granular, anhydrous, trace pure 10 - 60 mesh (purchased in a 2.5 kg glass amber jug from VWR - Baker #EM-SX0760E-3 or equivalent) placed in a Pyrex pan and heated at 400°C minimum 4 hrs, removed and cooled in open air in the extraction lab, placed in a 2.5 kg glass amber jug and left at room temperature.

NOTE: We deviate from SW-846 protocol as follows: We do not cool our sodium sulfate in a desiccator. This deviation has not presented a problem.

- Glass Wool - Silane Treated (purchased from Supelco #2-0410 in a white plastic tub or equivalent).
- Extraction Solvent - Methylene Chloride (**Please see SOP-336 before handling this solvent in our laboratory.**) (Dichloromethane - Omnisolv - suitable for spectrophotometer and gas chromatography # DX0831-1 or equivalent)
- Methanol - suitable for use in gas chromatography (Omnisolv MX0484-1 or equivalent)
- Acetone - suitable for spectrophotometer and gas chromatography (Omnisolv AX0116-1 or equivalent)
- TPH Surrogate - Surrogate (OTP) solution is prepared in acetone at a concentration of $20\ \mu\text{g/mL}$. Use 1 mL per 1000 mL of sample.
- TPH Spike - A spiking solution is prepared at a concentration of $1000\ \mu\text{g/mL}$ in acetone. Use 1 mL per 1000 mL of sample.

VI. PROCEDURE

1. Get samples from cooler. Inspect as to whether they are in glass amber jar and have a Teflon lid. Find out if any special dilutions need to be made for this client, if the sample is a SLUDGE (use only 100 mL and dilute to 1000 mL with reagent water), or if the sample has a particularly bad matrix, see your supervisor to find out what dilution, if any, should be made.
2. Mark the amber glass container of each sample at the water meniscus with "white out" for later determination of sample volume.
3. Get out enough separatory funnels to extract the number of samples you have plus any additional spikes, laboratory control samples, and a method blank. A method blank must be processed with each set of samples. A matrix spike and a duplicate or a matrix spike duplicate must be processed for each analytical batch (up to a maximum of 20 samples). In addition, duplicate laboratory control samples which contain 1 mL of the TPH Spike each in a blank matrix are to be extracted for each batch up to 20 samples.

Rinse with methylene chloride. Label the separatory funnels as follows on your Avery labels: Lab #.

4. Using the 1000 mL glass graduated cylinder, measure 1 liter of reagent water from the carboy and transfer it to a separatory funnel for the Method Blank. Transfer sample to separatory funnel that corresponds to the lab # on the sample bottle. Add 60 mL of Methylene Chloride to the empty sample bottles.
5. Using the 1.0 mL glass syringe marked TPH surrogate, add 1.0 mL of TPH surrogate to each sample, blank, lab control sample, and spike.

NOTE: Be sure to invert syringe and eliminate air bubble when obtaining surrogate solution and spiking solution.

6. For the TPH sample in each analytical batch selected for spiking, use a community 1 mL syringe rinsed well with methanol, acetone, and methylene chloride, and finally rinsed with acetone to add 1.0 mL of the TPH spike.

NOTE: Due to limited volume received, usually it is necessary to use half a liter to do a spike so that a spike duplicate can be extracted also. If only one liter is provided for spiking purposes, use a 500 mL glass cylinder to measure out half the sample. Transfer to a separatory funnel labeled for the Spike. Measure the remaining sample and transfer to a separatory funnel labeled Spike Duplicate. Add 1/2 the normal amount of spiking solution and 1/2 the normal amount of surrogate.

7. Stopper funnel, swirl, and invert so the glass stopper gets wet. Using wide-range pH paper, check pH of sample by touching pH - sensitive paper to the drop of liquid hanging from the glass stopper. Record this initial pH on the bench sheet in LIMS if it is anything other than 2 or less. Adjust the pH to less than 2 and notify your supervisor.
8. Swirl the 60 mL of methylene chloride that you added to the empty sample bottle and transfer to the corresponding separatory funnel. Using a 100 mL glass cylinder, add 60 mL of methylene chloride to the Method Blank. If using a liter, add 60 mL to the Spikes.
9. Seal and shake the separatory funnel vigorously for 2 minutes with periodic venting to release excess pressure.

NOTE: Methylene chloride creates excessive pressure very rapidly; therefore, initial venting should be done immediately after the separatory funnel has been sealed and shaken once.

10. Allow the sample to set for 10 minutes after it has been shaken. It will separate into two layers with the solvent layer on the bottom. If it forms an emulsion (thick, cloudy, viscous, mixture that you cannot see through), drain what you believe to be 50 mL into a 250 mL centrifuge bottle. If the layers are clearly separated, drain the solvent layer into a 400 mL glass beaker.

11. Repeat STEPS 8 through 10 one more time, only this time you may take the methylene chloride bottle directly to the separatory funnel and pump it twice. This should be 60 mL as it is set on 30 mL. Combine the two solvent extracts into the same 400 mL beaker.
12. On the bench sheet for the batch, enter anything unusual that may have occurred with this sample.
13. If the extract was drained into a centrifuge bottle, at this point you will need to take it to the centrifuge. Push the "ON" button to turn the centrifuge on. Be sure that the orange holders are available for the 250 mL centrifuge bottles. The sample must always be balanced. If necessary use a dummy bottle with similar weight using reagent water. Set the rpm at 2500 and the temperature at 25°C. Close the lid and be sure to press it down until you hear it lock. Move the lever at the front of the lid to the "LOCK" position. Turn the time to approximately 15 minutes and bring it back to 10 minutes. As the rotor begins to move, you will be able to see the rpm's in the digital readout. Stay with the centrifuge until it has come up to the rpm's set to insure that it does not become unbalanced. This looks like 8888 on the digital readout. Should this occur, refer to the manual. When the cycle is complete, the digital readout will read 0000. Push the "OPEN" button and the lid will pop up. Move the lever at the front of the lid to the "UNLOCK" position. Open lid and remove sample. The sample will usually be in two layers with the extract on the bottom.
14. Remove any water layer from the extract in the beaker or centrifuge bottle, with a Pasteur pipette by carefully pulling up the water layer, on top, and not the solvent. Discard this layer. Use the smallest amount possible of Na₂SO₄ by sprinkling the top layer with Na₂SO₄ until it hardens, separates, and drops to the bottom.

TURBO-VAP CONCENTRATION

15. Rinse a Turbo-Vap tube with methylene chloride and arrange it underneath a rinsed, packed funnel. Pour the extract through the funnel. It will collect in the tube. Rinse the 400 mL beaker twice with 10 mL of methylene chloride. The Turbo-Vap tubes only hold 200 mL. Rinse the funnel with 10 - 15 mL of methylene chloride. Total volume in the glass evaporator tube should not exceed 180 mL to avoid splattering on the lid of the Turbo-Vap. While waiting for the funnel to quit dripping, record the numbers of the Turbo-Vap tube on the batch bench sheet and remove the tube to a metal holder.
16. Turbo-Vap Operation: Adjust pressure of nitrogen gas tank to >30 psi. Make sure the tank has 200 psi or more on the main valve. Adjust the settings of the Turbo-Vap so that the solvent exchange is at "0" and dryness is at "NO". Push the reset button with the lid up to make the indicator light go to green at each individual station. Temperature of the bath should be at 45°C ± 1.0°C. **Higher temperature will result in lost of low boiling point analytes.**
17. Place the glass evaporator tube in the Turbo-Vap. Be sure to push tube down so the tip slides into the sensor well. Close the lid to start concentration. Check that each position with a tube has an orange light showing. If the orange light is not steady, bubbles may be in the sensor and need removal. (See Turbo-Vap manual).

18. When the beep sounds indicating the end of concentration, the extract will be at approximately one mL. Remove the tube from the bath. Hold the tube and the sample vial in one hand at about a 45° angle. Use a 9" Pasteur pipette to draw up the 1.0 mL sample and transfer it to the 2 mL vial. **THIS IS THE MOST CRITICAL PART OF THE ENTIRE OPERATION!!!** A single drop represents about 10 percent of the total sample. Before you move the tip of the pipette from the tube to the vial, be sure that a drop will not form on the end and fall off.
19. Add ≈0.25 mL of Meclz to the tube. Draw into the pipette and rinse down the conical portion of the tube several times. Transfer this rinse to the 2 mL vial. **Using a 2.0 mL vial filled to exactly 1.0 mL w/Meclz measure the actual volume of the sample. Adjust the volume to exactly 1.0 mL with methylene chloride or if further concentration is required use nitrogen blow down. Repeat the measurement with the 1.0 mL vial until an exact 1.0 mL sample volume is obtained.** Cover the extract with a Teflon-sealed screw cap. The extract obtained above may now be analyzed. Refrigerate at 4°C.
20. Determine the original sample volume by refilling the sample bottle to the mark made with "white out". Transfer the liquid to a plastic 1000 mL graduated cylinder and record the sample volume on the bench sheet to the nearest 10 mL. Record this information on the bench sheet in LIMS.
21. For sample analyses reference SOP-219.

VII. DOCUMENTATION OF CAPABILITY (DOC)

Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP-QS08 for guidance.

VIII. WASTE MANAGEMENT AND POLLUTION PREVENTION

Please see Waste Disposal SOP-QS14 for the proper disposal of waste generated from this area. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

IX. METHOD PERFORMANCE

Refer to SOP-219 for method performance.

X. HEALTH AND SAFETY

Refer to the MSDS sheets for the chemicals used for health and safety information. Also see SOP-QS13 for proper use of methylene chloride.

XI. REFERENCES

1. *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition
2. TN Division of Underground Storage Tanks.

**EMPIRICAL LABORATORIES, LLC
STANDARD OPERATING PROCEDURE**

ORGANICS: SOP 343 REVISION #: 02 EFFECTIVE DATE: 20101117

**BNA & Pesticide/PCBs & TPH NON-AQUEOUS MATRIX
(MICROWAVE EXTRACTION) USING SW-846 METHOD 3546**

APPROVALS:

Lab Director:  Date: 11/30/10

Data Quality Manager:  Date: 11/30/10

Section Supervisor:  Date: 11/30/10

Changes Summary

Revision 02, 11/17/2010

- SOP has been updated to reflect added volume correction for BNA surrogate
- clarified addition of sodium sulfate to microwave tubes
- Corrected # of samples associated to each of the specified microwave methods and added the name of the method identified on the instrument.

Revision 01, 09/09/2010

- SOP has been updated to reflect the correct QS SOPs and include missing solvent/spike information.

Revision 00, 08/01/09

- Review of SOP indicated no changes were necessary
- Additional requirements, based upon the DoD QSM 4.1, have been integrated into the routine sample flow; however, if the requirement is different from routine sample flow, then the requirement is outlined and documented as such to be followed only when DoD samples are analyzed.

BNA & Pesticide/PCB & TPH NON-AQUEOUS MATRIX
(Microwave Extraction)
Using SW846 METHOD 3546

1. SCOPE AND APPLICATION

- a. This SOP describes the extraction of BNAs, pesticides/PCBs, and TPHs from soil, sediment, sludges and waste solids by an automated method (3546).

2. SUMMARY

- a. Soil and solid samples are mixed with sodium sulfate and extracted with solvent in a Microwave extractor for BNAs, Pesticides/PCBs, or TPHs. The extracts are then concentrated by a Turbo Vap concentrator.

3. INTERFERENCES

- a. Solvents, reagents, glassware, and other sample processing apparatus can add interferences to sample analysis. Method blanks must be extracted under the same conditions as samples to demonstrate freedom from interferences.
- b. Phthalate esters commonly found in plastics can interfere with the analysis. Plastics should be avoided.
- c. Soap residue can degrade certain analytes such as aldrin and heptachlor. Glassware should be solvent rinsed to avoid this problem.

4. APPARATUS AND MATERIALS

- d. Stainless Steel spatula
- e. Microwave extractor unit with 40 position carousel, electronic components, and ample ventilation
- f. Microwave extraction Teflon tubes, capacity approximately 75mL
- g. Suitable Teflon cap and screw-top lid
- h. Drying column (Chromatographic column) – 20mm I.D. x 300mm
- i. Vial – 2mL clear with Teflon-lined screw cap
- j. Vial – 12mL clear with Teflon-lined screw cap
- k. Syringe – 1mL, 500uL
- l. Pasteur pipet – 9” length
- m. Pasteur pipet bulb
- n. Labels – Dymo
- o. Aluminum foil – heavy duty
- p. Nitrogen tank – equipped with pressure regulator
- q. TurboVap Concentrator with 200mL concentrator tubes
- r. Teflon funnels for pouring off
- s. Balance – capable of weighing to 0.1grams
- t. Aluminum pie pans for mixing samples
- u. Filter paper – 185mm

5. REAGENTS

- a. Sodium Sulfate (Na_2SO_4) – Granular, anhydrous, trace pure 10-60 mesh (purchased in bulk containers from Fisher #S415-10S or equivalent)
- b. Methylene Chloride (Please read SOP – 336 before handling this solvent in our laboratory) (Dichloromethane) – suitable for spectrophotometry and gas chromatography (Fisher #D151-4 or equivalent)
- c. Hexane – suitable for spectrophotometry and gas chromatography (Fisher #H303-4)
- d. Surrogate/Spike Solutions – Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes or if the initial concentration of stock is different than that listed below:
 - i. **BNA Surrogate (100ug/mL)** – The base neutral and acid surrogates are mixed together in one solution. This solution is prepared in methanol by making a dilution of stock purchased from a reputable vendor. Use 0.5mL of this solution per 15g of non-aqueous sample. **(For low-level PAHs use 0.5mL of 100ppm BN Surrogate spiking solution.)**
 - ii. **BNA Spiking Solution #1 & #2 (100 ug/mL)** – The base neutral and acid spiking solutions are mixed together in one solution. This solution is prepared in methanol by making a dilution of stock purchased from a reputable vendor with same compounds as for calibration. Use 0.5 mL of this solution per 15g of non-aqueous sample. **(For low-level PAHs use 1.0mL of 1.0 ug/mL LL PAH spiking solution.)** **The BNA Spiking solutions contain all targets that are calibrated for GC/MS. DOD QSM requires all targets to be spiked in the LCS and MS/MSD.**
 - iii. **TCMX/DCB(2,4,5,6-Tetrachloro-meta-xylene/Decachlorobiphenyl) Surrogate solution** is prepared in acetone by making a cut on stock purchased from a reputable vendor. 0.5mL at 0.5 ug/mL of this solution is added per 15g of non-aqueous sample.
 - iv. **PCB Spiking Solution** – Arochlor 1016/1260 or the PCB of choice (1242, 1248, 1254, or 1260 are the most common) is prepared in acetone at a concentration of 5.0ug/mL. PCB stock is usually purchased from RESTEK or equivalent. The PCB to use may be determined by viewing historical data or asking the GC operator. Use 0.5mL per 15.0g of non-aqueous sample.
 - v. **Pesticide Spiking Solution** – A spiking solution is prepared at 1.0 ug/mL. Use 0.5mL per 15g of non-aqueous sample.
 - vi. **TPH Surrogate** – Surrogate solution is prepared in acetone by diluting stock ortho-terphenyl standard to a final concentration of 20 ug/mL. Use 1mL per 15 grams of sample.
 - vii. **TPH Spike** – A spiking solution is prepared by extractions analyst that has a concentration of 1000 ug/mL in acetone.

6. SAMPLE COLLECTION, PRESERVATION, AND HOLDING TIMES

- a. Samples are collected in an appropriate size wide-mouth glass jar (4oz. or 8 oz.) with a Teflon-lined cap.
- b. Samples are preserved by cooling to 4°C.
- c. Holding time is 14 days from collection date to extraction.

7. PROCEDURE

- a. All soils have a 14-day holding time counted from the day they are sampled. Determine the samples necessary to extract using the following information. (DO NOT extract samples for which you have no information.):
 - i. Each day a backlog is generated in the LIMS providing all relevant sample information, including samples numbers and respective analysis required.
 - ii. Samples requiring RUSH turn around time may be logged in throughout the day which will require your immediate attention. Log-in personnel will generally communicate this need.
 - iii. Check the backlog throughout the day to re-evaluate priority if needed.
- b. Wearing lab coat, gloves, and safety glasses, get samples from cooler. Samples must be signed out of the walk-in refrigerator. Enter the sample numbers, your initials, and the date and time removed on the log provided. Inspect as to whether they are in glass and have a Teflon lid. Find out if any special dilutions need to be made for this client. If the sample has a particularly bad matrix or a strange matrix, see your supervisor to find out if a microwave extraction is truly necessary.
- c. Get twice the number of aluminum pie pans to prepare the number of samples you have plus any additional spikes of LCSs and a method blank. A method blank and LCS must be processed with each set of samples. A matrix spike, a duplicate or a matrix spike duplicate and a LCS must be processed for each analytical batch (up to a maximum of 20 samples). Using the LIMS, create a batch of samples and print off sample labels. The LIMS will create a unique batch sequence number.
- d. Decant and discard any water layer on a sediment sample by carefully pouring this off into a trashcan.
- e. Dump the entire sample into an aluminum pie pan and mix sample thoroughly with a spatula until mixture is homogenous. Discard any foreign objects such as sticks, leaves, and rocks.

It is extremely important that waste (when appropriate), soil and sediment samples be mixed thoroughly to ensure that the sample is as representative as possible of the sample media. The most common method of mixing is referred to as quartering. The quartering process should be performed as follows:

- *The material in the sample pan (inorganic-plastic/organic-aluminum) should be divided into quarters and each quarter should be mixed individually.*

- *Two quarters should then be mixed to form halves.*
- *The two halves should be mixed to form a homogenous matrix.*

This procedure should be repeated several times until the sample is adequately mixed.

NOTE: Samples that are clay type materials should be handled in a different manner. Due to these type sample matrices having an affinity to stick to most anything that touches it, another approach must be followed. Obtain a representative sub-sample aliquot from the center or middle section of the sample container

Place an aluminum pie pan on the balance and zero it. Calibrate balance with ASTM class-1 Troemner weights or equivalent, bracketing desired weight (50g, 20g, 10g, 5g, 1g). Record calibration in the Extraction calibration/temperature logbook. Using a spatula, transfer the appropriate weight, {10-20 grams depending upon client or project specific Detection Limits (DL) and/or Reporting Limits (RL)}, of a representative sample to the nearest 0.1 gram. Normally 10 or 15g sample weights are used. Record this amount on your label. Put your label on the side of the 400-mL beaker. For spiking purposes, weigh 3 aliquots of the appropriate sample. Pick a sample with a good matrix, one that mixes well, non-oily, etc.

- Add ~ 15 grams of sodium sulfate to the aluminum pie pan. Using a spatula and/or a glass rod, mix the sample thoroughly with the sodium sulfate until it becomes a sandy texture. If necessary, add additional sodium sulfate. When removing the spatula or glass rod from the mixed sample, leave behind all the sample possible. Cover the aluminum pie pan with foil and continue to weigh up the remaining samples. For the method blank and LCS, pour up approximately 15g of sodium sulfate in microwave tube. The matrix used for the method blank and LCS must be free of the analytes of interest and processed through the same analytical steps as the samples.
 - Carefully transfer samples to microwave tubes. Make sure samples are loaded in the rack in the order of the bench sheet.
 - Verify the amount of surrogate/spike to add to the sample prior to addition. It can change if a different detection limit is required or the volume of sample being analyzed changes. Set out the surrogate/spike at least ten minutes before use to allow it to warm to room temperature. Someone must verify that the surrogate/spike has been added by watching and signing off on bench sheet.
 - Surrogate: **BNA/PAH** - using the 1-mL glass syringe designated for BNA surrogate, add 0.5 mL of BNA surrogate to each sample, spike, and blank. **Pest/PCBs** - using the 1.0-mL glass syringe marked TCMX/DCB surrogate, add 0.5 mL of TCMX/DCB surrogate to each sample, blank and spike. TPH – use the appropriate 1.0-mL glass syringe to add 1.0 mL of the appropriate surrogate to each sample, blank and spike.
 - Spiking: For the BNA sample in each analytical batch selected for spiking, use the 0.5-mL glass syringe marked Base Neutral Acid Spiking to add 0.5 mL of the Base Neutral Acid Spiking solution. **(For low level PAHs use 1.0 ml of the 1.0µg/mL PAH spiking solution.)**
For Pest/PCB samples, determine if the sample will require a Pesticide

Spike and/or a PCB Spike. Proceed as follows:

Pesticide and PCB - set up two LCS's – one for Pesticide getting an AB MIX spike and one for PCB, which should be spiked with PCB 1660. In addition to the LCSs, a matrix spike/matrix spike duplicate is necessary for the pesticide. Prepare a PCB matrix spike/ matrix spike duplicate if requested by the client.

Pesticide only – To the sample in each analytical batch selected for spiking, add 0.5 mL of Pesticide Spike (Mix A&B) with a glass syringe dedicated for Pesticide Spike.

PCB only - To the sample in each analytical batch selected for spiking, add 0.5 mL of PCB 1016/1260 (unless otherwise specified, 1248 for BB&L) using a 1.0 mL glass syringe dedicated to that PCB.

For TPH - To the sample in each analytical batch selected for spiking, add 1mL of the appropriate spiking solution (i.e. DRO or TNEPH or MAEPH) using a 1.0 mL glass syringe dedicated to that spike.

- k. **Solvent:** Add 30mL methylene chloride for BNA/PAH/TPH extractions or 30ml hexane for Pest/PCB extractions.
- l. Place a Teflon cap and Teflon screw top on the Teflon microwave tube. Using the cap tightener station, tighten the caps and invert sample to insure proper mixing and check for leaks in cap.
- m. Place microwave tubes in microwave carousel making sure they are in order and spaced evenly throughout the carousel to insure proper heating while in microwave. Note position on bench sheet.
- n. Place microwave carousel in microwave making sure the carousel is properly lined up with the turning mechanism.
- o. Choose saved program option based on total number of samples to extract and begin process by pressing the start button. The program is set to EPA method 3546 specifications. **Note the method used on the bench sheet.**

For 1-16 samples (800W):

Method: 3546 800W 100% 16-Express

Max power: 800W

Ramp time: 15:00

Control temperature (in Celsius): 110

Hold time: 10:00

Cool down: 5:00

For 17-40 samples (1600W):

Method: 3546 1600W 100% 40-Express

Max power: 1600W

Ramp time: 15:00

Control temperature (in Celsius): 110

Hold time: 10:00

Cool down: 5:00

- p. Allow samples to cool in the carousel for an additional 30 minutes before attempting to handle the extracts.
- q. Transfer the extract to a pre-rinsed turbo vap tube by first passing through a funnel with P4 filter paper sodium sulfate. All tubes and funnels should be pre-rinsed with Methylene Chloride. After pouring the extract into the turbo, rinse the microwave tube 3 times with the extraction solvent and transfer the rinsate to the turbo. Finally, rinse the funnel with an adequate amount of the extraction solvent using a Teflon squirt bottle. This ensures optimum transfer of all compounds of interest.
- r. Now concentrate the extract to 1.0mL using the turbovap concentrator.
 - i. **Turbo-Vap Operation:** Adjust the pressure of nitrogen gas tank to 50 psi. Make sure the tank has 200 psi or more on the main valve. The temperature of the bath should be approximately 45°C. The pressure target range should be about 20-25 psi.
 - ii. Place the turbo vap tube in the Turbo-Vap. Be sure to push tube down so the tip slides into the sensor well. Close the lid to start concentration. Check that each position with a tube has an orange light showing. If the orange light is not steady, bubbles may be detected by the sensor and need removal. (See Turbo-Vap manual).
 - iii. When the beep sounds indicating the end of concentration, the extract will be at approximately 1 mL. Remove the tube from the bath.
- s. BNA and TPH samples need to be concentrated to ~1.0mL while Pesticides and PCB should be concentrated to ~5.0mL in turbo vap. Using clean solvent, rinse turbo with Pasteur pipet and bring sample to volume in sample vial.

8. DOCUMENTATION OF CAPABILITY (DOC)

- a. Each analyst must perform a DOC to demonstrate proficiency with this method. Refer to SOP QS08 for guidance.

9. WASTE MANAGEMENT AND POLLUTION PREVENTION

- a. Please see Waste Disposal SOP QS14 for the proper disposal of waste generated from this area.
- b. Quantity of chemicals purchased should be based on expected usage during its shelf-life and the disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

10. METHOD PERFORMANCE

- a. Refer to SOP-201, SOP-211 and SOP-219 for method performance.

11. REFERENCES

- a. EPA Methods SW-846, Method 3546

12. DEFINITIONS

- a. Refer to SOP QS08 for definitions.

13. HEALTH AND SAFETY

- a. Wear appropriate personal protection equipment when working with chemicals or samples.
- b. Use the lab hoods when working with solvents.
- c. Use caution when mixing strong acids or bases. Solutions will become extremely hot when mixing with water. Avoid splashing these solutions so they won't come in contact with the skin or eyes. If this happens, flush with lots of water. Contact your supervisor if serious and medical attention is needed.

7.0 TO-14A/TO-15 – VOLATILE ORGANIC COMPOUNDS

This method involves full scan GC/MS analysis of whole air samples collected in evacuated stainless steel canisters. Samples are analyzed for volatile organic compounds using EPA Method TO-14A/TO-15 protocols. An aliquot of the sample is withdrawn from the canister through a mass flow controller and is either concentrated using a cryogenic trap and/or concentrated using a hydrophobic multisorbent bed. The hydrophobic multisorbent bed functions as a drying system which removes water from the sample stream prior to analysis by full scan GC/MS. During analysis, the sample may be focused onto a cryogenic cooled column and/or a cryogenic cooled sleeve for analysis by full scan GC/MS.

Certain compounds are not included in ATL’s standard target analyte list. These compounds are communicated at the time of client proposal request. Unless otherwise directed, ATL reports these non-standard compounds with partial validation. Validation includes a 3-point calibration with the lowest concentration defining the reporting limit, no second source verification is analyzed, and no method detection limit study is performed unless previous arrangements have been made. In addition, stability of the non-standard compound during sample storage is not validated. Full validation may be available upon request.

Air Toxics Ltd. performs a modified version of this method. The method modifications, standard target analyte list, Limit of Quantitation, QC criteria, and QC summary can be found in the following tables.

Table 7-1. Summary of Method Modifications

Requirement	TO-14A	TO-15	Air Toxics Ltd. Modifications
Sample Drying System	Nafion Drier.	Multisorbent.	Multisorbent.
Blank acceptance criteria	< 0.2 ppbv.	< RL.	< RL.
Blanks and standards (applies to Low Level analysis only)	Zero Air.	Zero air.	Nitrogen.
BFB absolute abundance criteria	Within 10% of that from the previous day.	Not mandated.	CCV internal standard area counts are compared to ICAL, corrective action for > 40 %D.
Method Detection Limit	Not Specified.	Follow 40CFR Pt.136 App. B.	The MDL met all relevant requirements in Method TO-15 (statistical MDL less than the LOQ). The concentration of the spiked replicate may have exceeded 10X the calculated MDL in some cases.

Requirement	TO-14A	TO-15	Air Toxics Ltd. Modifications
Initial Calibration	≤ 30 % RSD.	≤ 30 % RSD with 2 compounds allowed out to ≤ 40 % RSD.	≤ 30 % RSD with 2 compounds allowed out to ≤ 40 % for QUAD and 5&20 analysis and 4 compounds allowed out to ≤ 40 % for Low Level analysis.
Daily CCV	≤ 30% D.	≤ 30% D.	For QUAD and 5&20 analysis: 70-130%. Compounds exceeding this criterion and associated data will be flagged and narrated. If more than two compounds from the standard list recover outside of 70-130%, corrective action will be taken. Unless prior client approval; under no circumstances will samples be analyzed if any compound exceeds 60-140%. For Low Level analysis the above applies except corrective action will be taken if more than four compounds from the standard list recover outside of 70-130%.
Sample collection media.	Summa canister.	Summa canister.	Methods TO-14A/TO-15 are validated for samples collected in specially treated canisters. As such, the use of Tedlar bags for sample collection is outside the scope of these methods and not recommended for ambient or indoor air samples. Associated results are considered qualified.

Table 7-2. Method TO-14A/TO-15 Analyte List

Analyte	RL (ppbv) TO-15/ LL/5&20	%RSD	Acceptance Criteria	
			LCS (%R)	Precision Limits (Max. RPD)
1,1,2,2-Tetrachloroethane	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,1,2-Trichloroethane	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,1-Dichloroethane	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,1-Dichloroethene	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,2,4-Trichlorobenzene	2.0/0.5/20	30%	70 - 130	≤ 25
1,2,4-Trimethylbenzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,2-Dibromoethane (EDB)	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,2-Dichlorobenzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,2-Dichloroethane	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,2-Dichloropropane	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,3,5-Trimethylbenzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,3-Dichlorobenzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
1,4-Dichlorobenzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Benzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Bromomethane	0.5/0.1/5.0	30%	70 - 130	≤ 25
Carbon Tetrachloride	0.5/0.1/5.0	30%	70 - 130	≤ 25
Chlorobenzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Chloroethane	0.5/0.1/5.0	30%	70 - 130	≤ 25
Chloroform	0.5/0.1/5.0	30%	70 - 130	≤ 25
Chloromethane	2.0/0.1/20	30%	70 - 130	≤ 25
Chlorotoluene (Benzyl Chloride)	0.5/0.1/5.0	30%	70 - 130	≤ 25
cis-1,2-Dichloroethene	0.5/0.1/5.0	30%	70 - 130	≤ 25
cis-1,3-Dichloropropene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Dichloromethane	0.5/0.2/5.0	30%	70 - 130	≤ 25
Ethylbenzene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Freon 11 (Trichlorofluoromethane)	0.5/0.1/5.0	30%	70 - 130	≤ 25
Freon 113 (Trichlorotrifluoroethane)	0.5/0.1/5.0	30%	70 - 130	≤ 25
Freon 114	0.5/0.1/5.0	30%	70 - 130	≤ 25
Freon 12 (Dichlorodifluoromethane)	0.5/0.1/5.0	30%	70 - 130	≤ 25
Hexachlorobutadiene	2.0/0.5/20	30%	70 - 130	≤ 25
m,p-Xylene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Methyl Chloroform	0.5/0.1/5.0	30%	70 - 130	≤ 25
o-Xylene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Styrene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Tetrachloroethene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Toluene	0.5/0.1/5.0	30%	70 - 130	≤ 25
trans-1,3-Dichloropropene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Trichloroethene	0.5/0.1/5.0	30%	70 - 130	≤ 25
Vinyl Chloride	0.5/0.1/5.0	30%	70 - 130	≤ 25

Table 7-3. Method TO-14A/TO-15 Analyte List

Analyte	RL (ppbv) TO-15/ LL/5&20	%RSD	Acceptance Criteria	
			LCS (%R)	Precision Limits
1,3-Butadiene	0.5/0.1/5.0	30%	60 – 140	≤ 25
1,4-Dioxane	2.0/0.1/20	30%	60 – 140	≤ 25
2-Butanone (Methyl Ethyl Ketone)	0.5/0.1/5.0	30%	60 – 140	≤ 25
2-Hexanone	2.0/0.5/20	30%	60 – 140	≤ 25
4-Ethyltoluene	0.5/0.1/5.0	30%	60 – 140	≤ 25
4-Methyl-2-Pentanone (MIBK)	0.5/0.1/20	30%	60 – 140	≤ 25
Acetone	2.0/0.5/20	30%	60 – 140	≤ 25
Bromodichloromethane	0.5/0.1/5.0	30%	60 – 140	≤ 25
Bromoform	0.5/0.1/5.0	30%	60 – 140	≤ 25
Carbon Disulfide	0.5/0.5/5.0	30%	60 – 140	≤ 25
Cyclohexane	0.5/0.1/5.0	30%	60 – 140	≤ 25
Dibromochloromethane	0.5/0.1/5.0	30%	60 – 140	≤ 25
Ethanol	2.0/0.5/20	30%	60 – 140	≤ 25
Heptane	0.5/0.1/5.0	30%	60 – 140	≤ 25
Hexane	0.5/0.1/5.0	30%	60 – 140	≤ 25
Isopropanol	2.0/0.5/20	30%	60 – 140	≤ 25
Methyl t-Butyl Ether (MTBE)	0.5/0.1/5.0	30%	60 – 140	≤ 25
Propylene	2.0/0.5/20	30%	60 – 140	≤ 25
Tetrahydrofuran	0.5/0.5/5.0	30%	60 – 140	≤ 25
trans-1,2-Dichloroethene	0.5/0.1/5.0	30%	60 – 140	≤ 25
2,2,4-Trimethylpentane	0.5/0.5/5.0	30%	60 – 140	≤ 25
Cumene	0.5/0.1/5.0	30%	60 – 140	≤ 25
Propylbenzene	0.5/0.1/5.0	30%	60 – 140	≤ 25
3-Chloroprene	2.0/0.5/20	30%	60 – 140	≤ 25
Naphthalene	2.0/0.5/20	30%	60 – 140	≤ 25
TPH (Gasoline) or NMOC (Hexane/Heptane)	10/2.0/50	One Point Calibration	NA	≤ 25

Table 7-4. Internal Standards

Analyte	Accuracy (% R)
Bromochloromethane	60 - 140
1,4-Difluorobenzene	60 - 140
Chlorobenzene-d ₅	60 - 140

Table 7-5. Surrogates

Analyte	Accuracy (% R)
1,2-Dichloroethane-d ₄	70 – 130
Toluene-d ₈	70 – 130
4-Bromofluorobenzene	70 – 130

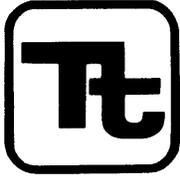
Table 7-6. Summary of Calibration and QC Procedures for Methods TO-14A/TO-15

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Tuning Criteria	Every 24 hours, or every 12 hours if project requires.	SW – 846 tune criteria.	Correct problem then repeat tune.
5-Point Calibration	Prior to sample analysis.	% RSD \leq 30 with two compounds allowed out to \leq 40% RSD for QUAD and 5&20 (4 allowed out for LL).	Correct problem then repeat Initial Calibration Curve.
LCS	After each initial calibration curve, and daily, prior to sample analysis.	Recoveries for 90% of "Standard" compounds must be 70-130%; for 80% of "Non-standard" compounds, recoveries must be 60-140%. No recovery may be <50%. * If specified by the client in-house generated control limits may be used.	Check the system and reanalyze the standard. Re-prepare the standard if necessary. Re-calibrate the instrument if the criteria cannot be met.
Continuing Calibration Verification (CCV)	At the start of each day and, if required by a specific project, every 12 hours.	For QUAD and 5&20: 70-130%. Compounds exceeding this criterion and associated data will be flagged and narrated with the exception of high bias associated with non-detects. If more than two compounds from the standard list recover outside of 70-130%, corrective action will be taken. Unless prior client approval; under no circumstances will samples be analyzed if any compound exceeds 60-140%. For Low Level analysis the above applies except corrective action will be taken if more than four compounds from the standard list recover outside of 70-130%.	Perform maintenance and repeat test. If the system still fails the CCV, perform a new 5 point calibration curve.
Laboratory	After the CCV/LCS.	Results less than the	Inspect the system and

QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
Blank		laboratory reporting limit.	Re-analyze the blank.
Internal Standard (IS)	As each standard, blank, and sample is being loaded.	Retention time (RT) for blanks and samples must be within ± 0.33 min of the RT in the CCV and within $\pm 40\%$ of the area counts of the daily CCV internal standards.	For blanks: inspect the system and reanalyze the blank. For samples: re-analyze the sample. If the ISs are within limits in the re-analysis, report the second analysis. If ISs are out-of-limits a second time, dilute the sample until ISs are within acceptance limits and narrate.
Surrogates	As each standard, blank, and sample is being loaded.	70 - 130%. * If specified by the client in-house generated control limits may be used.	For blanks: inspect the system and reanalyze the blank. For samples: re-analyze the sample unless obvious matrix interference is documented. If the %R is within limits in the re-analysis, report the second analysis. If %R is out-of-limits a second time, then narrate results.
Laboratory Duplicates	10% of the samples.	RPD $\leq 25\%$ for detections >5 X's the RL.	Re-analyze the sample a third time. If the limit is exceeded again, investigate the cause and bring the system back to working order. If no problem is found on the system, narrate results.

APPENDIX B

SELECTED FIELD STANDARD OPERATING PROCEDURES



TETRA TECH

STANDARD OPERATING PROCEDURES

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Effective Date	01/2012	Revision	3
Applicability	Tetra Tech, Inc.		
Prepared	Earth Sciences Department		
Approved	J. Zimmerly		

Subject EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

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5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

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The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful, the

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reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.
2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):
 - Well number.
 - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
 - Time and day of the measurement.
 - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

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5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

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5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

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ATTACHMENT A
MONITORING WELL INSPECTION SHEET

Monitoring Well Inspection Sheet

Project Name: _____ Date: _____
 Location: _____ Time: _____
 Tidally Influenced: Y / N Personnel: _____

Field Measurements				
Well ID	PID Reading PPM	Depth to Water *	Total Depth *	Flush Mt./ Stick-up

Well Construction Details (Taken from construction logs)		
Total Depth *	Ground Elev.	Top/Btm Screen *

Check List:

Riser Pipe Material:
Riser Notched for Surveyors:
Well ID Tag In-place:
Well security:
Photo taken:

Condition of Well:

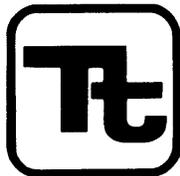
Protective Case:
Riser:
Well Pad:
Other:

Presence/Evidence of:

Standing Water Around Well:
Existing Sampling Equipment:
Sediment build-up in Well Btm:

<p>Comments:</p>

* = Measurements are from the top of the inner case to the nearest 0.01'



TETRA TECH

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech, Inc.		
Prepared	Earth Sciences Department		
Approved	J. Zimmerly		

Subject
BOREHOLE AND SAMPLE LOGGING

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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

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5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).

This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inch Φ -1/2 inch Φ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4

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Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

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FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

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Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

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FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

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5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite (CaCO_3). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 **Rock Type**

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

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FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

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5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).
- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.
- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.
- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD

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(After Deere, 1964)

$$\text{RQD \%} = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.

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- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C - Coarse	Lt - Light	Yl - Yellow
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Med - Medium	BR - Broken	Or - Orange
F - Fine	BL - Blocky	SS - Sandstone
V - Very	M - Massive	Sh - Shale
Sl - Slight	Br - Brown	LS - Limestone
Occ - Occasional	Bl - Black	Fgr - Fine-grained
Tr - Trace		

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.
- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.
- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.
- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)



BORING LOG

PROJECT NAME: NSB - SITE BORING NUMBER: SB/MW 1
 PROJECT NUMBER: 9594 DATE: 3/8/96
 DRILLING COMPANY: SOILTEST CO. GEOLOGIST: SJ CONTI
 DRILLING RIG: CME-55 DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Fl.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Fl.) or Screened Interval	MATERIAL DESCRIPTION			U S C S *	Remarks	PID/FID Reading (ppm)			
					Soil Density/Consistency or Rock Hardness	Color	Material Classification			Sample	Sampler BZ	Borehole*	Driller BZ**
S-1 e 0800	0.0 2.0	7 6 9 10	1.5/2.0		M DENSE	BRN TO BLK	SILTY SAND - SOME Rock FR - TR BRICKS (FILL)	SM	MOIST SL. ORG. ODOR FILL TO 4'±	5	0	0	0
S-2 e 0810	4.0 6.0	5 7 9 8	2.9/2.0	4.0	M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE SB01-0406 FOR ANALYSIS	10	0	-	-
S-3 e 0820	8.0 10.0	6 8 17 16	1.9/2.0	7.0 ± 8.0	DENSE	TAN BRN	FINE TO COARSE SAND TR.F. GRAVEL	SW	WET HIT WATER: 7'±	0	0	0	0
S-4 e 0830	12.0 14.0	7 6 5 8	1.6/2.0	12.0	STIFF	GRAY	SILTY CLAY	CL	MOIST → WET AUGER REF @ 15'	0	.5	-	-
9/5 ①	15.0 16.0	4.0/5.0		11.0 16.0	M HARD	BRN	SILTSTONE	VER	WEATHERED LO & JNTS @ 15.5 WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
4.0/5.0 ②	19.0 20.0	5.0/5.0		19.0	HARD	GRAY	SANDSTONE - SOME SILTSTONE	BR	DRILL H2O @ 17'± SET TEMP 6" CAS TO 15.5				
	25.0			25.0					SET 2"Ø PVC SCREEN 16-25 SAND 14-25 PELLETS 12-14	0	0	0	0

* When rock coring, enter rock brokenness.
 ** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.
 Remarks: CME-55 RIG, 4 1/4" ID HSA - 9" OD ± • 1-20Z
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP 1-80Z
NX CORE IN BEDROCK RUN ① = 25 min, RUN ② = 15 min Drilling Area Background (ppm):
 Converted to Well: Yes No Well I.D. #: MW-1

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- Enter color of the material in the appropriate column.
- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:
 - Trace: 0 - 10 percent
 - Some: 11 - 30 percent
 - And/Or: 31 - 50 percent
- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.
- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.
- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:
 - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.
 - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.
 - Particle shape - flat, elongated, or flat and elongated.
 - Maximum particle size or dimension.
 - Water level observations.
 - Reaction with HCl - none, weak, or strong.
- Additional comments:
 - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.
 - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.
 - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.
 - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).
 - Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

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- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.
- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.
- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.
- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.
- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.
- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.
- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:
 - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70E angle from horizontal, high angle.
 - Indicate calcareous zones, description of any cavities or vugs.
 - Indicate any loss or gain of drill water.
 - Indicate drop of drill tools or change in color of drill water.
- Remarks at the bottom of Boring Log shall include:
 - Type and size of core obtained.
 - Depth casing was set.
 - Type of rig used.
- As a final check the boring log shall include the following:
 - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.
 - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole

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logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.



TETRA TECH

STANDARD OPERATING PROCEDURES

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Effective Date	01/2012	Revision	8
Applicability	Tetra Tech, Inc.		
Prepared	Earth Sciences Department		
Approved	J. Zimmerly		

Subject
 GROUNDWATER SAMPLE ACQUISITION AND
 ONSITE WATER QUALITY TESTING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 microSiemens per centimeter (mS/cm) at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Groundwater Sample – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 mV from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCl) in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCl) to 205 (3.5 Molar KCl) to 222 mV (1 Molar KCl) at 25°C and are greater at lower temperatures.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

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Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol ($^0/_{00}$) is not the same as the percent symbol (%).

Turbidity – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Project Hydrogeologist – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

Field Operations Leader (FOL) – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

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- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas and roadways and along highways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations – To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.

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- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel.** Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 General

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or

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extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample. To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

CAUTION

Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

1. If possible, position yourself (and the sampling equipment) upwind of the well head.
2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.
3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid (generally 300 mL per minute or greater), attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

CAUTION

For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:
 - Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.

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- While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.
- Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 **Sampling, Monitoring, and Evacuation Equipment**

Sample containers shall conform to the guidelines in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.
- Field tools and instrumentation
 - Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable)
 - pH Paper
 - Camera and film (if appropriate)
 - Appropriate keys (for locked wells)
 - Water level indicator and/or oil-water interface probe if separate-phase product is expected
- Pumps
 - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.
 - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment – Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).
- Pails – Plastic, graduated.
- Clean paper or cotton towels for cleaning equipment.
- Buckets with lids for collecting purge water.

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- Decontamination solutions – Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

6.3 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

1. Obtain all available information on well construction (location, casing, screen, etc.).
2. Determine well or inner casing diameter.
3. Measure and record static water level (depth below ground level or top of casing reference point).
4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.
5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where: V = Static volume of well in gallons.
T = Linear feet of water in the well.
r = Inside radius of well casing in inches.
0.163 = Conversion factor (compensates for conversion of casing radius from inches to feet and cubic feet to gallons and pi.

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

1. Saturate a paper towel or clean cotton towel with deionized water.
2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.
3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly

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remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Material Safety Data Sheet (MSDS) is obtained, kept on site at a readily available location with other MSDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the TtNUS Health and Safety Guidance Manual [HSGM], Hazard Communication Program and OSHA Standard 29 CFR 1910.1200).

6.4 Evacuation of Static Water – Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom. Bailers are comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

Advantages of bailers include the following:

- There are few limitations on size and materials used.
- No external power source is needed.
- Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.

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- Splashing the bailer into the water or transfer of sample may cause aeration.
- The use of a bailer does not permit constant in-line monitoring of groundwater parameters.
- Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.

Safety concerns using a bailer include the following:

- Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.
- Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.
- Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.

Control measures for these hazards are provided in Section 6.6.2.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it will operate from a portable battery source. Safety measures associated with these pumps are provided below.

Air-Lift and Gas-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

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Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time consuming.

Compressed Gases

Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 psi. If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through an appropriate pressure-reducing regulator.
- When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.
- If the cylinder is designed to accept a valve protection cap, always keep that protection cap in place, except the cylinder is connected for use.
- When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).
- DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential danger of an embolism.

See the project-specific HASP for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of a running car to access the battery as a power source. To control these hazards:

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- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.
- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the HSGM.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ORP
- Turbidity
- Salinity

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This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

6.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

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- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 Code of Federal Regulations (CFR) 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain MSDSs from the manufacturer for the specific buffer solutions (see Section 4 of the HSGM regarding the Hazard Communication Program)
- pH indicator paper to cover the pH range 2 through 12.
- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

1. Inspect the instrument and batteries prior to initiation of the field effort.
2. Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.
5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.
6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).
7. Rinse the electrode(s) with deionized water.
8. Store the electrode(s) in an accordance with manufacturer's instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

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pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

1. Collect a small portion of sample into a clean container.
2. Dip the pH paper into this small portion of sample.
3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.
4. Record the pH value from the chart on the sampling log sheet.
5. Discard the used pH paper as trash.
6. Discard the small volume of sample that was used for the pH measurement with the other investigative derived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form.

6.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also

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be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.
4. Immerse the electrode in the sample and measure the conductivity.
5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

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6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.
2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

1. Calibrate the instrument according to manufacturer's recommendations prior to use.
2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.
3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 Principles of Equipment Operation

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH⁻) occurs at the cathode surface. An electrical

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current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

1. Check the DO meter batteries before going to the field.
2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
5. Rinse the probe with deionized water.
6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.

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7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.
8. Rinse the probe with deionized water.
9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.
2. Thoroughly rinse the electrode with deionized water.

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3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater). Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).
- Calibration solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
2. Check batteries and calibrate the meter before going into the field.

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3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.
5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (e.g., LaMotte 2020) that calibrates easily using test cells with standards of 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution and sample tubes, as specified by the manufacturer.
- Manufacturer's operation manual.

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6.5.7.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization shall be done according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
2. Check batteries and calibrate the instrument before going into the field.
3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.
4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.
5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, and close the lid.
6. Immerse the electrode in the sample and measure the turbidity.
7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated.

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Refer to the project-specific HASP for appropriate information and direction on air monitoring requirements.

- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.
- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP, indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP author.
- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow. Where sampling teams are made up of personnel from multiple locations, personal sampling experiences may vary. Therefore the FOL shall review project-specific requirements, SOPs, and protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are being completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like to sun themselves on concrete well pads. Follow provisions in the project-specific HASP and/or HSGM for addressing natural hazards.
2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases from contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:
 - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.
 - DO NOT place your face or any other part of your body over the well when opening because this may place you in a strike zone.
 - Open the well cover at arms length, then step away and allow the well to off gas and stabilize.

Follow directions provided in the project-specific HASP, Work Plan and/or Sampling Plan pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the

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sampler during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP).

3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.
4. Calculate volume of well water to be removed as described in Section 6.3.
5. Select the appropriate purging equipment (see Attachment A to this SOP) or as designated within your Work Plan/Sampling Plan. If an electric submersible pump with packer is chosen, go to Step 10.
6. Lower the purging equipment or intake into the well to a short distance below the water level or mid-screen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.
7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.
8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.
9. Purge a minimum of three to five casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.
10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.
11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record

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this occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.
14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.
15. Process sample containers as described in SOP SA-6.1.
16. Decontaminate equipment as described in SOP SA-7.1.

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, polychlorinated biphenyls [PCBs], metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing – Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.
- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).

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- Interface probe.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators - ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic compounds (VOCs) per the HASP.

6.7.3 Purging and Sampling Procedure

1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP (typically with a PID or FID).
2. Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.
3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.
4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well
5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.

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6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease and the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.
 7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
 8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.
 9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.
 10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.
 11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:
 - pH ± 0.2 standard units
 - Specific conductance $\pm 10\%$
 - Temperature $\pm 10\%$
 - Turbidity less than 10 NTUs
 - DO $\pm 10\%$
 12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.
- NOTE:** VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.
13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:

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- Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.
- Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.
- Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.
- Prepare samples for shipping as per SOP SA-6.1.

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**ATTACHMENT A
PURGING EQUIPMENT SELECTION**

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

**ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 2**

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	\$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	\$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	\$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	\$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	\$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	\$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	\$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	\$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	\$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	\$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	\$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	\$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A
PURGING EQUIPMENT SELECTION
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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	\$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; (positive displacement) piston	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	\$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	\$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; (positive displacement) grab	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	\$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; (positive displacement) grab	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	\$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	\$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; (positive displacement) bladder	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	\$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
 PP Polypropylene
 PVC Polyvinyl chloride
 SS Stainless steel
 PC Polycarbonate
 EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA Not applicable
 AC Alternating current
 DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.



TETRA TECH

STANDARD OPERATING PROCEDURES

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Prepared	Earth Sciences Department		
Approved	J. Zimmerly		

Subject
SOIL SAMPLING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE

This document applies to the collection of surface, near-surface, and subsurface soil samples exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites for laboratory testing, onsite visual examination, and onsite testing.

3.0 GLOSSARY

Composite Sample - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall not be collected for volatile organics analysis.

Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. Tetra Tech considers all confined space as permit-required confined spaces.

Grab Sample - One sample collected at one location and at one specific time.

Hand Auger - A sampling device used to extract soil from the ground.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Sample for Non-Volatile Analyses - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches OD. The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).

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Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, selecting proposed sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring, and excavation activities and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation, and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and/or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

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5.0 HEALTH AND SAFETY

Health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard or uneven surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas, along roadways and highways.

Methods of avoiding these hazards are provided below.

Knee injuries – If kneeling is required during soil sampling, this could result in knee injuries from stones/foreign objects and general damage due to stress on the joints. To minimize this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.
- Stretch ligaments, tendons and muscles before, during and after. Take breaks as frequently as necessary.
- Report pre-existing conditions to the SSO if you feel this activity will aggravate an existing condition.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample locations. To minimize these hazards:

- Pre-survey sampling locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations - To prevent cuts and lacerations associated with soil sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.

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- Keep cutting surfaces clean and smooth.
- Secure items to be cut – do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken sample jars or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel.** Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket.**

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6.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at hazardous waste sites.

6.2 Soil Sample Collection

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol or sodium bisulfate may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is needed.

Soil samples to be preserved by the laboratory are currently being collected using Method SW-846, 5035. For samples preserved in the field, laboratories are currently performing low-level analyses (sodium bisulfate preservation) and high- to medium-level analyses (methanol preservation) depending on the needs of the end user.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

6.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample shall be

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obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore™ sampler when requested and purchased. Collect the sample in the following manner for each EnCore™ sampler:

1. Scene Safety - Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.
2. Wear the appropriate personal protective equipment (PPE). This will include, at a minimum, safety glasses and nitrile surgeon's gloves. If you must kneel on the ground or place equipment on the surface being sampled, cover the ground surface with plastic to minimize surface contamination of your equipment and clothing. Wear knee pads to protect your knees from kneeling on hard or uneven surfaces.
3. Load the Encore™ sampler into the T-handle with the plunger fully depressed.
4. Expose the area to be sampled using a hand trowel or similar device to remove surface debris.
5. Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.
6. When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.
7. Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.
8. With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.
9. Remove any surface soil from the outside of the sampler and place in the foil bag provided with the sampler. Good work hygiene practices and diligent decontamination procedures prevents the spread of contamination even on the outside of the containers.
10. Label the bag with appropriate information in accordance with SOP SA-6.3.
11. Place the full sampler inside a lined cooler with ice and cool to 4°C ± 2 °C. Make sure any required trip blanks and temperature blanks are also in the cooler. Secure custody of the cooler in accordance with SOP SA-6.3.
12. Typically, collect three Encore™ samplers at each location. Consult the SAP or laboratory to determine the required number of Encore™ samplers to be collected.
13. The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the project planning documents.

Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler.

After the Encore™ samples are collected, they should be placed on ice immediately and delivered to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

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6.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) and high- to medium-level (methanol preservation) methods.

Safety Reminder

When using chemicals in the field to preserve samples, the FOL and/or SSO must ensure that Materials Safety Data Sheets (MSDSs) have been provided with the chemicals to be used. They also must ensure that these chemicals have been added to the Chemical Inventory List contained within Section 5.0, Hazard Communication, of your Health and Safety Guidance Manual (HSGM). Lastly, but most importantly, the FOL and/or SSO must review the hazards with personnel using these chemicals and ensure that provisions are available for recommended PPE and emergency measures (e.g., eyewash, etc.).

Methanol Preservation (High to Medium Level):

Bottles may be pre-spiked with methanol in the laboratory or prepared in the field. Soil samples to be preserved in the field with methanol shall utilize 40 to 60 mL glass vials with septum-lined lids. Each sample bottle shall be filled with 25 mL of demonstrated analyte-free purge-and-trap grade methanol. The preferred method for adding methanol to the sample bottle is by removing the lid and using a pipette or scaled syringe to add the methanol directly to the bottle.

CAUTION

NEVER attempt to pipette by mouth

In situations where personnel are required to spike the septum using a hypodermic needle, the following provisions for handling sharps must be in place:

- Training of personnel regarding methods for handling of sharps
- Hard-sided containers for the disposal of sharps
- Provisions for treatment in cases where persons have received a puncture wound

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer's requirements.

The sample should be collected as follows:

1. Weigh the unused syringe and plunger to the nearest 0.01 gram.
2. Pull the plunger back and insert the syringe into the soil to be sampled.
3. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.
4. Weigh the sample and adjust until obtaining the required amount of sample.

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5. Record the sample weight to the nearest 0.01 gram in the field logbook and/or on the sample log sheet.
6. Extrude the weighed soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.
7. If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.
8. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.
9. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

CAUTION

Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as Encore™ or 2-ounce jar.

Bottles may be prepared in the laboratory or in the field with sodium bisulfate solution. Samples to be preserved in the field using the sodium bisulfate method are to be prepared and collected as follows:

1. Add 1 gram of sodium bisulfate to 5 mL of laboratory-grade deionized water in a 40 to 60 mL glass vial with septum-lined lid.
2. Collect the soil sample and record the sample weight to the nearest 0.01 gram in the field logbook or on the sample log sheet as described for methanol preservation
3. Add the weighed sample to the sample vial.
4. Collect duplicate samples using the methanol preservation method on a one-for-one sample basis because it is necessary for the laboratory to perform both low-level and medium-level analyses.
5. Place the samples on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

NOTE

If lower detection limits are necessary, an option to field preserving with sodium bisulfate may be to collect EnCore™ samplers at a given sample location. Consult the planning documents to determine whether this is required. If it is, collect samples in accordance with the Encore™ sampling procedure above and then send all samplers to the laboratory to perform the required preservation and analyses.

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

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1. With a stainless steel trowel or other approved tool, transfer a portion of soil to be sampled to a stainless steel bowl or disposable inert plastic tray.
2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.
3. Thoroughly mix the soil in the bowl or tray to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases, it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.
4. Transfer the mixed soil to the appropriate sample containers and close the containers.
5. Label the sample containers in accordance with SOP SA-6.3.
6. Place the containers in a cooler of ice as soon after collection as possible.
7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

NOTE

Cooling may not be required for some samples depending on the scheduled analyses. Consult the planning documents if in doubt regarding correct sample preservation conditions. When in doubt – Cool to 4° C.

NOTE

Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

6.2.3 Procedure for Collecting Undisturbed Soil Samples

NOTE

Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly used.

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:

1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:
 - Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.

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REMEMBER

If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.

- Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the HASP.
 - Review the Safe Work Permit prior to conducting the activity.
 - Review the activity to be conducted.
2. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

CAUTION

The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.

3. Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.
4. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.
5. A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.
6. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.
7. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.
8. Remove disturbed material in the upper end of the tube and measure the length of sample again.
9. After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.

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10. Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.
11. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.
12. Mark the "up" direction on the side and upper end of the tube with indelible ink.
13. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).
14. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

CAUTION

To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.

CAUTION

A primary concern in the preparation of the wax plugs is the potential for the heat source and melted wax to cause a fire and/or burns. Follow the directions below to prevent injury or fire.

Electrical Heating

Using hot plates to melt the wax is acceptable. In an outdoor setting, make sure a Ground Fault Circuit Interrupter (GFCI) is employed within the electrical circuit. If a portable generator is used, ensure that the generator is an adequate distance from the sampling operation (at least 50 feet). Ensure that the extension cord is rated for the intended load and for outdoor use and is free from recognizable damage. Ensure flammable preservatives are not employed or stored near the hot plate. Although a Hot Work Permit is not required, scene safety evaluation by site personnel of the above elements is. As always, if a fire potential exists, the provisions for extinguishing must be immediately accessible as well as any provisions for first aid measures.

Open Flame

If an open flame is used, the following provisions are necessary:

- Complete a Hot Work Permit and any local permit required for elevated temperature applications. The Hot Work Permit, provided in your HASP, will aid the FOL and/or the SSO in ensuring that fire protection provisions (extinguishers, fire watches, etc.) are in place as well as ensuring that local requirements have been addressed.
- Ensure that water is available to address any wax splashes or contact. If possible, immerse the contacted area. Where this is not possible, run water over the area and apply cold compresses. The need for medical attention or first aid shall be determined on site under the direction of the SSO.

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6.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.

NOTE

Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.

For the purposes of instruction, the terms "surface soil" and "near-surface soil" are used in this SOP as follows:

- Surface soil - 0 to 6 inches bgs
- Near-surface soil - 6 to 18 inches bgs

If these intervals are defined differently in the planning documents, substitute the appropriate depth ranges.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Stainless steel hand auger, soil corer, or shovel.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in project planning document.
- Required PPE.
 - Nitrile surgeon's or latex gloves may be used, layered as necessary.
 - Safety glasses
 - Other – Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP)
- Required decontamination equipment
- Required sample container(s)
- Wooden stakes or pin flags

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- Sealable polyethylene bags (e.g., Ziploc® baggies)
- Heavy duty cooler
- Ice
- Chain-of-custody records and custody seals

When acquiring surface soil samples, use the following procedure:

1. Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross- contamination.
2. Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.
3. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the planning document.
4. Using decontaminated sampling tools, thoroughly mix in place a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.
5. Transfer the sample into those containers utilizing a stainless steel trowel.
6. Cap and securely tighten all sample containers.
7. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.
9. Site restoration – Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas when pedestrian traffic may exist.

6.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.

To obtain near-surface soil samples, the following protocol shall be used:

1. With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.
2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

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3. Follow steps 1 through 9 of Section 6.3.

6.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-inch lengths), and a T-handle connected to extension rods and to the auger bucket. A larger-diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes)
- Stainless steel mixing bowls
- The equipment listed in Section 6.3
- Miscellaneous hand tools as required to assemble and disassemble the hand auger units

CAUTION

Potential hazards associated with hand augering include:

- Muscle strain and sprain due to over twisting and/or over compromising yourself.
- Equipment failure due to excessive stress on the T-handle or rods through twisting. Failure of any of these components will result in a sudden release and potential injury due to that failure.

As in all situations, any intrusive activities that could damage underground utilities shall be preceded by a Dig/Excavation permit/ticket. Call the Utility Locating service in the area or your Project Health and Safety Officer for more information. When in doubt – **Get the Ticket!**

To obtain soil samples using a hand auger, use the following procedure:

1. Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.
2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).
3. Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.
4. As the auger bucket fills with soil, periodically remove any unneeded soil.

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5. Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.
6. After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.
7. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.
8. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.
9. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.
10. Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.
11. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.
12. Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl.
13. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.
14. Follow steps 4 through 7 listed in Section 6.3.

6.5.1 Sampling Using Stainless Steel Soil Corers

A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.

Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.

SAFETY REMINDER

Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:

- Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).

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- Job rotation – Share the duties so that repetitive actions do not result in fatigue and injury.
- Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.
- Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.
- Do not over compromise yourself when applying force to the soil corer or hand auger. If there is a sudden release, it could result in a fall or muscle injury due to strain.

6.6 Subsurface Soil Sampling with a Split-Barrel Sampler

A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.

Safety Reminder

It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Equipment listed in Section 6.3.

The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):

1. Attach the split-barrel sampler to the sampling rods.

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2. Lower the sampler into the borehole inside the hollow stem auger bits.
3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.
4. When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.
5. Detach the sampler from the drill rods.
6. Place the sampler securely in a vise so it can be opened using pipe wrenches.

CAUTION

Pipe wrenches are used to separate the split spoon into several components. The driller's helper should not apply excessive force through the use of cheater pipes or push or pull in the direction where, if the wrench slips, hands or fingers will be trapped against an immovable object.

7. Remove the drive head and nosepiece with the wrenches, and open the sampler to reveal the soil sample.
8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.
9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings were encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).
10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl.
11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).
12. Follow steps 4 through 7 in Section 6.3.

6.7 Subsurface Soil Sampling Using Direct-Push Technology

Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

6.8 Excavation and Sampling of Test Pits and Trenches

6.8.1 Applicability

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

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CAUTION

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise from the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden, steel, or aluminum support structures or through sloping and benching. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments; therefore, monitoring will be conducted by the Competent Person to determine if it is safe to enter. Any entry into a trench greater than 4 feet deep will constitute a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. In all cases involving entry, substantial air monitoring, before entry, appropriate respiratory gear and protective clothing determination, and rescue provisions are mandatory. There must be at least three people present at the immediate site before entry by one of the field team members. This minimum number of people will increase based on the potential hazards or complexity of the work to be performed. The reader shall refer to OSHA regulations 29 CFR 1926.650, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146. High-hazard entries such as this will be supported by members of the Health Sciences Group professionally trained in these activities.

Excavations are generally not practical where a depth of more than about 15 to 20-feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15-feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

6.8.2 Test Pit and Trench Excavation

Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).

Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration
- The space required for efficient excavation
- The chemicals of concern
- The economics and efficiency of available equipment

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Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.

Equipment	Typical Widths, in Feet
Trenching machine	0.25 to 1.0
Backhoe/Track Hoe	2 to 6

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, the following field conditions may necessitate revisions to the initial plans:

- Subsurface utilities
- Surface and subsurface encumbrances
- Vehicle and pedestrian traffic patterns
- Purpose for excavation (e.g., the excavation of potential ordnance items)

The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.

No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example, samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.

Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially

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contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

Where possible excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:

- Trench covers/street plates
- Fences encompassing the entire excavation intended to control access
- Warning signs warning personnel of the hazards
- Amber flashing lights to demarcate boundaries of the excavation at night

Excavations left open will have emergency means to exit should someone accidentally enter.

6.8.3 Sampling in Test Pits and Trenches

6.8.3.1 General

Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the project-specific HASP.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

6.8.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.
- Sample container - bucket with locking lid for large samples; appropriate bottle ware for chemical or geotechnical analysis samples.

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- Polyethylene bags for enclosing sample containers; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps, and right angle adapter for conduit (see Attachment D).

6.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.

- Excavate the trench or pit in several 0.5- to 1.0-foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.
- After each increment:
 - the operator shall wait while the sampler inspects the test pit from grade level
 - the sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet or where lithological changes are noted.
- The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:
 - Any fluid phase, including groundwater seepage, is encountered in the test pit
 - Any drums, other potential waste containers, obstructions, or utility lines are encountered
 - Distinct changes of material being excavated are encountered

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.
- Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)
- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:
 - a. The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.
 - b. The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.

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- c. After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.
 - d. When signaled by the operator that it is safe to do, the sampler will approach the bucket.
 - e. The soil shall be monitored with a photoionization or flame ionization detector (PID or FID) as directed in the project -specific planning documents.
 - f. The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.
- If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

CAUTION

Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.

- Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:
 - a. Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bucket.
 - b. Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.
 - c. Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.
- Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.

6.8.3.4 In-Pit Sampling

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

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In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There are no practical alternative means of obtaining such data.
- The SSO and Competent Person determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.
- A company-designated Competent Person determines that the pit/trench is stable through soil classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.

If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.

A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self rescue or assisted self rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon.

6.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.
- Suitable driving (e.g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe,

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rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.

A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to remove the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SOPs SA-6.3 and SA-6.1.

6.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.

If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

6.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in

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the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs if required
- Groundwater levels
- PID/FID/LEL/O₂ meter readings
- Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists
- Soil type classification

7.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

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NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

OSHA, Confined Space Entry 29 CFR 1910.146.

USEPA, November 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.

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**ATTACHMENT A
SOIL & SEDIMENT SAMPLE LOG SHEET**



SOIL & SEDIMENT SAMPLE LOG SHEET

Page ___ of ___

Project Site Name: _____	Sample ID No.: _____
Project No.: _____	Sample Location: _____
<input type="checkbox"/> Surface Soil	Sampled By: _____
<input type="checkbox"/> Subsurface Soil	C.O.C. No.: _____
<input type="checkbox"/> Sediment	Type of Sample:
<input type="checkbox"/> Other: _____	<input type="checkbox"/> Low Concentration
<input type="checkbox"/> QA Sample Type: _____	<input type="checkbox"/> High Concentration

GRAB SAMPLE DATA:			
Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

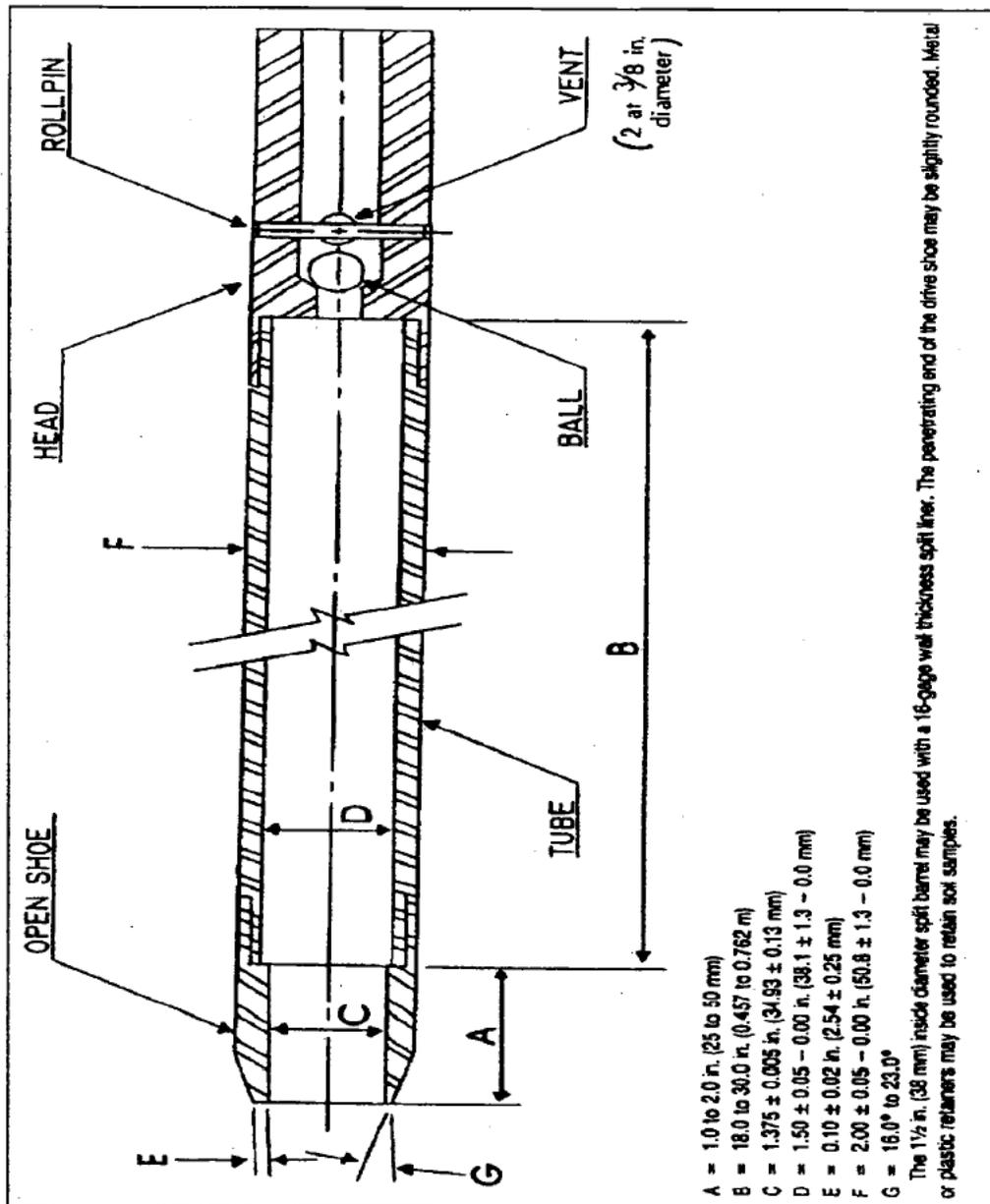
COMPOSITE SAMPLE DATA:				
Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:			
Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:	MAP:

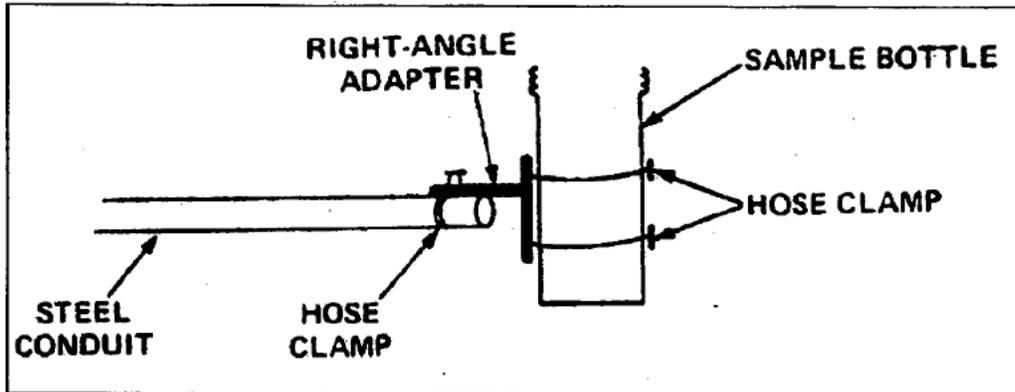
Circle if Applicable:	Signature(s):
MS/MSD Duplicate ID No.:	

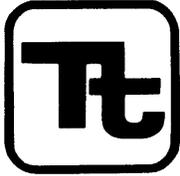
ATTACHMENT B SPLIT-SPOON SAMPLER



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**ATTACHMENT D
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING**





TETRA TECH

STANDARD OPERATING PROCEDURES

Number	SA-2.5	Page	1 of 6
Effective Date	01/2012	Revision	4
Applicability	Tetra Tech, Inc.		
Prepared	Earth Sciences Department		
Approved	J. Zimmerly		

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe7 - Geoprobe7 is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe7 relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe7 equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch[®] - HydroPunch[®] is a manufacturer of stainless steel and Teflon[®] sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch[®] is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

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Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.
- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.
- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.
- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.
- Place the acetate liner containing the soils in the trough.

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- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.
- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.
- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).
- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

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6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.
- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.
- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (∇ 10 percent), the well may be sampled.
- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.
- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).
- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

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**ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS**

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

- I. Work limited to the following (description, area, equipment used): **Monitoring well drilling and installation through direct push technology**
- II. Required Monitoring Instruments: _____
- III. Field Crew: _____
- IV. On-site Inspection conducted Yes No Initials of Inspector Tetra Tech

SECTION II: General Safety Requirements (To be filled in by permit issuer)

- V. Protective equipment required
 - Level D Level B
 - Level C Level A
 - Detailed on Reverse
- Respiratory equipment required
 - Full face APR
 - Half face APR
 - SKA-PAC SAR
 - Skid Rig
- Escape Pack
- SCBA
- Bottle Trailer
- None

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern	Action Level(s)	Response Measures
_____	_____	_____

VII. Additional Safety Equipment/Procedures

- | | | |
|---|---|--|
| Hard-hat..... | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Safety Glasses | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Chemical/splash goggles..... | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Splash Shield..... | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Barricades <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Splash suits/coveralls | <input type="checkbox"/> Yes <input type="checkbox"/> No | Gloves (Type - _____) <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Steel toe Work shoes or boots <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | | Work/warming regimen <input type="checkbox"/> Yes <input type="checkbox"/> No |

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors	Yes	NA	Yes	NA
Safety shower/eyewash (Location & Use)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Emergency alarms	<input type="checkbox"/>
Daily tail gate meetings.....	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Evacuation routes	<input type="checkbox"/>
Contractor tools/equipment/PPE inspected	<input type="checkbox"/>	<input type="checkbox"/>	Assembly points.....	<input type="checkbox"/>

IX. Site Preparation

- Utility Clearances obtained for areas of subsurface investigation Yes No
- Physical hazards removed or blockaded Yes No
- Site control boundaries demarcated/signage Yes No

X. Equipment Preparation

- | | Yes | NA |
|---|--------------------------|-------------------------------------|
| Equipment drained/depressurized | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Equipment purged/cleaned..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Isolation checklist completed..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Electrical lockout required/field switch tested | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Blinds/misalignments/blocks & bleeds in place..... | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| Hazardous materials on walls/behind liners considered | <input type="checkbox"/> | <input checked="" type="checkbox"/> |

XI. Additional Permits required (Hot work, confined space entry)..... Yes No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

Permit Issued by: _____ Permit Accepted by: _____



STANDARD OPERATING PROCEDURES

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Effective Date 01/2012	Revision 7
Applicability Tetra Tech, Inc.	
Prepared Earth Sciences Department	
Subject DECONTAMINATION OF FIELD EQUIPMENT	Approved J. Zimmerly

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1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment, chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

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4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

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- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities

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- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:
 - Well removed from pedestrian/vehicle thoroughfares.
 - Avoidance of areas where control/custody cannot be maintained.
 - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.
 - Avoidance of potentially contaminated areas.
 - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

The selected decontamination site should include the following, where possible:

- Areas where potable water and electricity are provided.

Safety Reminder

When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:

- All power is routed through a Ground Fault Circuit Interrupter (GFCI).
- All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.

In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

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- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.
- Areas that offer sufficient size to carry out the specific decontamination sequence.
- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:
 - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.
 - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.
 - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.
 - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.
 - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:
 - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

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- Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.
- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.
2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.
3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.
4. Remove the pump and tubing/bailer from the container
5. Rinse external pump components using tap water.

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6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents –
Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.
8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.
9. Drain residual deionized water to the extent possible.
10. Allow components of the equipment to air dry.
11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.
12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

SAFETY REMINDER

Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

NOTE

In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

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7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.
- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:
 1. Wash with soap and water
 2. Rinse with tap water
 3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 **Downhole Drilling Equipment**

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

CAUTION

Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

CAUTION

In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

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4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol
5. To the extent possible, allow components to air dry.
6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.
7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 °F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0° tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40° fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.
2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.
3. Always wear PPE as specified in the HASP such as:
 - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.
4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.
5. Do not modify equipment unless the manufacturer has approved the modifications.

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7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.
2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.
3. Rinse the equipment with tap water.

CAUTION

Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.
5. Rinse the equipment with deionized water.
6. To the extent possible, allow components to air dry.
7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.
8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device
- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.
- Extract the dredge and wash it in soap and water per the project-specific planning documents.

CAUTION

When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

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7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

NOTE

Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.
2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).
4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:
 - Enclose areas accessible by the general public using construction fencing and signs.
 - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
 - Maintain the retaining bolt and label on the outside of storage containers where readily visible.
 - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.
 - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.
 - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

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- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

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CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 Decontamination Evaluation

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.
- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:
 - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.
 - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.
 - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:
 - Per decontamination method
 - Per disposable article/batch number of disposable articles

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NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.



STANDARD OPERATING PROCEDURES

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Prepared	Earth Sciences Department		

Subject
DECONTAMINATION OF FIELD EQUIPMENT

Approved
J. Zimmerly

Attachment A iDW Label

INVESTIGATION DERIVED WASTE

GENERATOR INFORMATION:

SITE _____ JOB NO. _____

LOCATION _____

DATE _____

DRUM# _____

CONTENTS _____

VOLUME _____

CONTACT _____

EMERGENCY PHONE NUMBER _____



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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06/99

Revision

1

Applicability

Tetra Tech NUS, Inc.

Prepared

Health Sciences Department

Subject

PHOTOVAC 2020 PHOTOIONIZATION AIR MONITOR

Approved

D. Senovich

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1.0 PURPOSE

To establish procedures for the use, maintenance, and calibration of the Photovac 2020 Photoionization Air Monitor.

2.0 SCOPE

Applies to each usage of the Photovac 2020 Photoionization Air Monitor by TtNUS personnel.

3.0 GLOSSARY

Electron volt (eV) - A unit of energy equal to the energy acquired by an electron when it passes through a potential difference of 1 volt in a vacuum. It is equal to $1.602192 \pm 0.000007 \times 10^{-19}$ volts.

Intrinsically Safe (I.S.) - Based on wiring, configuration, design, operation, gasketing, construction, this instrument may be employed within locations in which flammable gases and/or vapors may exist.

Ionization Potential (I.P.) - The energy required to remove an electron from a molecule yielding a positively charged ion and a negatively charged free electron. The instrument measures this energy level.

Photoionization Detector (PID) - Photoionization detector employed as general reference to air monitors of this type. PIDs detection method employs ultraviolet (UV) radiation as an energy source. As air and contaminant are drawn through the ionization chamber the UV light source causes the contaminant with ionization potentials equal to or less than the UV source to break into positive and negatively charge ions. The created ions are subjected to an electrostatic field. The voltage difference is measured in proportion to the calibration reference and the concentration of the contaminant.

Ultraviolet Radiation (UV) - Ultraviolet radiation is the energy source employed by the instrument to ionize collected sample gas streams. The UV lamp source is required to be equal to or greater than the ionization potential of the substance drawn through the instrument in order to create separate ionized species.

4.0 RESPONSIBILITIES

Office Managers – Office Managers are responsible for ensuring that personnel under their direction who may use this device are first provided with adequate training and information.

Project Managers – Project Managers are responsible for ensuring that appropriate health and safety requirements and resources are addressed for their assigned projects.

Health and Safety Manager (HSM) - The HSM shall ensure that appropriate training is available to users of the Photovac 2020 instrument.

Equipment Manager - The Equipment Manager shall ensure all air monitoring instrumentation slated for field activities has been operationally checked out, fully charged, and calibrated prior to issuing any instrument for field service. Maintenance deficiencies identified by the Equipment Manager will require those instruments to be pulled from service until repairs can be facilitated.

Field Operations Leader (FOL)/Field Team Leader (FTL) - The FOL/FTL shall ensure all field team members employing the monitoring instruments as part of their assigned duties are adequately trained in

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the operation and limitations of this instrument. The FOL/FTL shall ensure that the air monitoring instruments are employed as directed by site guidance documents (i.e., Work Plan, Health and Safety Plan, etc.). Additionally, the FOL/FTL shall ensure that the appropriate documentation and recordkeeping requirements are fulfilled including Documentation of Calibration and Direct Reading Instrument Response Data Sheets for air monitoring activities. On projects where a dedicated SSO is not assigned, the FOL/FTL is responsible for assuming the duties of that position.

Health and Safety Officer (HSO) - The HSO is responsible for determining air monitoring requirements for the site activities, and providing direction for air monitoring during specific site activities. This identification of types of air monitoring and direction for use are indicated within the Site-Specific Health and Safety Plan (HASP).

Site Safety Officer (SSO) - The SSO shall ensure the instruments identified are employed in the manner directed by the HSO, and that any action levels specified are observed for the application of engineering controls, personal protective equipment (PPE) use, and administrative controls. Additionally, he/she shall ensure the instruments are properly maintained and calibrated prior to use in the field. The SSO, during specific air monitoring applications including STEL and TWA mode measurements, will be responsible for the operation and application of this specialty air monitoring device. The SSO is also responsible for addressing relevant Hazard Communication requirements (e.g., MSDS, chemical inventories, labeling, training, etc.) on each assigned project.

5.0 PROCEDURES

5.1 Principle of Operation

Direct-reading instruments such as a photoionization detector are typically used to monitor for airborne releases that could present an inhalation threat to personnel, and to screen and bias environmental samples. Proper use of these instruments by trained, qualified personnel is essential to the validity of any acquired results. Also essential is that the devices are properly calibrated according to manufacturers instructions (and the specifications of this SOP), and that users of the instrument properly document results.

The Photovac portable photoionizer detects many organic (and a few inorganic) vapors. The basis for detection of this instrument is the ionization of components of captured gaseous streams. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many gaseous compounds. Molecules are transformed into charged-ion pairs, creating a current between two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively-charged ion and the free electron. The instrument measures this energy level.

This instrument measures the concentration of airborne photoionizable gases and vapors and automatically displays and records these concentrations. It does not distinguish between individual substances. Readings displayed represent the total concentration of all photoionizable chemicals present in the sample. This instrument is factory set to display concentration in units of ppm or mg/m³.

The 2020 instrument is easy to operate. The meter display updates itself once per second. Concentrations are directly displayed on the readout.

The 2020 instrument also performs short-term exposure limit (STEL), time-weighted average (TWA) and PEAK calculations. Any of these results can be viewed, but only one mode may be viewed at a time.

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2020 has 6 keys for alphanumeric entry and for accessing multiple functions. The keys are used to set up and calibrate the 2020 instrument. They allow for the manipulation of the data in various ways.

All information entered with the keys and stored in the instrument's memory. This is retained when the instrument is switched off. The clock and calendar continue to operate and do not need to be set each time the instrument is turned on.

5.1.1 Displays

The 2020 instrument has a meter display for reporting detected concentration, and a display used to indicate status information and guide the user through configuration options. All functions of the instrument will be controlled or reported using one of these displays.

5.1.1.1 Meter Display

The meter has a 4-digit display. It will always be used for reporting detected concentrations. When the detector and pump are off, the meter display will be blank.

In order to accommodate the entire range of concentrations the 2020 can detect, the instrument has 2 resolution settings. The 0.1 resolution setting should be used for concentrations below 100 ppm, and the 1 resolution setting should be used for concentrations above 100 ppm.

5.1.1.2 Status Display

The status display is a 2 line by 16 character display. The top line is used to display status information and prompts the user for information. The bottom line is used for soft key names. Up to 3 names can be displayed for the 3 soft keys. If a name does not appear for a soft key, then the soft key has no associated function.

5.1.2 Keys

5.1.2.1 Fixed Keys

The three round keys below the soft keys each have a fixed function. The first key is the ON/OFF key, the middle key is the EXIT key, and the last key is the ENTER key.

The ON/OFF key is used both to turn power on to the 2020 as well as to turn the power off. To turn on 2020, press the ON/OFF key. To turn the power off, press the ON/OFF key and hold it down for 2 seconds, and then release it. This is done to prevent an accidental power off.

The EXIT key provides a way of returning to the default display. In the functional map, the soft keys allow the user to advance and the EXIT key provides a way to go back. At the initial entry of the menu, EXIT will return the user to the default display.

The ENTER key has a context sensitive function. When operating or navigating through the function map, the ENTER key is used to exit the functions and return to the default display. When entering data such as a name, number, date, or time, ENTER is used to confirm the entry.

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5.1.2.2 Soft Keys

The three soft keys on the 2020 are located directly below the status display. Each key has varying functions for configuring the 2020, editing the data logger, and controlling the display. Since only three soft keys are available, each function is broken down into a path.

5.1.2.3 Entering Text With the Soft Keys

For all information that must be entered, the left, center, and right soft keys correspond to the up, down, and right arrow.

The up and down arrows are used to change the character highlighted by the cursor. The right arrow is used to advance the cursor to the next character to the right. When the cursor is advanced past the right most character, it wraps around to the first character again. To accept the changes, press the ENTER key. To ignore the change, press the EXIT key.

Formatting characters, such as the colon (:) in the time, the decimal (.) in a concentration, and the slash (/) in the date are skipped when advancing the cursor.

All inputs 8 characters long, which is displayed on the right side of the status display line. The prompt, describing the input, occupies the left side of the top line. The soft keys are defined on the bottom line of the status display.

5.2 Default Display

The meter display shows the detected concentration. The resolution of the display automatically changes with the magnitude of the reading. A reading of 0 to 99.9 will be displayed with a resolution of 0.1 ppm or mg/m³. A reading greater than 99.9 will be shown with a resolution of 1 ppm or mg/m³. The meter will display concentrations up to 2000 ppm or 2(XX) mg/m³.

The status display is used to indicate the instrument status, date, time, units, and active soft keys.

The default display provides the following information: instrument status, current detected concentration, time, date, and measurement units. The status display toggles between showing time and units and then the date.

When the display mode is MAX, the date and time correspond to the date and time the MAX concentration was recorded. In TWA mode, the time represents the number of hours and minutes during which the TWA has been accumulating. For PEAK and STEL monitoring, the date and time correspond to the current date and time.

5.3 Monitoring

5.3.1 Use and Documentation of Results

As with any direct-reading instrument, understanding not only how – but when to use this instrument is essential to gathering relevant and valid data. This device will only respond to volatile substances in sampled air that have ionization potentials below the UV lamp strength. Inappropriate instrument selection, or use/interpretation of instrument results by an unqualified user not only can yield inaccurate

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results, but could place personnel at risk of exposure to hazardous agents. Only personnel who are properly trained and authorized to use this device will be permitted to operate it.

It is essential that instrument operators understand and comply with the requirements to document results. This includes the need to document calibration results as well as operational readings. Calibration results must be recorded using Figure 5-1. Operational results can be recorded in several ways, including:

- Direct-Reading Instrument Response Data (Figure 5-2) – preferred method
- Boring Log Forms (Figure 5-3)
- Test Pit Log Forms (Figure 5-4)
- Log book entries

When using direct-reading instruments, it is important to monitor the air near the source of potential releases (e.g., drilling boreholes, tank entrances, drum openings, etc.) and at worker breathing zone areas. All readings should be recorded, including readings noted where background levels were not exceeded.

5.3.2 Instrument Status

The instrument status is shown on the left side of the first line of the status display and on the Table and Graph outputs. Each status has an assigned priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off.

5.3.3 Alarms

While operating the instrument, any one of three audible alarm conditions can occur. To accurately identify the source of the alarm, each type of alarm has been given a unique status.

The 2020 also has an audible alarm and a visual alarm LED. To conserve power, the 2020 alternates between these two alarm indicators, rather than operating both concurrently. Different alarms are identified by the frequency at which the 2020 alternates as follows: PEAK alarm-5 times per second; STEL alarm-2.5 times per second; and TWA alarm-1.25 times per second.

The left soft key is used for acknowledging alarm conditions, and is named "Ack." If no alarm conditions exist, then the "Ack" key is not shown. To clear an alarm, press the "Ack" key. Once acknowledged, the alarm indicators are cleared. The alarm status will remain until the alarm condition clears.

The 2020 updates the peak concentration once every second. Following every update, the peak concentration is compared to the peak alarm level, and if exceeded, an alarm is triggered.

If the 15 minute average exceeds the selected STEL, a STEL alarm is generated.

The TWA alarm is generated when the current average of concentration, since the TWA was last cleared, has exceeded the TWA exposure limit.

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During calibration, all alarms are disabled. Once the calibration is complete the alarms are re-enabled.

5.4 STEL, TWA, MAX, and PEAK Operation

The 2020's display can be configured to show one of four values: STEL, TWA, PEAK, and MAX.

5.4.1 Short-term Exposure Limit (STEL) Mode

The Short-term Exposure Limit (STEL) mode displays the concentration as a 15 minute moving average. The 2020 maintains 15 samples, each representing a one-minute averaging interval.

Once every minute, the oldest of the 15 samples is replaced with a new one minute average. This moving average provides a 15-minute average of the last 15 minutes with a one-minute update rate. Since the average is calculated using 15 one-minute averages, the meter display will only update once every minute.

STEL is set to zero each time the instrument is turned on. Since STEL is a 15-minute moving average, there is no need to clear or reset the STEL.

STEL calculations are always being performed by the 2020. The results of the calculations can be displayed by selecting STEL as the Display mode.

5.4.2 Time-weighted Average (TWA) Mode

The TWA accumulator sums concentrations every second until 8 hours of data have been combined. If this value exceeds the TWA alarm setting, a TWA alarm is generated. The TWA is not calculated using a moving average. Once 8 hours of data have been summed, the accumulation stops. In order to reset the TWA accumulator, press the "Clr" key.

This sum will only be complete after 8 hours, so the meter displays the current sum divided by 8 hours. While in the TWA mode, the time on the status display will show the number of minutes and hours of data that TWA data has been accumulated. When the sample time reaches 8 hours, the 2020 stops accumulating data and the TWA is complete.

TWA calculations are always being performed by the 2020. The results of the calculations can be displayed by selecting TWA as the Display mode. When the sampling period is less than 8 hours, record the TWA readout along with the sampling duration displayed on the meter.

5.4.3 MAX Mode

The MAX mode displays the maximum signal, with the date and time that it was recorded. 2020 continues to log data according to the selected averaging interval, but only the maximum detected concentration is shown on the meter display.

The right soft key is used to clear the meter when displaying MAX. The "Clr" key only affects the reading that the meter is displaying. For example, if you display the MAX reading, and you press "Clr," only the MAX value is cleared. The TWA is still accumulating in the background.

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5.4.4 PEAK Mode

The PEAK mode displays the current detected concentration. The reading is updated every second. In the background, the 2020 data logger is sampling the concentration and measuring minimum, maximum, and average concentrations for the selected averaging interval. At the end of every interval, one entry is placed in the data logger until the data logger is full. Typically, the instrument is operated in the PEAK mode. Operation within the other specialized modes are the responsibility of the SSO.

5.5 Set Functions

Pre-set functions are used to setup the 2020. There are three functions which can be used: Calibration, Pump and Clock.

5.5.1 Pump

The Pump function is used to control the pump. After selecting Set Pump, the 2020 responds by displaying the new pump status.

The detector is also turned off when turning the pump off. This prevents the detector from being damaged when there is no sample flowing through the detector.

When the pump and the detector are off, the meter display will be blank. Turn the pump and detector off when concentration measurements are not necessary, and the 2020 will only be used for reviewing data or generating reports. Operating the instrument with the pump and detector turned off will conserve the lives of the battery and ultraviolet (UV) lamp.

1. Press the ENTER key. The top line of the status display changes to "Select?". The bottom line displays 3 soft key names: "Set," "Log," and "Disp."
2. Press the soft key below "Set."
3. The names of the soft keys change to reflect the Set options. The display now shows 3 devices which can be set: "Clock," "Pump," and "Cal." Press the "Pump" key.
4. If the pump is off, pressing the "Pump" key will turn the pump on.
5. A message will be displayed showing the status of the pump. The display reverts back to the previous menu after a few seconds.
6. To return to the default display, press the ENTER key.

5.5.2 Clock

The Clock function is used to set both the current date and time.

1. Press the ENTER key.
2. Press the "Set" key.
3. When the names of the soft keys change, press the "Clock" key.

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The up and down arrows are used to change the character underlined by the cursor. The right arrow is used to advance the cursor to the next character to the right. When the cursor is advanced past the right-most character, it wraps around to the first character again.

Formatting characters, such as the colon (:) in the time and the slash (/) in the date are skipped when advancing the cursor.

4. Use the "arrow keys" to enter the correct time. The time is formatted as Hour:Minute:Second.
5. Press the ENTER key to confirm the time and move to the date option.
6. When setting the date, the 2020 prompts the user to input the current date formatted as Year/Month/Day. Use the "arrow keys" to enter the correct date.
7. Press the ENTER key to confirm the date and return to the Set options.

5.5.3 Calibration (Cal)

The Cal function allows the user to setup and calibrate the 2020. Three options are available under the Cal function: "Zero," "Span," and "Mem."

A calibration memory consists of a name, a response factor, and PEAK, TWA, and STEL alarm levels.

The "Zero" and "Span" keys are covered in detail in the manufacturer's operations manual for the instrument.

To edit the calibration memory, select "Mem" and then "Chng." The 2020 prompts the user with two new soft keys: "User" and "Lib."

5.5.4 Library (Lib)

Library selections simplify Cal Memory programming, and provide standard response factors for approximately 70 applications. "Lib" allows you to select an entry from a pre-programmed library. The name, response factor, and three alarm levels are all set from the library. To select a library entry to program the selected Cal Memory:

1. Select "Set," "Cal," "Mem," "Chng," and "Lib."
2. Use the "Next" and "Prev" keys to scroll through the list. See the manufacturer's manual for a list of the library entries.

5.6 Preparing for Field Operation of the Photovac 2020

Turning 2020 On

1. Turn the 2020 on by pressing the ON/OFF key.
2. The instrument will display the software version number. Wait for the 2020 to proceed to the default display.

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3. Allow 10 minutes for the instrument to warm up and stabilize.
4. Press the "Enter" Key. The default display will provide 3 soft key selections: "Set," "Log," and "Display."
5. Press "Set." From this option 3 other soft key selections will be offered: "Pump," "Clock," and "Cal."
6. Press "Cal." This will begin the calibration sequence. The first selection is to Zero the instrument.
7. Press "Enter," zeroing will begin. (Note: When employing zero gas attach and activate zero gas supply at this time.)
8. The next selection is for Span determination. Press "Enter" and the concentration will be requested. The isobutylene calibration gas employed under general service will be marked on the side of the container. Use the soft keys to toggle into position and to log the concentration. Once the concentration is logged press "Enter." The direction or status display will indicate spanning. At this time hook up the span gas with a regulator to the Photovac 2020, and open it to supply enough flow to elevate the flow rate indicator to the green indicator line (1/8" from the rest position).
9. Once spanning is complete, the alarms which have been disabled during calibration will activate indicating that calibration is complete.
10. Document this calibration procedure using a Documentation of Calibration form as illustrated in Figure 5-1.

This instrument is ready for use.

Calibration is to be performed daily or prior to each use in accordance with Sections 5.6 and 5.7 of this SOP, and with manufacturer's recommendations.

5.7 Maintenance and Calibration Schedule

Function	Frequency
Routine Calibration	Prior to each use. Complete Figure 5-4 for each calibration.
Factory Inspection and Calibration	Once a year, or when malfunctioning
Wipe Down the Outer Casing of the Unit	After each use
Clean UV Light Source	Every 24 hours of operation
Sample Inlet Filter	Change on a weekly basis or as required by level of use
Battery charging	After each use
Clean ionization chamber	Monthly

5.7.1 Cleaning the UV Light Source Window

1. Turn the FUNCTION switch to the OFF position. Use the instrument's multi-tool and remove lamp housing cover.

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2. Tilt the lamp housing with one hand over the opening, slide the lamp out of the housing.
3. The lamp window may now be cleaned with any of the following compounds using lens paper:
 - a. 11.7 eV Lamp - Dry Aluminum Oxide Powder (3.0 micron powder)
 - b. All other lamps - HPLC Grade Methanol

Observe manufacturer's MSDS requirements when handling these substances.

4. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace o-ring as necessary, reinstall lamp housing cover, tighten using the multi-tool. (Do not over tighten).
5. Recalibrate as per Section 5.6.

5.7.2 Cleaning the Ionization Chamber

1. Turn the FUNCTION switch to the OFF position and remove the lamp housing cover and lamp as per Section 5.7.1.
2. Using a gentle jet of compressed air, gently blow out any dust or debris.
3. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Replace o-ring as necessary, reinstall lamp housing cover, tighten using the multi-tool. (Do not over tighten).
4. Recalibrate as per Sections 5.6 and 5.7.

5.8 Instrument Advantages

The Photovac 2020 is easy to use in comparison to many other types of monitoring instrumentation. Its detection limit is in the low parts-per-million range. Response time quickly reaches 90 percent scale of the indicated concentration (less than 3 seconds for benzene). This instrument's automated performance covers multiple monitoring functions simultaneously, and incorporates data logging capabilities.

5.9 Limitations of the Photovac 2020 Photoionization Monitor

- Since the 2020 is a nonspecific total gas/vapor detector, it cannot be used to identify unknown chemicals; it can only quantitate them in relationship to a calibration standard (relative response ratio).
- For appropriate application of the 2020, ionization potentials of suspected contaminants must be known.
- Because the types of compounds that the 2020 can potentially detect are only a fraction of the chemicals possibly present at a hazardous waste site, a background or zero reading on this instrument does not necessarily signify the absence of air contaminants.
- The 2020 instrument can monitor only certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected.

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- PID's are generally not compound-specific. Their response to different compounds is relative to the calibration gas used. This is generally referred to as the relative response ratio. Instrument readings may be higher or lower than the true concentration. This can be especially serious when monitoring for total contaminant concentrations if several different compounds are being detected at once.
- The 2020 is a small, portable instrument which cannot be expected to yield results as accurately as laboratory instruments.

5.9.1 Variables Affecting Monitoring Data

Monitoring hazardous waste site environments can pose a significant challenge in assessing airborne concentrations and the potential threats to site personnel. Several variables may influence both dispersion and the instrument's ability to detect actual concentrations. Some of the variables which may impact these conditions are as follows:

- Temperature Pressure - changes in temperature and/or pressure will influence volatilization, and effect airborne concentrations. Additionally, an increase or decrease in temperature ranges may have an adverse effect on the instrument's ability to detect airborne concentrations. Significant changes in temperature or pressure from the time of calibration to the time of sample measurement may result in erroneous results.
- Humidity - excessive levels of humidity may interfere with the accuracy of monitoring results.
- Rainfall - through increased barometric pressure and water may influence dispersion pathways effecting airborne emissions.
- Electromagnetic interference - high voltage sources, generators, other electrical equipment may interfere with the operation and accuracy of direct-reading monitoring instruments.

6.0 TROUBLESHOOTING

6.1 Fault Messages

When the "Fault" status is displayed, the 2020's operation is comprised.

Fault 1: Signal from zero gas is too high.

Cause: If another fault occurred while the 2020 was setting its zero point, then this fault is displayed.

Action: Ensure no faults are occurring and calibrate the 2020 again.

Cause: Contamination of sample line, sample probe or fittings before the detector.

Action: Clean or replace the sample line, sample probe or the inlet filter.

Cause: Span gas and zero air are mixed up.

Action: Ensure clean air is used to zero the 2020. If you are using Tedlar bags, mark the calibration and zero gas Tedlar bags clearly.

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Cause: Ambient air is contaminated.

Action: If the quality of ambient air is unknown, use a supply of commercial zero grade air.

Fault 2: Signal from span gas is too small.

Cause: Operator may have incorrectly used the span gas for the zero air source.

Action: Ensure clean air is used to zero the 2020. If you are using Tedlar bags, mark the calibration and zero gas Tedlar bags clearly.

Action: Ensure the span gas is of a reliable concentration.

Cause: UV lamp window is dirty.

Note: Do not remove the detector lamp in a hazardous location.

Action: Clean the UV lamp window.

Cause: UV lamp is failing.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Incompatible application.

Action: The concentration and sample gas are incompatible for use with the 2020.

Fault 3: UV lamp fault. UV lamp has not started.

Cause: UV lamp has not started immediately.

Action: This fault may be seen momentarily when the 2020 is first turned on. Allow 30 to 60 seconds for the UV lamp to start and the fault to clear.

Cause: UV lamp serial number label is blocking the photocell.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: The UV lamp has a white serial number label, it is possible that the label is blocking the photocell. Rotate the lamp approximately 90 degree and then try to start the 2020 again. If the fault persists, replace the lamp.

Cause: UV lamp not installed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a UV lamp.

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Cause: UV lamp has failed.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: Install a new UV lamp.

Cause: Electronic problem.

Action: If a new UV lamp still generates this fault, then contact the Photovac Service Department.

Fault 4: Pump current too low or too high.

Cause: If the pump sounds labored, then the pump is operating beyond normal operating parameters.

Action: Check for an obstruction in the sample line. Make sure sample line, sample probe or inlet filter are not plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace the inlet filter.

Action: Ensure the sample outlet, located on the underside of the 2020, is not obstructed.

Cause: UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If the UV lamp has a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the Equipment Manager.

Cause: The pump has failed.

Action: Contact the Equipment Manager.

6.2 Specific Problems

Problem: Very low or no instrument response detected, yet compounds are suspected to be present.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in the User's Manual.

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After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not, contact the Equipment Manager.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Disconnect the battery charger before calibrating the 2020.

Cause: Calibration Memories have not been programmed correctly.

Action: Program all the calibration memories required for the intended application. You must use the correct calibration gas and concentration for each Cal Memory.

Cause: Response factor has been set to zero.

Action: Enter the correct response factor. Refer to the list of response factors. If the compound is not listed or you are measuring gas mixtures, then enter a value of 1.0. See User's Manual.

Cause: Not using the correct Cal Memory.

Action: Select the correct Cal Memory for the intended application.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: Detector is leaking. A decrease in sensitivity may be due to a leak in the detector.

Note: Do not remove or replace the detection lamp in a hazardous location.

Action: Ensure the UV lamp has been installed correctly.

Action: Ensure the lamp cover has been tightened. Do not overtighten the cover.

Action: Ensure the o-ring seal on the lamp cover is positioned correctly.

Cause: UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If the UV lamp has a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the Equipment Manager.

Cause: UV lamp is too wide, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If the UV lamp has a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the Equipment Manager.

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Cause: Sampling environment is extremely humid.

Action: Water vapor is not ionized by the PID, but it does scatter and absorb the light and results in a lower reading.

The 2020 detector has been designed to operate under high humidity conditions. Under extreme humidity conditions, there may be a decreased response.

Cause: UV lamp is failing.

Action: Replace UV lamp.

Note: Do not remove or replace the detector lamp in a hazardous location.

Cause: High concentration of non-ionizable compounds suspected.

Action: Chemical compounds, such as methane, with IPs greater than the 10.6 eV scatter and absorb the UV light. Sensitivity may be decreased significantly.

Application with high backgrounds of such materials, may be incompatible with the 2020. Contact the Photovac Applications Group for more information.

Problem: Erroneously high readings.

Cause: Sampling environment is extremely humid.

Action: Water vapor may contain mineral salts which conduct a charge. The water vapor becomes an electrolytic solution which becomes ionized when it enters the detector.

Atmospheric water in areas around the sea or stagnant water may produce a response in the absence of contaminants. The same effect may be seen when conducting ground water investigations in areas where the water contains a significant concentration of minerals.

Cause: The 2020 has not been calibrated properly.

Action: Ensure the calibration gas is of a reliable concentration and then calibrate the instrument as outlined in Sections 5.6 and 5.7.

After the instrument has been calibrated, sample the bag of calibration gas. A reading equivalent to the calibration gas should be displayed. If not contact the Equipment Manager.

Cause: Cal Memories have not been programmed correctly.

Action: Program all the Cal Memories required for the intended application. The correct calibration gas and concentration must be used for each Cal Memory. See the User's Manual.

Cause: Not using the correct Cal Memory.

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Action: Select the correct Cal Memory for the intended application. See the User's Manual.

Note: It does not matter which Cal Memory is selected or which response factor is entered. The 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.

Cause: Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the Equipment Manager.

Problem: Date and time settings are not retained.

Cause: The battery pack was removed before the 2020 was turned off.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack and reset the time and date. Ensure that the 2020 has been turned off before removing the battery pack.

Cause: The 2020 has not been used for 3 months or more and the internal battery (not the external battery pack) has discharged.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Connect the 2020 to the AC adapter and turn the instrument on. Turn the pump off. While the 2020 is running the internal battery is charging. Leave the instrument running for approximately 24 hours.

Problem: Instrument status shows "Over."

Cause: High concentrations of gases and vapors will cause a rapid change in signal level. The detector and associated electronics may become temporarily saturated.

Action: Wait a few seconds for the status to return to normal. PIDs are designed to detect relatively low concentrations of gases and vapors. Exposure to very high concentrations may result in a very high or maximum response.

Cause: The detector has become saturated.

Action: Move the 2020 to a location where it can sample clean air. Sample clean air until the reading stabilizes around 0.

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Cause: Detector has been short circuited by foreign matter in the detector cell.

Note: Do not service the 2020 in a hazardous location.

Action: Do not touch the wire grid inside the detector cell. Use a gentle jet of compressed air to remove any dust or dirt in the detector cell.

Warning: Do not insert any object, other than the UV lamp, into the lampholder.

Cause: There is an undetermined problem.

Action: Contact the Equipment Manager.

Problem: Display is blank.

Cause: Battery pack is critically low.

Note: Do not remove or recharge the battery pack in a hazardous location.

Action: Replace the battery pack or connect the 2020 to the AC adapter.

Cause: The battery pack is not connected to the instrument correctly.

Action: Ensure the battery pack connector is securely attached to the connector on the 2020.

Cause: There is an undetermined problem.

Action: Reset the 2020. Leave the instrument on while disconnecting the battery pack. This will reset the instrument. Reconnect the battery pack and close the battery hatch. Turn on the 2020, set the time and date and program all the calibration memories.

Action: Contact the Equipment Manager.

Problem: Sample flow rate is less than 300 ml/min.

Cause: Inlet filter is plugged.

Note: Do not replace the inlet filter in a hazardous location.

Action: Replace inlet filter.

Cause: Inlet filter has not been installed properly.

Action: Ensure that the inlet filter has been installed correctly.

Cause: UV lamp is too long, causing flow to be restricted.

Note: Do not remove or replace the detector lamp in a hazardous location.

Action: If the UV lamp has a white serial number label, it is possible that the lamp is too long for the lampholder. Replace the lamp and contact the Equipment Manager.

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Cause: UV lamp is too wide, causing flow to be restricted.

Action: If the UV lamp has a white serial number label, it is possible that the lamp is too wide for the lampholder. Contact the Equipment Manager.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter and liquid has been aspirated.

Action: Contact the Equipment Manager.

Cause: Sample outlet is obstructed.

Action: Ensure the sample outlet is not obstructed in any way.

Cause: Pump has been damaged.

Action: Contact the Equipment Manager.

Problem: Liquid has been aspirated.

Cause: The 2020 has been exposed to a solvent that can pass through the inlet filter.

Action: Contact the Equipment Manager.

Problem: Corrosive gases and vapors have been sampled.

Cause: The 2020 has been exposed to corrosive gases and vapors.

Action: Corrosive gases and vapors can affect the electrodes within the detector as well as the lamp window. Prolonged exposure to corrosive materials may result in permanent fogging or etching of the window. If the 2020 is exposed to corrosive material, contact the Equipment Manager.

7.0 SHIPPING

- The Photovac may be shipped as cargo or carried on as luggage provided that there is no calibration gas cylinder accompanying the kit. When shipping or transporting the calibration gas, a Hazardous Materials (Dangerous Good) Airbill, including the information as stipulated in Figure 5-5 will be prepared. **Only personnel who have been properly trained are permitted to offer a hazardous material for shipment.** The "Shipping Hazardous Materials" course offered by Tetra Tech NUS is considered acceptable training for this purpose. Specific instructions on packaging, labeling, and otherwise preparing a hazardous material shipment are presented in the Student Manual that accompanies the course.

8.0 REFERENCES

Photovac 2020 Photoionization Monitor User's Manual, 1995.

Student Manual from "Shipping Hazardous Materials" course, Tetra Tech NUS, 1999.

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FIGURE 5-5

FedEx *Dangerous Goods* **Sender's Copy**
6/300 7181180 *Airbill* RETAIN THIS COPY FOR YOUR RECORDS

The World On Time

1 From (please print and press hard)
Date _____ Sender's FedEx Account Number _____
Sender's Name _____ Phone (____) _____
Company _____
Address _____ Dept./Floor/Suite/Room _____
City _____ State _____ ZIP _____

2 Your Internal Billing Reference Information
(Optional) (First 24 characters will appear on invoice)

3 To (please print and press hard)
Recipient's Name **Tom Patton** Phone (412) 262-4583
Company **Tetra Tech NUS**
Address **Spring Run Road Extension, Suite 140** Check here if residence (Extra charge applies for FedEx Express Saver)
(To "HOLD" at FedEx location, print FedEx address here) (We Cannot Deliver to P.O. Boxes or P.O. ZIP Codes) Dept./Floor/Suite/Room _____
City **Coraopolis** State **PA** ZIP **15108**

4a Express Package Service Packages under 150 lbs.
 FedEx Priority Overnight (Next business morning) FedEx Standard Overnight (Next business afternoon)
 FedEx 2Day (Second business day) FedEx Express Saver (Third business day)

4b Express Freight Service Packages over 150 lbs.
 FedEx Overnight Freight (Next business day) FedEx 2Day Freight (Second business day) FedEx Express Saver Freight (Up to 3 business days)

Delivery commitments may be later in some areas.

5 Packaging
 Other Packaging
Dangerous Goods cannot be shipped in FedEx packaging.

6 Special Handling
 Dangerous Goods as per attached Shipper's Declaration Cargo Aircraft Only

7 Payment
Bill to: Sender (Account No. in Section 1 will be billed) Recipient (Enter FedEx Account No. or Credit Card No. below) Third Party Credit Card Cash/Check
FedEx Account No. _____
Credit Card No. _____ Exp. Date _____
Total Packages _____ Total Weight _____ Total Declared Value* \$ _____ Total Charges \$ _____

*When declaring a value higher than \$100 per shipment, you pay an additional charge. See SERVICE CONDITIONS, DECLARED VALUE, AND LIMIT OF LIABILITY section for further information.

Signature Release Unavailable PART #154251 • Rev. Date 4/98 ©1994-99 FedEx • PRINTED IN U.S.A.

FedEx Tracking Number **807286974806** Form I.D. No. **0204**

Page 1 of 1 Pages **Two completed and signed copies of this Declaration must be handed to the operator.**

TRANSPORT DETAILS
This shipment is within the limitations prescribed for: (delete non-applicable)
 PASSENGER AND CARGO AIRCRAFT
Airport of Departure: _____
Airport of Destination: _____

Shipment type: (delete non-applicable)
 NON-RADIOACTIVE RADIOACTIVE XX

NATURE AND QUANTITY OF DANGEROUS GOODS
Dangerous Goods Identification

Proper Shipping Name	Class or Division	UN or I.D. No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization
Compressed Gas N.O.S. (mixture Nitrogen and Oxygen)	2.2	UN 1956			1 Plastic box x 0.56 Kg	200	

Additional Handling Information _____

Prepared for AIR TRANSPORT according to: (Customer MUST check one)
 49 CFR ICAO / IATA

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labelled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.
Emergency Telephone Number (Required for US Origin or Destination Shipments) **1-800-535-5053 InfoTRAC**

Name/Title of Signatory _____
Place and Date _____
Signature (see warning above) _____

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

APPENDIX C
FIELD DOCUMENTATION FORMS



SOIL & SEDIMENT SAMPLE LOG SHEET

Project Site Name: _____ Project No.: _____ <input type="checkbox"/> Surface Soil <input type="checkbox"/> Subsurface Soil <input type="checkbox"/> Sediment <input type="checkbox"/> Other: _____ <input type="checkbox"/> QA Sample Type: _____	Sample ID No.: _____ Sample Location: _____ Sampled By: _____ C.O.C. No.: _____ Type of Sample: <input type="checkbox"/> Low Concentration <input type="checkbox"/> High Concentration
---	--

GRAB SAMPLE DATA:

Date:	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.: _____
--------	-------------------------

Signature(s): _____



Tetra Tech

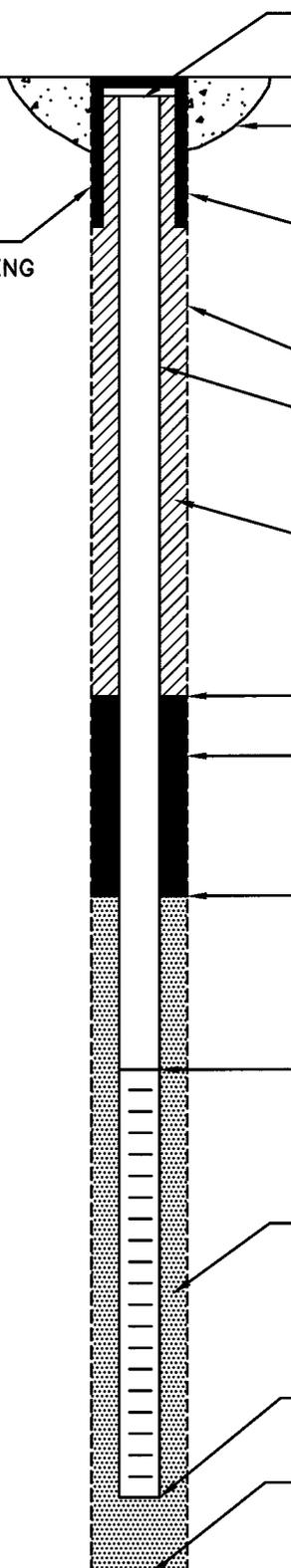
OVERBURDEN MONITORING WELL SHEET FLUSH - MOUNT

WELL NO.: _____

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
DATE BEGUN _____	DATE COMPLETED _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		
GROUND ELEVATION _____	DATUM _____	

ACAD: FORM_MWFM.dwg 07/20/99 INL

FLUSH MOUNT
SURFACE CASING
WITH LOCK



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

ELEVATION/DEPTH TOP OF SEAL: _____ / _____

TYPE OF SEAL: _____

ELEVATION/DEPTH TOP OF SAND: _____ / _____

ELEVATION/DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF SAND: _____ / _____

ELEVATION/DEPTH BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____



PROJECT NO:		FACILITY:		PROJECT MANAGER		PHONE NUMBER		LABORATORY NAME AND CONTACT:													
SAMPLERS (SIGNATURE)				FIELD OPERATIONS LEADER		PHONE NUMBER		ADDRESS													
				CARRIER/WAYBILL NUMBER				CITY, STATE													
STANDARD TAT <input type="checkbox"/> RUSH TAT <input type="checkbox"/> <input type="checkbox"/> 24 hr. <input type="checkbox"/> 48 hr. <input type="checkbox"/> 72 hr. <input type="checkbox"/> 7 day <input type="checkbox"/> 14 day				TOP DEPTH (FT)		BOTTOM DEPTH (FT)		MATRIX (GW, SO, SW, SD, QC, ETC.)		COLLECTION METHOD GRAB (G) COMP (C)		No. OF CONTAINERS		CONTAINER TYPE PLASTIC (P) or GLASS (G)		PRESERVATIVE USED					
DATE YEAR		TIME												LOCATION ID				SAMPLE ID		TYPE OF ANALYSIS	
1. RELINQUISHED BY				DATE		TIME		1. RECEIVED BY				DATE		TIME							
2. RELINQUISHED BY				DATE		TIME		2. RECEIVED BY				DATE		TIME							
3. RELINQUISHED BY				DATE		TIME		3. RECEIVED BY				DATE		TIME							
COMMENTS																					

APPENDIX D

LABORATORY DoD ELAP ACCREDITATION

**Scope of Accreditation
For
Spectrum Analytical, Inc.
featuring Hanibal Technology, Rhode Island Division**

646 Camp Ave.
North Kingstown, RI 02852
Sharyn Lawler
401-732-3400

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.2) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Spectrum Analytical, Inc., featuring Hanibal Technology, Rhode Island Division to perform the following tests:

Accreditation granted through: **April 1, 2016**

Testing – Environmental

Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260C	1,1,1-Trichloroethane
GC/MS	EPA 8260C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 8260C	1,1,2-Trichloroethane
GC/MS	EPA 8260C	1,1-Dichloroethane
GC/MS	EPA 8260C	1,1-Dichloroethene
GC/MS	EPA 8260C	1,1-Dichloropropene
GC/MS	EPA 8260C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260C	1,2,3-Trichloropropane
GC/MS	EPA 8260C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260C	1,2-Dibromo-3-chloropropane
GC/MS	EPA 8260C	1,2-Dibromoethane
GC/MS	EPA 8260C	1,2-Dichlorobenzene
GC/MS	EPA 8260C	1,2-Dichloroethane
GC/MS	EPA 8260C	1,2-Dichloropropane



Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260C	1,3-Dichlorobenzene
GC/MS	EPA 8260C	1,3-Dichloropropane
GC/MS	EPA 8260C	1,4-Dichlorobenzene
GC/MS	EPA 8260C	1-Chlorohexane
GC/MS	EPA 8260C	2,2-Dichloropropane
GC/MS	EPA 8260C	2-Butanone
GC/MS	EPA 8260C	2-Chlorotoluene
GC/MS	EPA 8260C	2-Hexanone
GC/MS	EPA 8260C	4-Chlorotoluene
GC/MS	EPA 8260C	4-Isopropyltoluene
GC/MS	EPA 8260C	4-Methyl-2-pentanone
GC/MS	EPA 8260C	Acetone
GC/MS	EPA 8260C	Acetonitrile
GC/MS	EPA 8260C	Acrolein
GC/MS	EPA 8260C	Acrylonitrile
GC/MS	EPA 8260C	Allyl Chloride
GC/MS	EPA 8260C	Benzene
GC/MS	EPA 8260C	Bromobenzene
GC/MS	EPA 8260C	Bromochloromethane
GC/MS	EPA 8260C	Bromodichloromethane
GC/MS	EPA 8260C	Bromoform
GC/MS	EPA 8260C	Bromomethane
GC/MS	EPA 8260C	Carbon disulfide
GC/MS	EPA 8260C	Carbon tetrachloride
GC/MS	EPA 8260C	Chlorobenzene
GC/MS	EPA 8260C	Chloroethane
GC/MS	EPA 8260C	Chloroform
GC/MS	EPA 8260C	Chloromethane
GC/MS	EPA 8260C	cis-1,2-Dichloroethene
GC/MS	EPA 8260C	cis-1,3-Dichloropropene
GC/MS	EPA 8260C	Cyclohexane
GC/MS	EPA 8260C	Dibromochloromethane
GC/MS	EPA 8260C	Dibromomethane
GC/MS	EPA 8260C	Dichlorodifluoromethane



Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260C	Diethyl Ether
GC/MS	EPA 8260C	Diisopropyl ether
GC/MS	EPA 8260C	Ethanol
GC/MS	EPA 8260C	Ethylbenzene
GC/MS	EPA 8260C	Ethyl methacrylate
GC/MS	EPA 8260C	Ethyl tert-butyl ether
GC/MS	EPA 8260C	Hexachlorobutadiene
GC/MS	EPA 8260C	Hexachloroethane
GC/MS	EPA 8260C	Iodomethane
GC/MS	EPA 8260C	Isobutyl alcohol
GC/MS	EPA 8260C	Isopropylbenzene
GC/MS	EPA 8260C	m,p-Xylene
GC/MS	EPA 8260C	Methacrylonitrile
GC/MS	EPA 8260C	Methyl acetate
GC/MS	EPA 8260C	Methylcyclohexane
GC/MS	EPA 8260C	Methyl methacrylate
GC/MS	EPA 8260C	Methyl tert-butyl ether
GC/MS	EPA 8260C	Methylene chloride
GC/MS	EPA 8260C	n-Butylbenzene
GC/MS	EPA 8260C	n-Propylbenzene
GC/MS	EPA 8260C	Naphthalene
GC/MS	EPA 8260C	o-Xylene
GC/MS	EPA 8260C	Propionitrile
GC/MS	EPA 8260C	sec-Butylbenzene
GC/MS	EPA 8260C	Styrene
GC/MS	EPA 8260C	tert-Amyl Methyl ether
GC/MS	EPA 8260C	tert-Butyl alcohol
GC/MS	EPA 8260C	tert-Butylbenzene
GC/MS	EPA 8260C	Tetrachloroethene
GC/MS	EPA 8260C	Tetrahydrofuran
GC/MS	EPA 8260C	Toluene
GC/MS	EPA 8260C	trans-1,2-Dichloroethene
GC/MS	EPA 8260C	trans-1,3-Dichloropropene
GC/MS	EPA 8260C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260C	Trichloroethene



Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8260C	Trichlorofluoromethane
GC/MS	EPA 8260C	Vinyl acetate
GC/MS	EPA 8260C	Vinyl chloride
GC/MS	EPA 8260C	Xylene (Total)
GC/MS	EPA 8270D	1,1'-Biphenyl
GC/MS	EPA 8270D	Acetophenone
GC/MS	EPA 8270D	Benzaldehyde
GC/MS	EPA 8270D	Caprolactam
GC/MS	EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270D	1,2-Dichlorobenzene
GC/MS	EPA 8270D	1,3-Dichlorobenzene
GC/MS	EPA 8270D	1,4-Dichlorobenzene
GC/MS	EPA 8270D	1,4-Dioxane
GC/MS	EPA 8270D	1-Methylnaphthalene
GC/MS	EPA 8270D	2,2'-oxybis(1-Chloropropane)
GC/MS	EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 8270D	2,4-Dinitrotoluene
GC/MS	EPA 8270D	2,6-Dinitrotoluene
GC/MS	EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 8270D	2-Chlorophenol
GC/MS	EPA 8270D	2-Methylnaphthalene
GC/MS	EPA 8270D	2-Methylphenol
GC/MS	EPA 8270D	2-Nitroaniline
GC/MS	EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	3,3'-Dichlorobenzidine
GC/MS	EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270D	4-Bromophenyl-phenylether
GC/MS	EPA 8270D	4-Chloro-3-methylphenol



Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270D	4-Chloroaniline
GC/MS	EPA 8270D	4-Chlorophenyl-phenylether
GC/MS	EPA 8270D	4-Methylphenol
GC/MS	EPA 8270D	4-Nitroaniline
GC/MS	EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	Acenaphthene
GC/MS	EPA 8270D	Acenaphthylene
GC/MS	EPA 8270D	Aniline
GC/MS	EPA 8270D	Anthracene
GC/MS	EPA 8270D	Atrazine
GC/MS	EPA 8270D	Azobenzene
GC/MS	EPA 8270D	Benzidine
GC/MS	EPA 8270D	Benzyl Alcohol
GC/MS	EPA 8270D	Benzo(a)anthracene
GC/MS	EPA 8270D	Benzo(a)pyrene
GC/MS	EPA 8270D	Benzo(b)fluoranthene
GC/MS	EPA 8270D	Benzo(g,h,i)perylene
GC/MS	EPA 8270D	Benzo(k)fluoranthene
GC/MS	EPA 8270D	Bis(2-chloroethoxy)methane
GC/MS	EPA 8270D	Bis(2-chloroethyl)ether
GC/MS	EPA 8270D	Bis(2-ethylhexyl)phthalate
GC/MS	EPA 8270D	Butylbenzylphthalate
GC/MS	EPA 8270D	Carbazole
GC/MS	EPA 8270D	Chrysene
GC/MS	EPA 8270D	Di-n-butylphthalate
GC/MS	EPA 8270D	Dibenzofuran
GC/MS	EPA 8270D	Diethylphthalate
GC/MS	EPA 8270D	Dimethylphthalate
GC/MS	EPA 8270D	Di-n-octylphthalate
GC/MS	EPA 8270D	Dibenzo(a,h)anthracene
GC/MS	EPA 8270D	Fluoranthene
GC/MS	EPA 8270D	Fluorene
GC/MS	EPA 8270D	Hexachlorobenzene
GC/MS	EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 8270D	Hexachlorocyclopentadiene



Non-Potable Water		
Technology	Method	Analyte
GC/MS	EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D	Isophorone
GC/MS	EPA 8270D	N-Nitroso-di-n-propylamine
GC/MS	EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Pentachlorophenol
GC/MS	EPA 8270D	N-Nitrosodimethylamine
GC/MS	EPA 8270D	N-Nitrosodiphenylamine
GC/MS	EPA 8270D	Naphthalene
GC/MS	EPA 8270D	Phenanthrene
GC/MS	EPA 8270D	Phenol
GC/MS	EPA 8270D	Pyrene
GC/MS	EPA 8270D	Pyridine
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-chloropropane (DBCP)
GC/ECD	EPA 8081B	4,4'-DDD
GC/ECD	EPA 8081B	4,4'-DDE
GC/ECD	EPA 8081B	4,4'-DDT
GC/ECD	EPA 8081B	Aldrin
GC/ECD	EPA 8081B	alpha-BHC
GC/ECD	EPA 8081B	alpha-Chlordane
GC/ECD	EPA 8081B	beta-BHC
GC/ECD	EPA 8081B	delta-BHC
GC/ECD	EPA 8081B	Dieldrin
GC/ECD	EPA 8081B	Endosulfan I
GC/ECD	EPA 8081B	Endosulfan II
GC/ECD	EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 8081B	Endrin
GC/ECD	EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin ketone
GC/ECD	EPA 8081B	gamma-BHC (Lindane)
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 8081B	Heptachlor
GC/ECD	EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Methoxychlor



Non-Potable Water		
Technology	Method	Analyte
GC/ECD	EPA 8081B	Toxaphene
GC/ECD	EPA 8081B	Chlordane (technical)
GC/ECD	EPA 8082A	2,2',4,5,5'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3,3',4,4'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3,4,4',5-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4',5'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4',5'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	3,3',4,4',5-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',4,4'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',4,4',5,5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,3,3',4,4',5-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,3,3',4,4',5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4',5-Pentachlorobiphenyl
GC/ECD	EPA 8082A	3,3',4,4',5,5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',4,4',5-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',5-Trichlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',5,5'-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',5',6-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',5,6'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4',5,5',6-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',6'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,6-Octachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl
GC/ECD	EPA 8082A	Decachlorobiphenyl
GC/ECD	EPA 8082A	2,4,4'-Trichlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,5'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,2',4,5'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,2',5,5'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	3,3',4,4'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,4'-Dichlorobiphenyl
GC/ECD	EPA 8082A	3,4,4',5-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,5'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	Aroclor-1016

Non-Potable Water		
Technology	Method	Analyte
GC/ECD	EPA 8082A	Aroclor-1221
GC/ECD	EPA 8082A	Aroclor-1232
GC/ECD	EPA 8082A	Aroclor-1242
GC/ECD	EPA 8082A	Aroclor-1248
GC/ECD	EPA 8082A	Aroclor-1254
GC/ECD	EPA 8082A	Aroclor-1260
GC/ECD	EPA 8082A	Aroclor-1262
GC/ECD	EPA 8082A	Aroclor-1268
GC/MS/SIM	EPA 680Mod	Decachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Dichlorobiphenyl
GC/MS/SIM	EPA 680Mod	Heptachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Hexachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Monochlorobiphenyl
GC/MS/SIM	EPA 680Mod	Nonachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Octachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Pentachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Tetrachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Trichlorobiphenyl
GC/MS/SIM	EPA 680Mod	Total PCBs
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4,5-TP (Silvex)
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichlorprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/FID	EPA 8015D	Diesel Range Organics
GC/FID	EPA 8015D	Gasoline Range Organics
ICP/AES	EPA 6010C	Aluminum
ICP/AES	EPA 6010C	Antimony
ICP/AES	EPA 6010C	Arsenic
ICP/AES	EPA 6010C	Barium



Non-Potable Water		
Technology	Method	Analyte
ICP/AES	EPA 6010C	Beryllium
ICP/AES	EPA 6010C	Boron
ICP/AES	EPA 6010C	Cadmium
ICP/AES	EPA 6010C	Calcium
ICP/AES	EPA 6010C	Chromium
ICP/AES	EPA 6010C	Cobalt
ICP/AES	EPA 6010C	Copper
ICP/AES	EPA 6010C	Iron
ICP/AES	EPA 6010C	Lead
ICP/AES	EPA 6010C	Magnesium
ICP/AES	EPA 6010C	Manganese
ICP/AES	EPA 6010C	Molybdenum
ICP/AES	EPA 6010C	Nickel
ICP/AES	EPA 6010C	Potassium
ICP/AES	EPA 6010C	Selenium
ICP/AES	EPA 6010C	Silver
ICP/AES	EPA 6010C	Sodium
ICP/AES	EPA 6010C	Thallium
ICP/AES	EPA 6010C	Tin
ICP/AES	EPA 6010C	Vanadium
ICP/AES	EPA 6010C	Zinc
ICP/AES	SM 2340 B-1997	Hardness, Ca/Mg (As CaCO ₃) BY CALCULATION
ICP/MS	EPA 6020A	Aluminum
ICP/MS	EPA 6020A	Antimony
ICP/MS	EPA 6020A	Arsenic
ICP/MS	EPA 6020A	Barium
ICP/MS	EPA 6020A	Beryllium
ICP/MS	EPA 6020A	Cadmium
ICP/MS	EPA 6020A	Calcium
ICP/MS	EPA 6020A	Chromium
ICP/MS	EPA 6020A	Cobalt
ICP/MS	EPA 6020A	Copper
ICP/MS	EPA 6020A	Iron
ICP/MS	EPA 6020A	Lead
ICP/MS	EPA 6020A	Magnesium



Non-Potable Water		
Technology	Method	Analyte
ICP/MS	EPA 6020A	Manganese
ICP/MS	EPA 6020A	Nickel
ICP/MS	EPA 6020A	Potassium
ICP/MS	EPA 6020A	Selenium
ICP/MS	EPA 6020A	Silver
ICP/MS	EPA 6020A	Sodium
ICP/MS	EPA 6020A	Thallium
ICP/MS	EPA 6020A	Vanadium
ICP/MS	EPA 6020A	Zinc
CVAA	EPA 7470A	Mercury
FIA	EPA 9012B	Total Cyanide
IC	EPA 9056A	Bromide
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrogen, Nitrate (As N)
IC	EPA 9056A	Nitrogen, Nitrite (As N)
IC	EPA 9056A	ortho-Phosphate (As P)
UV/VIS	SM 4500 P B(5)+E_1999	Total Phosphorus
IC	EPA 9056A	Sulfate
IC	EPA 300.0 mod.	Acetic Acid
IC	EPA 300.0 mod.	Butyric Acid
IC	EPA 300.0 mod.	Lactic Acid
IC	EPA 300.0 mod.	Propionic Acid
IC	EPA 300.0 mod.	Pyruvic Acid
UV/VIS	SM 4500 S2- D_2000	Sulfide
combustion/IR	EPA 9060A	Organic Carbon, Total
UV/VIS	SM 3500 Cr B_2009	Chromium, Hexavalent
Pensky-Marten	EPA 1010A	Ignitability
pH meter	SM 4500 H+B_2000	pH
Titration	SM 2320 B_1997	Alkalinity, Total (As CaCO ₃)
Gravimetric	SM 2540 C_1997	Total Dissolved Solids
Gravimetric	SM 2540 D_1997	Total Suspended Solids
Gravimetric	EPA 1664A	Oil & Grease, Total Recoverable
Conductivity Meter	EPA 120.1	Specific Conductance
UV/VIS	SM 5220 D_1997	Chemical Oxygen Demand

Non-Potable Water		
Technology	Method	Analyte
UV/VIS	SM 3500 Fe B _1997	Ferrous Iron
GC/FID	RSK-175	Ethane
GC/FID	RSK-175	Ethene
GC/FID	RSK-175	Methane
Preparation	Method	Type
Organic Preparation	EPA 3510C	Separatory Funnel
Organic Preparation	EPA 3520C	Continuous Liquid Liquid
Inorganic Preparation	EPA 3005A	Hotblock
Inorganic Preparation	EPA 3010A	Hotblock
Volatile Organic Preparation	EPA 5030B	Purge and Trap
Organic Extract Cleanup	EPA 3660B	Sulfur cleanup
Organic Extract Cleanup	EPA 3665A	Acid cleanup

Solid and Chemical Waste		
Technology	Method	Analyte
CVAA	EPA 7471B	Mercury
FIA	EPA 9012B	Total Cyanide
Titration	WALKLEY BLACK	Organic Carbon, Total
Combustion/IR	EPA 9060A	Organic Carbon, Total
Combustion/IR	Lloyd Kahn	Organic Carbon, Total
UV/VIS	EPA 7196A	Chromium, Hexavalent
Oven	ASTM D2216	Percent moisture
pH meter	EPA 9045D	pH
ICP/AES	EPA 6010C	Aluminum
ICP/AES	EPA 6010C	Antimony
ICP/AES	EPA 6010C	Arsenic
ICP/AES	EPA 6010C	Barium
ICP/AES	EPA 6010C	Beryllium
ICP/AES	EPA 6010C	Boron
ICP/AES	EPA 6010C	Cadmium
ICP/AES	EPA 6010C	Calcium
ICP/AES	EPA 6010C	Chromium
ICP/AES	EPA 6010C	Cobalt



Solid and Chemical Waste

Technology	Method	Analyte
ICP/AES	EPA 6010C	Copper
ICP/AES	EPA 6010C	Iron
ICP/AES	EPA 6010C	Lead
ICP/AES	EPA 6010C	Magnesium
ICP/AES	EPA 6010C	Manganese
ICP/AES	EPA 6010C	Molybdenum
ICP/AES	EPA 6010C	Nickel
ICP/AES	EPA 6010C	Potassium
ICP/AES	EPA 6010C	Selenium
ICP/AES	EPA 6010C	Silver
ICP/AES	EPA 6010C	Sodium
ICP/AES	EPA 6010C	Thallium
ICP/AES	EPA 6010C	Tin
ICP/AES	EPA 6010C	Vanadium
ICP/AES	EPA 6010C	Zinc
ICP/MS	EPA 6020A	Aluminum
ICP/MS	EPA 6020A	Antimony
ICP/MS	EPA 6020A	Arsenic
ICP/MS	EPA 6020A	Barium
ICP/MS	EPA 6020A	Beryllium
ICP/MS	EPA 6020A	Cadmium
ICP/MS	EPA 6020A	Calcium
ICP/MS	EPA 6020A	Chromium
ICP/MS	EPA 6020A	Cobalt
ICP/MS	EPA 6020A	Copper
ICP/MS	EPA 6020A	Iron
ICP/MS	EPA 6020A	Lead
ICP/MS	EPA 6020A	Magnesium
ICP/MS	EPA 6020A	Manganese
ICP/MS	EPA 6020A	Nickel
ICP/MS	EPA 6020A	Potassium
ICP/MS	EPA 6020A	Selenium
ICP/MS	EPA 6020A	Silver
ICP/MS	EPA 6020A	Sodium



Solid and Chemical Waste		
Technology	Method	Analyte
ICP/MS	EPA 6020A	Thallium
ICP/MS	EPA 6020A	Vanadium
ICP/MS	EPA 6020A	Zinc
GC/FID	EPA 8015D	Diesel Range Organics
GC/FID	EPA 8015D	Gasoline Range Organics
GC/ECD	EPA 8082A	Aroclor-1016
GC/ECD	EPA 8082A	Aroclor-1221
GC/ECD	EPA 8082A	Aroclor-1232
GC/ECD	EPA 8082A	Aroclor-1242
GC/ECD	EPA 8082A	Aroclor-1248
GC/ECD	EPA 8082A	Aroclor-1254
GC/ECD	EPA 8082A	Aroclor-1260
GC/ECD	EPA 8082A	Aroclor-1262
GC/ECD	EPA 8082A	Aroclor-1268
GC/ECD	EPA 8082A	2,2',4,5,5'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3,3',4,4'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3,4,4',5-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4',5'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4',5'-Pentachlorobiphenyl
GC/ECD	EPA 8082A	3,3',4,4',5-Pentachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',4,4'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',4,4',5,5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,3,3',4,4',5-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,3,3',4,4',5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4',5-Pentachlorobiphenyl
GC/ECD	EPA 8082A	3,3',4,4',5,5'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',4,4',5-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',5-Trichlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',5,5'-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',5',6-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',5,6'-Hexachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4',5,5',6-Heptachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,4',6'-Hexachlorobiphenyl



Solid and Chemical Waste		
Technology	Method	Analyte
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,6-Octachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl
GC/ECD	EPA 8082A	Decachlorobiphenyl
GC/ECD	EPA 8082A	2,4,4'-Trichlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,5'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,2',4,5'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,2',5,5'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,3',4,4'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	3,3',4,4'-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,4'-Dichlorobiphenyl
GC/ECD	EPA 8082A	3,4,4',5-Tetrachlorobiphenyl
GC/ECD	EPA 8082A	2,2',3,4,5'-Pentachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Decachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Dichlorobiphenyl
GC/MS/SIM	EPA 680Mod	Heptachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Hexachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Monochlorobiphenyl
GC/MS/SIM	EPA 680Mod	Nonachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Octachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Pentachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Tetrachlorobiphenyl
GC/MS/SIM	EPA 680Mod	Trichlorobiphenyl
GC/MS/SIM	EPA 680Mod	Total PCBs
GC/ECD	EPA 8081B	4,4'-DDD
GC/ECD	EPA 8081B	4,4'-DDE
GC/ECD	EPA 8081B	4,4'-DDT
GC/ECD	EPA 8081B	Aldrin
GC/ECD	EPA 8081B	alpha-BHC
GC/ECD	EPA 8081B	alpha-Chlordane
GC/ECD	EPA 8081B	beta-BHC
GC/ECD	EPA 8081B	delta-BHC
GC/ECD	EPA 8081B	Dieldrin
GC/ECD	EPA 8081B	Endosulfan I
GC/ECD	EPA 8081B	Endosulfan II



Solid and Chemical Waste		
Technology	Method	Analyte
GC/ECD	EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 8081B	Endrin
GC/ECD	EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin ketone
GC/ECD	EPA 8081B	gamma-BHC (Lindane)
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 8081B	Heptachlor
GC/ECD	EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 8081B	Toxaphene
GC/ECD	EPA 8081B	Chlordane (technical)
GC/MS	EPA 8260C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260C	1,1,1-Trichloroethane
GC/MS	EPA 8260C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 8260C	1,1,2-Trichloroethane
GC/MS	EPA 8260C	1,1-Dichloroethane
GC/MS	EPA 8260C	1,1-Dichloroethene
GC/MS	EPA 8260C	1,1-Dichloropropene
GC/MS	EPA 8260C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260C	1,2,3-Trichloropropane
GC/MS	EPA 8260C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260C	1,2-Dibromo-3-chloropropane
GC/MS	EPA 8260C	1,2-Dibromoethane
GC/MS	EPA 8260C	1,2-Dichlorobenzene
GC/MS	EPA 8260C	1,2-Dichloroethane
GC/MS	EPA 8260C	1,2-Dichloropropane
GC/MS	EPA 8260C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260C	1,3-Dichlorobenzene
GC/MS	EPA 8260C	1,3-Dichloropropane
GC/MS	EPA 8260C	1,4-Dichlorobenzene
GC/MS	EPA 8260C	1,4-Dioxane
GC/MS	EPA 8260C	1-Chlorohexane



Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260C	2,2-Dichloropropane
GC/MS	EPA 8260C	2-Butanone
GC/MS	EPA 8260C	2-Chlorotoluene
GC/MS	EPA 8260C	2-Hexanone
GC/MS	EPA 8260C	4-Chlorotoluene
GC/MS	EPA 8260C	4-Isopropyltoluene
GC/MS	EPA 8260C	4-Methyl-2-pentanone
GC/MS	EPA 8260C	Acetone
GC/MS	EPA 8260C	Acetonitrile
GC/MS	EPA 8260C	Acrolein
GC/MS	EPA 8260C	Acrylonitrile
GC/MS	EPA 8260C	Allyl Chloride
GC/MS	EPA 8260C	Benzene
GC/MS	EPA 8260C	Bromobenzene
GC/MS	EPA 8260C	Bromochloromethane
GC/MS	EPA 8260C	Bromodichloromethane
GC/MS	EPA 8260C	Bromoform
GC/MS	EPA 8260C	Bromomethane
GC/MS	EPA 8260C	Carbon disulfide
GC/MS	EPA 8260C	Carbon tetrachloride
GC/MS	EPA 8260C	Chlorobenzene
GC/MS	EPA 8260C	Chloroethane
GC/MS	EPA 8260C	Chloroform
GC/MS	EPA 8260C	Chloromethane
GC/MS	EPA 8260C	cis-1,2-Dichloroethene
GC/MS	EPA 8260C	cis-1,3-Dichloropropene
GC/MS	EPA 8260C	Cyclohexane
GC/MS	EPA 8260C	Dibromochloromethane
GC/MS	EPA 8260C	Dibromomethane
GC/MS	EPA 8260C	Dichlorodifluoromethane
GC/MS	EPA 8260C	Diethyl Ether
GC/MS	EPA 8260C	Diisopropyl ether
GC/MS	EPA 8260C	Ethanol
GC/MS	EPA 8260C	Ethylbenzene



Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260C	Ethyl methacrylate
GC/MS	EPA 8260C	Ethyl tert-butyl ether
GC/MS	EPA 8260C	Hexachlorobutadiene
GC/MS	EPA 8260C	Hexachloroethane
GC/MS	EPA 8260C	Iodomethane
GC/MS	EPA 8260C	Isobutyl alcohol
GC/MS	EPA 8260C	Isopropylbenzene
GC/MS	EPA 8260C	m,p-Xylene
GC/MS	EPA 8260C	Methacrylonitrile
GC/MS	EPA 8260C	Methyl acetate
GC/MS	EPA 8260C	Methylcyclohexane
GC/MS	EPA 8260C	Methyl methacrylate
GC/MS	EPA 8260C	Methyl tert-butyl ether
GC/MS	EPA 8260C	Methylene chloride
GC/MS	EPA 8260C	n-Butylbenzene
GC/MS	EPA 8260C	n-Propylbenzene
GC/MS	EPA 8260C	Naphthalene
GC/MS	EPA 8260C	o-Xylene
GC/MS	EPA 8260C	Propionitrile
GC/MS	EPA 8260C	sec-Butylbenzene
GC/MS	EPA 8260C	Styrene
GC/MS	EPA 8260C	tert-Amyl Methyl ether
GC/MS	EPA 8260C	tert-Butyl alcohol
GC/MS	EPA 8260C	tert-Butylbenzene
GC/MS	EPA 8260C	Tetrachloroethene
GC/MS	EPA 8260C	Tetrahydrofuran
GC/MS	EPA 8260C	Toluene
GC/MS	EPA 8260C	trans-1,2-Dichloroethene
GC/MS	EPA 8260C	trans-1,3-Dichloropropene
GC/MS	EPA 8260C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260C	Trichloroethene
GC/MS	EPA 8260C	Trichlorofluoromethane
GC/MS	EPA 8260C	Vinyl acetate
GC/MS	EPA 8260C	Vinyl chloride

Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8260C	Xylene (Total)
GC/MS	EPA 8270D	Acetophenone
GC/MS	EPA 8270D	Benzaldehyde
GC/MS	EPA 8270D	Caprolactam
GC/MS	EPA 8270D	1,1'-Biphenyl
GC/MS	EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270D	1,4-Dioxane
GC/MS	EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270D	1,2-Dichlorobenzene
GC/MS	EPA 8270D	1,3-Dichlorobenzene
GC/MS	EPA 8270D	1,4-Dichlorobenzene
GC/MS	EPA 8270D	1-Methylnaphthalene
GC/MS	EPA 8270D	2,2'-oxybis (1-Chloropropane)
GC/MS	EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 8270D	2,4-Dinitrotoluene
GC/MS	EPA 8270D	2,6-Dinitrotoluene
GC/MS	EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 8270D	2-Chlorophenol
GC/MS	EPA 8270D	2-Methylnaphthalene
GC/MS	EPA 8270D	2-Methylphenol
GC/MS	EPA 8270D	2-Nitroaniline
GC/MS	EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	3,3'-Dichlorobenzidine
GC/MS	EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4,6-Dinitro-2-methylphenol
GC/MS	EPA 8270D	4-Bromophenyl-phenylether
GC/MS	EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270D	4-Chloroaniline
GC/MS	EPA 8270D	4-Chlorophenyl-phenylether



Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270D	4-Methylphenol
GC/MS	EPA 8270D	4-Nitroaniline
GC/MS	EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	Acenaphthene
GC/MS	EPA 8270D	Acenaphthylene
GC/MS	EPA 8270D	Aniline
GC/MS	EPA 8270D	Anthracene
GC/MS	EPA 8270D	Atrazine
GC/MS	EPA 8270D	Azobenzene
GC/MS	EPA 8270D	Benzyl Alcohol
GC/MS	EPA 8270D	Benzo(a)anthracene
GC/MS	EPA 8270D	Benzo(a)pyrene
GC/MS	EPA 8270D	Benzo(b)fluoranthene
GC/MS	EPA 8270D	Benzo(g,h,i)perylene
GC/MS	EPA 8270D	Benzo(k)fluoranthene
GC/MS	EPA 8270D	Bis(2-chloroethoxy)methane
GC/MS	EPA 8270D	Bis(2-chloroethyl)ether
GC/MS	EPA 8270D	Bis(2-ethylhexyl)phthalate
GC/MS	EPA 8270D	Butylbenzylphthalate
GC/MS	EPA 8270D	Carbazole
GC/MS	EPA 8270D	Chrysene
GC/MS	EPA 8270D	Di-n-butylphthalate
GC/MS	EPA 8270D	Dibenzofuran
GC/MS	EPA 8270D	Diethylphthalate
GC/MS	EPA 8270D	Dimethylphthalate
GC/MS	EPA 8270D	Di-n-octylphthalate
GC/MS	EPA 8270D	Dibenzo(a,h)anthracene
GC/MS	EPA 8270D	Fluoranthene
GC/MS	EPA 8270D	Fluorene
GC/MS	EPA 8270D	Hexachlorobenzene
GC/MS	EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Indeno(1,2,3-cd)pyrene

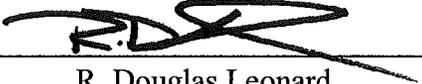


Solid and Chemical Waste		
Technology	Method	Analyte
GC/MS	EPA 8270D	Isophorone
GC/MS	EPA 8270D	N-Nitroso-di-n-propylamine
GC/MS	EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Pentachlorophenol
GC/MS	EPA 8270D	N-Nitrosodimethylamine
GC/MS	EPA 8270D	N-Nitrosodiphenylamine
GC/MS	EPA 8270D	Naphthalene
GC/MS	EPA 8270D	Phenanthrene
GC/MS	EPA 8270D	Phenol
GC/MS	EPA 8270D	Pyrene
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4,5-TP (Silvex)
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichlorprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
UV/VIS	EPA 9031 Mod	Extractable Sulfides
Preparation	Method	Type
Organic Preparation	EPA 3550B	Sonication
Inorganics Preparation	EPA 3050B	Hotblock
Organic Preparation	EPA 3545	Pressurized Fluid
Organic Preparation	EPA 3540C	Soxhlet
Volatile Organics Preparation	EPA 5035A	Closed System Purge and Trap
Inorganics Preparation	EPA 3060A	Alkaline Digestion
Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure
Preparation	ASTM D3987	Shake ext of solid waste with water
Organic Extract Cleanup	EPA 3660B	Sulfur cleanup
Organic Extract Cleanup	EPA 3665A	Acid cleanup



Notes:

- 1) This laboratory offers commercial testing service.

Approved by: 
R. Douglas Leonard
Chief Technical Officer

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