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FINAL TIER II ASSESSMENT WORKPLAN FIBER OPTIC VAULT WITH TRANSMITTAL
MCRD PARRIS ISLAND SC
5/31/2002
TETRA TECHNUS, INC



TETRA TECH NUS, INC.

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0502-A083

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0502-A083

May 31, 2002

Project Number N4211

Commander, Southern Division
Naval Facilities Engineering Command
ATTN.: Gabriel Magwood (Code ES24)
P.O. Box 190010
2155 Eagle Drive
North Charleston, South Carolina 29419-9010

Reference: a. [REDACTED] MCRD Parris Island UST
b. CLEAN Contract No. N62467-94-D-0888

Subject: Final Tier II Assessment Workplan
Fiber Optic Vault, MCRD Parris Island, South Carolina

Dear Mr. Magwood:

Tetra Tech NUS is pleased to submit one copy of the Final Tier II Assessment Workplan for the Fiber Optic Vault at MCRD Parris Island for your review.

If you have questions or comments please contact me at (865) 483-9900.

Sincerely,

Bryn Howze, P.G.
Task Order Manager

BH/cf

Enclosure

c: Mr. Jim Clark, MCRD Parris Island (2 copies)
Mr. Mark Perry, Tetra Tech NUS (1 copy unbound)
Ms. Debra Wroblewski, Tetra Tech NUS (w/o enclosure)
File/Edb

Tier II Assessment Work Plan for **Fiber Optics Vault**

Marine Corps Recruit Depot
Parris Island, South Carolina



Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO 0236

May 2002

N4211-3.1-7



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Marine Corps Recruit Depot
Parris Island, South Carolina



Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO 0236

May 2002

**TIER II ASSESSMENT WORK PLAN
FOR
FIBER OPTICS VAULT**

**MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA**

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

**Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406**

**Submitted by:
Tetra Tech NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220**

**CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0236**

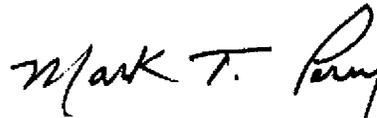
MAY 2002

PREPARED UNDER THE SUPERVISION OF:



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ACRONYMS

ASTM	American Society for Testing and Materials
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	Corrective Action Plan
CLEAN	Comprehensive Long-term Environmental Action - Navy
CTO	Contract Task Order
DAR	Daily Activities Record
DOT	Department of Transportation
DPT	Direct-Push Technology
DRO	Diesel Range Organics
EC	Electrical Conductivity
EDB	ethylene dibromide
FID	Flame Ionization Detector
FOC	fractional organic carbon
FOL	Field Operations Leader
GC	Gas Chromatograph
ID	inside diameter
IDW	Investigation-Derived Waste
MCRD	Marine Corps Recruit Depot
mg/kg	milligrams per kilogram
MIP	Membrane Interface Probe
MSL	Mean Sea Level
MTBE	Methyl Tert Butyl Ether
NAD	North American Datum
NIST	National Institute of Standards and Technology
NREAO	Natural Resources and Environmental Affairs Officer
NSF	National Sanitation Foundation
NTU	Nephelometric Turbidity Unit
OVA	Organic Vapor Analyzer
QC	quality control
PAH	Polycyclic Aromatic Hydrocarbon
PID	Photoionization Detector
ppm	parts per million
PVC	polyvinyl chloride
RBSLs	Risk Based Screening Level
RPM	Remedial Project Manager
SCDHEC	South Carolina Department of Health and Environmental Control
SOP	Standard Operating Procedure
SOUTHNAVFACENCOM	Southern Division, Naval Facilities Engineering Command
SSTL	Site Specific Target Level
TOC	total organic carbon
TOM	Task Order Manager
TPH	total petroleum hydrocarbon
TtNUS	Tetra Tech NUS, Inc.
µg/kg	micrograms per kilogram
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
UTM	Universal Transverse Mercator
VOA	Volatile Organic Aromatic
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Tetra Tech NUS (TtNUS) has prepared this Tier Assessment Work Plan for the Fiber Optic Vault, located at the Marine Corps Recruit Depot (MCRD), Parris Island, South Carolina. This work plan was prepared for the U.S. Navy Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) under Contract Task Order (CTO) 0236, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract Number N62467-94-D-0888.

This work plan provides the rationale and methodology for performing field activities to evaluate petroleum hydrocarbons in the subsurface at the referenced site. Data collected during the site assessments will be used to prepare a Tier Assessment Report in accordance with South Carolina Department of Health and Environmental Control (SCDHEC) Underground Storage Tank Regulations R.61-92. In accordance with SCDHEC's March 15, 2000, guidance document, "Tier II Assessment," TtNUS has prepared a Tier II Assessment Plan for the Fiber Optic Vault. The Tier II Assessment Plan is provided in Appendix A.

1.1 GENERAL SITE DESCRIPTION

The MCRD Parris Island is located approximately 5 miles south of the town of Beaufort, within Beaufort County, South Carolina. The MCRD is located on an island north of Port Royal Sound between the Broad River and the Beaufort River. The Fiber Optic Vault is located at the northwestern end of the island. Figure 1 presents the location of the Fiber Optic Vault. Figure 2 shows the Fiber Optic Vault site plan.

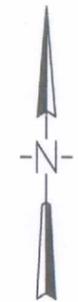
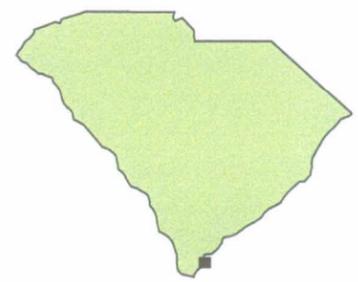
The MCRD Parris Island is an active facility. The mission of MCRD is to provide for the reception and recruit training of enlisted male personnel east of the Mississippi River and all female personnel upon their entry into the Marine Corps. The MCRD also provides field and combat skills training for recruits; schools to train enlisted Marines as Drill Instructors and Field Staff; rifle marksmanship training for Marine officers and enlisted personnel in the southeastern United States; and training for Marine reserves.

1.2 OBJECTIVE

The objective of this investigation is to evaluate the extent of petroleum hydrocarbon contamination in soil and groundwater and assess if further action is required to remediate the sites. The results of the investigation will be submitted in a Tier II Assessment Report. If the Tier II Assessment Report concludes that active remediation is required, an Active Corrective Action Plan (CAP) will be prepared. An Intrinsic CAP recommending "monitoring only" or "no further action" will be submitted if the Tier II Assessment Report concludes that active remediation is not required.



SOURCE:
 TAKEN FROM U.S.G.S. TOPOGRAPHIC QUADRANGLE
 PARRIS ISLAND (1979 EDITION).



2000 0 2000
 SCALE IN FEET



FIGURE 1
 SITE LOCATION MAP
 TIER ASSESSMENT WORKPLAN
 FIBER OPTIC VAULT
 MCRD
 PARRIS ISLAND, SOUTH CAROLINA

n1x7h.dgn



LEGEND

-  LIGHT POLE
-  POWER POLE
-  MH O SEWER MANHOLE
-  FENCE
-  GROUND CONTOURS



FIGURE 2
SITE PLAN
TIER ASSESSMENT WORK PLAN

FIBER OPTIC VAULT
MCRD
PARRIS ISLAND, SOUTH CAROLINA

2.0 SITE DESCRIPTION

The MCRD Parris Island is located in the Lower Coastal Plain Province of South Carolina and is characterized by flat terrain dissected by rivers and streams which flow into the Atlantic Ocean. Due to its location between two rivers, it is also surrounded by diverse ecosystems. There are many wetlands and tidal marsh areas with a variety of aquatic life as well as plants, birds, and animals.

The fiber optics cable vault is located approximately 20 feet east of Atsugi Street, 110 feet southwest of Building 401, and 130 feet north of Building 405 at the northwestern part of MCRD Parris Island, South Carolina (Figure 2). The site is relatively flat with both grassy and paved areas being present. Overhead power lines are present near the vault and an underground sewer line is located approximately 70 feet to the northeast. Presently there are no known sources or spills in the area of the vault.

The water table occurs within a few feet of the ground surface. At the Fiber Optic Vault the water table is anticipated to be approximately 8 to 10 feet below ground surface (bgs). The water table at Parris Island has been documented to vary by several feet depending upon the amount of recent precipitation. In general, the water table is deeper during the dry summer months and higher during the wetter winter months. The surficial aquifer in the area is restricted to the shallow, Pliocene to Holocene age, coarse-grained sedimentary deposits. Pathways exist for contaminants to migrate via surface water runoff and via infiltration into the shallow aquifer to adjacent ecosystems.

The potable water for MCRD Parris Island is not obtained from facility water wells. MCRD Parris Island officials confirmed that Parris Island is supplied by the Beaufort-Jasper Water and Sewer Authority. Two former drinking water wells were identified on the island; however, they are no longer in use.

3.0 SITE HISTORY

During construction and installation activities of the fiber optic cable vault in September 2001, petroleum hydrocarbons and water were observed in the vault. The fiber optics cable vault is a pre-cast concrete vault with inner dimensions of 12 feet long, 6 feet wide, and 7 feet deep. The walls include blanked cutouts for the fiber optic cables to enter the vault from the north, east, south, and west. SCDHEC was notified of the petroleum hydrocarbons at the fiber optic vault and requested an assessment be performed. Various depths of water and free product have been observed in the vault. In late October 2001 approximately one half-inch of free product was observed in the vault floating on approximately 1 foot of water. In late fall the product and water in the vault were pumped out and the vault steam cleaned. The water table has since fallen and the lower row of cutouts have been capped to prevent additional accumulation of fluids.

As per SCDHEC requirements, a Tier II Assessment Plan has been prepared for the site and is included in Appendix A.

4.0 SCOPE OF PROPOSED ASSESSMENT

The proposed scope of work for assessment activities will be performed in two phases. Phase 1 will consist of performing a soil and groundwater assessment using a direct-push technology (DPT) rig equipped with a membrane interface probe (MIP) to evaluate the extent of product saturated soil at the Fiber Optic Vault. The preliminary assessment will install approximately 30 to 40 soil borings into the water table at a depth of approximately 10 feet bgs to delineate the horizontal and vertical extent of vadose soil contamination. One mobilization is planned for the field screening effort. Initial borings will involve the use of a MIP with an Electrical Conductivity detector (MIP/EC) to determine the extent of free product and to provide subsurface geologic information. Based on the initial MIP/EC profiling, additional borings will be used to collect soil and groundwater samples for screening by a mobile laboratory to define the extents of contamination in soil and groundwater. The mobile laboratory will screen samples for benzene, toluene, ethylbenzene, and xylenes (BTEX) and naphthalene. The information derived from the field screening will be used to determine the optimum locations of confirmatory soil sampling and the number of permanent monitoring wells.

It is anticipated that five temporary piezometers will be installed to determine free product thickness and water table elevations. The piezometers will be field surveyed to obtain relative top of casing (TOC) elevations. Data collected from the piezometers will aid in the placement of permanent monitoring wells. Additionally, some piezometers may be used to provide source area groundwater data at areas where utilities prevent the installation of a conventional monitoring well.

Phase 2 will involve permanent well installation, groundwater and soil sampling, and surveying of monitoring wells. The placement of the monitoring wells will be based on groundwater gradients and water quality data collected during the Phase 1 field investigation.

In accordance with the "Rapid Assessment" guidance, a South Carolina registered surveyor will survey each site after the Phase 2 investigation activities have been completed. The survey will include the locations and elevations of all monitoring wells.

4.1 SOIL INVESTIGATION

The MIP will be used in conjunction with DPT drilling in Phase 1 to collect real time continuous volatile organic compound (VOC) data in the vadose zone. The DPT adapted probe houses a membrane that heats the soil and water up to 250° F, volatilizing the contaminants. The volatiles are then analyzed using a flame ionization detector (FID), a photo ionization detector (PID), and electron capture detector resulting

in a continuous vertical profile for VOCs. In addition, the MIP records soil conductivity utilizing a dipole measurement arrangement at one-foot intervals. In general, lower soil conductivities indicate sands while higher conductivities are indicative of silts and clays. Approximately 20 DPT/MIP borings will be drilled to a depth of approximately 10 to 20 feet to delineate the extent of the product saturated soil and to provide lithologic information. Approximately two borings will be extended to 30 to 40 feet bgs to provide lithologic information to help determine the design of vertical extent monitoring wells. Initial borings will be installed at and near the Fiber Optic Vault where the product in groundwater was encountered during construction activities. Additional MIP boring locations may be determined as results from the initial borings are evaluated. Prior to beginning each bore hole, the drilling crew will hand auger or post hole from the surface to 4 feet bgs to ensure that no underground utilities are present.

Based on the initial MIP/EC profiling, soil and groundwater samples will be collected at selected locations using DPT standard operating procedures. These samples will be field screened with a FID or PID and selected samples analyzed at the mobile laboratory for BTEX and naphthalene to help define the lateral and vertical extents of contamination. Approximately 20 DPT soil borings will be installed during this part of the Phase 1 field investigation. Soil samples will be collected every 5 feet from the ground surface to the water table. Soil samples will be collected using either a 2-foot or 4-foot sampler with plastic liners. Vadose zone soil samples will be screened with a FID or PID following procedures for headspace analysis. The soil borings will be advanced until the water table is encountered. It is anticipated that groundwater will be encountered within 10 feet of the ground surface. One soil sample from each DPT boring will be selected based on OVA headspace screening to be analyzed by the mobile lab.

Approximately 8 soil samples will be collected for fixed-base laboratory analysis to confirm the results of the field screening investigation. The soil sample intervals will be selected to coincide with samples that exhibit high mobile lab screening results. These samples will be collected during monitoring well installation activities. The samples will be analyzed for BTEX, naphthalene, polynuclear aromatic hydrocarbons (PAHs), and lead. The location with the highest mobile lab screening levels will also be analyzed for total petroleum hydrocarbons. One soil sample will also be collected for grain size analysis and one from a background location for total organic carbon (TOC) analysis.

Each soil boring will be backfilled with Type 1 Portland Cement. All locations drilled through asphalt or concrete will be completed with similar material and finished flush to existing grade.

A lithologic description will be made of each DPT sample tube and/or grab sample collected and a completed log of each boring will be maintained by the on-site geologist in accordance with Standard

Operating Procedure (SOP) GH 1.5 included in Appendix B. At a minimum, the boring log will contain the following information:

- Sample Numbers and Types
- Sample Depths
- Sample Recovery/Sample Interval
- Soil Density or Cohesiveness
- Soil Color
- Unified Soil Classification System (USCS) Material Description

In addition, depths of changes in lithology, sample moisture observations, depth to water, OVA readings, drilling methods, and total depth of each borehole, as well as any other pertinent observations, will be included on each log. An example of the boring log form is provided in Appendix B.

The lithology and soil quality will be assessed from soil samples collected during the DPT investigation and from confirmatory soil samples collected during monitoring well installation. No split-spoon samples will be collected during installation of the monitoring wells for lithologic characterization as sufficient data should be available from the MIP/DPT investigation. Split-spoon samples will only be used for the collection of target-samples for confirmatory laboratory analysis (8 samples). Only grab samples from the auger flights will be logged during installation of the monitoring wells.

4.2 GROUNDWATER FIELD SCREENING

During the Phase 1 OVA soil screening (DPT investigation), a groundwater sample will be collected at each boring location from the water table for on-site analysis. The samples will be placed into appropriate sample bottles and immediately analyzed for BTEX and naphthalene using a mobile lab equipped with a gas chromatograph (GC). The DPT method for conducting field screening of water samples is the preferred method for delineating groundwater impacts due to the number of groundwater samples that can be collected over a short period of time without installing temporary and/or permanent monitoring wells.

The results from the Phase I groundwater investigation will be tabulated and plotted. The summarized data will be sent to the SCDHEC and the Navy for review. After the data have been reviewed, a consensus and approval for the optimum number and placement of permanent monitoring wells will be obtained.

4.3 GROUNDWATER INVESTIGATION

It is anticipated that approximately six to ten shallow monitoring wells will be installed to approximately 18 to 20 feet bgs will be required to assess the horizontal extent of dissolved hydrocarbons. The installation of the monitoring wells will be completed during the Phase 2 field investigation. In addition, one to three vertical extent monitoring wells may be installed to delineate the vertical extent of dissolved hydrocarbons. The proposed monitoring well locations will be determined based on groundwater quality data and flow directions obtained during the Phase 1 investigation. The Navy and SCDHEC will be contacted to discuss the locations of the proposed monitoring wells prior to installation.

4.3.1 Monitoring Well Installation

All permanent monitoring wells will be installed in accordance with the *Monitoring Well Design, Installation, Construction and Development Guidelines* (March 27, 1997) provided by SOUTHNAVFACENGCOM. Permanent monitoring wells will be installed using hollow stem auger drilling techniques. These wells will be used to monitor water quality and evaluate the horizontal and vertical extent of contamination. Monitoring wells will be constructed of 2-inch inside diameter (ID) Schedule 40, flush-joint polyvinyl chloride (PVC) riser and flush-joint factory slotted well screen. Each section of casing and screen will be National Sanitation Foundation (NSF) approved. Screen slot size will be 0.01 inch. The shallow monitoring wells will be constructed with 10 feet of screen with the top of the screen interval positioned approximately 4 feet above the water table. After the borings are drilled to the desired depth (6-inch minimum diameter boring for 2-inch ID wells), the well will be installed through the augers.

The lithology has been sufficiently characterized from previous investigations at MCRD Parris Island such that a sieve analysis of the soils is not needed to determine the type of sand pack and screen slot size for well completion. Clean silica sand of U.S Standard Sieve Size No. 20/30 will be installed into the boring annulus around the well screen as the augers are withdrawn from the boring. The sand pack will be set from the bottom of the hole to approximately two feet above the top of the well screen. A minimum two-foot-thick bentonite pellet or fine-sand seal will be installed above the sand pack. The remainder of the boring will be backfilled with a Type I Portland cement/bentonite grout. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless steel tape. The position of the top of the screen interval, sand pack, and fine-sand seal may be adjusted as site conditions warrant (elevated water table, etc.).

For any monitoring well installations that will potentially pass through contaminated zones or confining layers, an outer casing will be installed to prevent cross contamination of the aquifer below. The outer casing will be installed using hollow-stem auger drilling techniques to advance the boring to the confining

layer or contaminated zone. Upon completion of the boring the casing will be set to the desired depth and the annular space tremie grouted from total depth to the surface. After allowing the grout to cure for a minimum of 24 hours, the mud-rotary drilling method will be used to drill through the outer casing to install the monitoring well to the desired depth. Double-cased monitoring well construction details will be similar to other wells.

Flush-mounted steel well covers and manholes will be installed around the 2-inch ID wells. The manhole will consist of a flush-mounted, 22-gauge steel, water resistant, welded box with 3/8-inch steel lid. A 2-foot by 2-foot by 6-inch thick concrete apron will be constructed around the manhole. The manhole will be completed 2 inches above existing grade and the apron tapered to be flush with the existing grade at the edges such that water will run off the apron. All locks supplied for the wells will be keyed alike. After installation, the ground surface and the top of the PVC riser pipe will be surveyed to within 0.01-foot vertical accuracy using datum points as discussed previously in Section 4.0. A monitoring well construction diagram will be completed for each well installed.

The monitoring wells will be developed no sooner than 24 hours after installation to remove fine material from around the monitored interval of the well. Wells will be developed by bailing and surging, or by pumping, as determined by the field geologist. The pH, temperature, specific conductance and turbidity measurements will be collected from the purge water. Wells will be developed up to a maximum of one hour or until these measurements become stable and the purge water is visibly clear. Water quality stabilization will be determined using the following criteria: temperature +/- 1.0°C (plus or minus one degree Celsius), pH +/- 0.1unit, and specific conductivity +/- 10 percent, and turbidity remains within a 10 Nephelometric Turbidity Unit (NTU) range for two consecutive readings. Wells will be developed until approved by the field geologist.

4.3.2 Groundwater Sampling

Groundwater samples will be obtained from monitoring wells in accordance with SCDHEC's May 15, 2001 guidance document "South Carolina Risk-Based Corrective Action for Petroleum Releases." Prior to obtaining samples, water levels, product thickness, and total well depths will be measured and the wells will be purged using a submersible pump and a low-flow quiescent purging technique. Three to five well volumes will be purged. If wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover at least 80 percent, then a sample will be collected. Field measurements of pH, temperature, specific conductance, and turbidity will be taken after each volume of water is purged.

Stabilization water quality parameters is defined in the previous paragraphs. If these parameters do not stabilize after three volumes, up to five volumes will be removed. Before purging, a clear bailer or an oil

water interface probe will be used to check for free product. No samples will be collected from a well that exhibits measurable free product. The thickness of the free product will be measured and recorded.

Groundwater samples obtained for laboratory analysis will be collected with a submersible pump and Teflon tubing using a low-flow quiescent sampling technique. The samples will be transferred directly into the appropriate (pre-preserved) sample bottles for analysis. The sample constituents to be analyzed are summarized in Table 4-1.

TABLE 4-1
FIELD INVESTIGATION
ENVIRONMENTAL SAMPLE SUMMARY
MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

Analyte	Proposed Method (1)	Env. Samples	IDW Samples (2)	Duplicate Samples	Rinsate Blanks (Aqueous)	Field Blank (Aqueous)	Trip Blanks (Aqueous)	Total Samples
Groundwater								
BTEX, EDB, MTBE, & Naphthalene	EPA 8260B	13	0	2	1	1	2	19
PAH	EPA 8270C	13	0	2	1	1	0	17
Total Lead	EPA 6010B or 7421	13	0	2	1	1	0	17
Nitrate, Sulfate	EPA 9056	4	0	0	0	0	0	4
Dissolved Methane	EPA 5030B	4	0	0	0	0	0	4
Soil								
BTEX, Total Naphthalene	EPA 5035B/8260B	8	0	1	1	1	2	13
PAH	EPA 3550B/8270C	8	0	1	1	1	0	11
Lead	EPA 7421	8	0	1	1	1		11
TPH	EPA 3550B/8015B	2	0	0	0	0	0	2
TOC	EPA 9060	2	0	0	0	0	0	1
Grain Size /Hydrometer	ASTM D422	2	0	0	0	0	0	2
TCLP BTEX	SW-846 1311/8260B	0	2	0	0	0	0	2
TCLP Lead	SW-846 1311/6010B	0	2	0	0	0	0	2

BTEX - Benzene, Toluene, Ethylbenzene, Xylene

MTBE - Methyl Tert Butyl Ether

PAH - Polynuclear Aromatic Hydrocarbons

TOC - Total Organic Carbon

TPH - Total Petroleum Hydrocarbons

EDB - Ethylene Dibromide

(1) Method referenced reflects SCDHEC requirements.

(2) IDW samples are based on collecting two composite soil samples.

All analyses are based on a standard 30-day laboratory turnaround time.

4.3.3 Groundwater Level Measurements

Synoptic water level measurements will be taken from all monitoring wells at the sites. Static water level measurements will be measured from the north rim of the top of the PVC riser pipe using an electronic water level indicator. The newly installed wells will be notched and marked so that the same point will be referenced for all measurements. The depth to water will be measured to the nearest 0.01 foot below the top of the PVC riser pipe. Three consecutive water level readings will be recorded from the well to the nearest 0.01-foot to assure an accurate water level is recorded. Water level measurements will be recorded to the nearest 0.01-foot in the appropriate field logbook.

4.4 EQUIPMENT DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. This equipment includes drill rigs, downhole tools, augers, well casing and screens, and soil and water sampling equipment.

4.4.1 Major Equipment

All downhole drilling equipment used in the construction and sampling of permanent monitoring wells, including downhole drill and sampling tools will be high pressure cleaned prior to beginning work, between boreholes, any time the drill rig leaves the drill site prior to completing a boring, and at the conclusion of the drill program.

These decontamination operations will consist of washing equipment using a phosphate-free detergent and a high-pressure steam wash from a potable water supply. The equipment will be rinsed with potable water. All decontamination activities will take place at a predetermined location. Additional requirements for drilling equipment decontamination can be found in SOP SA-7.1 included in Appendix B.

4.4.2 Sampling Equipment

All equipment such as trowels, bailers, and split spoon samplers used for collecting samples will be decontaminated prior to beginning field sampling and between sample locations. The following decontamination steps will be taken:

- Potable water and Liquinox detergent wash.
- Potable water rinse.
- Rinse thoroughly with de-ionized, analyte-free water.

- Rinse with isopropanol.
- Rinse thoroughly with de-ionized, analyte-free water.
- Air dry.
- Wrap equipment in aluminum foil until used.

Field meters such as pH, conductivity and temperature instrument probes will be rinsed first with tap water, then with de-ionized, analyte-free water, and finally with the sample liquid during subsequent use.

4.5 WASTE HANDLING

Drill cuttings from monitoring well installations, well development water, and purge water will be collected and containerized in Department of Transportation (DOT) approved (Specification 17C) 55-gallon drums. Each drum will be sealed and labeled and left at a drum staging area pending groundwater analytical results and/or composite waste sample results for disposal. A waste staging area will be established at the site location to store investigation-derived waste (IDW) generated during the site assessment investigation. A lined decontamination pad will be constructed and used to collect the water from steam cleaning of drilling equipment. All decontamination materials generated during the site investigation will be containerized for proper disposal.

4.6 SAMPLE HANDLING

Sample handling includes the field-related activities such as the selection of sample containers and preservatives, meeting allowable holding times, and specifying the required analysis. In addition, sample identification, packaging, and shipping are addressed. All sample handling procedures will be in accordance with SCDHEC and EPA Region IV requirements. A summary of bottleware requirements, preservation requirements, and sample holding times are provided in Table 4-2. The required analyses were specified in Table 4-1.

4.7 SOIL BORING, MONITORING WELL, AND SAMPLE IDENTIFICATION

Each soil boring, monitoring well, soil sample, and groundwater sample will be assigned a unique identification number. The following text describes the nomenclature to be used in generating these numbers and explains the information each number contains.

TABLE 4-2

SUMMARY OF ANALYSIS, BOTTLEWARE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES

MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA

PAGE 1 OF 2

Parameter	Analytical Method	Sample Container	Volume	Preservation	Maximum Holding Time ⁽¹⁾
Aqueous Samples					
BTEX, MTBE, EDB, Naphthalene	EPA Method 8260B	Glass Volatile Vial	3 x 40 mL	Add HCL to pH < 2; Chill to 4 degrees Celsius	14 days
PAHs	EPA Method 8270C	Amber Glass	1 L	Chill to 4 degrees Celsius	7 days until extraction 14 days to analysis
Lead (Total)	EPA Method 6010B or 7421	High Density Polyethylene	500 mL	Add HNO ₃ to pH < 2; Chill to 4 degrees Celsius	180 days
Nitrate, Sulfate	EPA Method 9056	High Density Polyethylene	500 mL	Chill to 4 degrees Celsius	Nitrate – 48 hours Sulfate - 28 days
Dissolved Methane	EPA Method 5030B	Glass Volatile Vial	3 x 40 mL	Add HCL to pH < 2; Chill to 4 degrees Celsius	28 days

TABLE 4-2

**SUMMARY OF ANALYSIS, BOTTLEWARE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
MARINE CORPS RECRUIT DEPOT**

PARRIS ISLAND, SOUTH CAROLINA

PAGE 2 OF 2

Parameter	Analytical Method	Sample Container	Volume	Preservation	Maximum Holding Time ⁽¹⁾
Solid Samples					
BTEX and Naphthalene	EPA Method 5035B/8260B	Encore Sampler	4 x 5 grams	Chill to 4 degrees Celsius (laboratory does additional preservation)	48 hours – preservation 14 days - analysis
PAHs	EPA Method 3550B/8270C	Clear Wide Mouth Glass	8 oz	Chill to 4 degrees Celsius	7 days to extraction; 40 days to analysis
TPH (DRO)	EPA Method 3550B/8015B	Clear Wide Mouth Glass	4 oz	Chill to 4 degrees Celsius	28 days
Total Lead	SW-846 Method 7421	Clear Wide Mouth Glass	4 oz	Chill to 4 degrees Celsius	28 days
Total Organic Carbon	EPA Method 9060	Glass Wide Mouth	4 oz	Chill to 4 degrees Celsius	28 days
Grain Size Including Hydrometer	ASTM D422	Wide Mouth Glass	8 oz	None	None

BTEX - Benzene, Toluene, Ethylbenzene, Xylene
 EDB - Ethylene Dibromide
 HCl - Hydrochloric acid
 HNO₃ - Nitric Acid
 MTBE - Methyl-tert-butyl-ether
 PAHS - Polynuclear Aromatic Hydrocarbons
 TPH - Total Petroleum Hydrocarbons

⁽¹⁾ - Holding time is measured from date of sample collection to date of sample extraction or analysis.

Base and Site Designations

The base designation for MCRD Parris Island is PAI. The site designation for the Fiber Optic Vault site will be FOV.

Soil Boring Identification

Soil boring identification numbers will consist of a three part alphanumeric code that identifies (1) the base identifier (PAI), (2) the site designation (FOV), and (3) the discriminator "B" combined with a consecutive numerical value. Thus, the soil boring identification number for the third soil boring installed at the Fiber Optic Vault would be PAI-FOV-B03.

Monitoring Well Identification

Monitoring well identification numbers will be similar to soil boring identification numbers, except that they use an "M" as a discriminator. For deep wells the discriminator "D" will be added after the consecutive numerical value for the well. For example, the fifth monitoring well installed at the Fiber Optic Vault would be designated PAI-FOV-M05. If the sixth well installed at the Fiber Optic Vault was a deep well, it would be designated PAI-FOV-M06D.

Soil and Groundwater Sample Identification

A sample tracking number will consist of a five- to six-segment, alphanumeric code that identifies the site number, sample medium, data type, location, the sampling event or sample depth (in case of soil samples) and the QC designation. The QC designation is only used if applicable. Any other pertinent information regarding sample identification will be recorded in the field logbook.

The alphanumeric coding to be used in the sample system and examples of possible sample identification numbers follow:

AAA	-	Site Number
A	-	Medium
A	-	Data Type
ANN	-	Location
NN	-	Sampling Event or Sample Depth
NNN(N)	-	QC Designation (if applicable)

Character Type:

A = Alpha

N = Numeric

Medium:

G = Groundwater

A = Air

W = Surface Water

E = Effluent

S = Soil

D = Sediment

E = Equipment Rinsate

F = Field Blank

T = Trip Blank

X = Other

Data Types:

L = Fixed-Base Laboratory Analytical Data

F = Field Laboratory Data

S = Field Screening Data

QC Identifier:

D = Duplicate Sample

M = Matrix Spike Sample

S = Matrix Spike Duplicate

Example 1: The fixed base analytical soil sample collected from PAI-FOV-B01 at 4 feet bgs would be called FOVSLB0104 and its duplicate would be FOVSLB0104D.

Example 2: The field laboratory groundwater sample collected from PAI-FOV-B01 at 7 feet bgs would be called FOVGFB0107.

Example 3: The fixed-base analytical groundwater sample collected from PAI-FOV-M01 during the first sampling event would be called FOVGLM0101. The sample collected during the next event would be FOVGLM0102.

Example 4: The fixed-base analytical groundwater sample and matrix spike collected from PAI-FOV-M01 during the first sampling event would be called FOVGLM0101 and FOVGLM0101M.

Example 5: The first fixed-base analytical trip blank for the first sampling event at the Fiber Optic Vault would be called FOVTL00101, the second trip blank during the same event would be FOVTL00201. The first trip blank collected for the second event would be FOVTL00102.

Information regarding sample labels to be attached before shipment to a laboratory is contained in SOP SA-6.3 included in Appendix A.

4.8 SAMPLE PACKAGING AND SHIPPING

Samples will be packaged and shipped in accordance with the SCDHEC, EPA Region IV, and DOT requirements. The Field Operations Leader will be responsible for completion of the following forms when samples are collected for shipping.

- Sample labels
- Chain-of-Custody labels
- Appropriate labels applied to shipping coolers
- Chain-of Custody Forms
- Federal Express Air Bills

4.9 SAMPLE CUSTODY

The chain-of-custody begins with the release of the sample bottles from the laboratory and must be documented and maintained from that point forward. To maintain custody of the sample bottles or samples, they must be in someone's physical possession, in a locked room or vehicle, or sealed with an intact custody seal. When the possession of the bottles or samples is transferred from one person to another, it will be documented on the field logbook and on the chain-of-custody. An example of a chain-of-custody record is provided in Appendix B.

4.10 QUALITY CONTROL (QC) SAMPLES

In addition to periodic calibration of field equipment and appropriate documentation, QC samples will be collected or generated during environmental sampling activities. QC samples include field blanks, field duplicates, and trip blanks. Each type of field QC sample is defined as follows:

Rinsate Blank - Rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (bailer, split-spoon, etc.) after decontamination and placing it in the appropriate containers for analysis. Rinsate blanks will be used to assess the effectiveness of decontamination procedures. Rinsate blanks will be collected for each type of nondedicated sampling equipment used. Rinsate blanks will be submitted to the laboratory for analyses as shown in Table 4-1 at the frequencies shown in Table 4-3.

TABLE 4-3

**QUALITY CONTROL SAMPLE FREQUENCY
MARINE CORPS RECRUIT DEPOT
PARRIS ISLAND, SOUTH CAROLINA**

No. of Samples	Precleaned Equipment BLK	Field cleaned Rinsate BLK	Trip BLK (VOCs)	Duplicate
10+	Minimum of one then 5%	Minimum of one then 5%	One per cooler	Minimum of one then 10%
5-9	one*	one*	One per cooler	one
< 5	one*	one*	NR	NR

NR = Not required
BLK = Blank

* Note: For nine or fewer samples, a precleaned equipment blank or a field cleaned equipment blank is required. A field cleaned equipment blank must be collected if equipment is cleaned in the field.

Field Duplicate - Field duplicates are two water samples collected independently at a sample location during a single act of sampling under representative field conditions. Field duplicates sample frequencies are provided in Table 4-3. The duplicates will be analyzed for the same parameters in the laboratory as indicated in Table 4-1.

Trip Blanks - Trip blanks will be prepared at the laboratory facility and will accompany the volatile organic aromatic (VOA) vials to the sampling site and back to the laboratory. Trip blank sample frequencies are provided in Table 4-3.

4.11 FIELD MEASUREMENTS

Certain field measurements will be recorded during sampling activities including groundwater temperature, pH, specific conductance, and turbidity. Instruments used in the field to record these data and additional instruments will be calibrated according to the procedures described below.

4.11.1 Parameters

- Air monitoring - OVA
- Temperature – field meter
- Specific conductance - specific conductance meter
- pH - pH meter
- Turbidity - turbidity meter
- Depth to water table - electronic water level indicator and/or interface probe

4.11.2 Equipment Calibration

The electronic water-level indicator and/or interface probe will be calibrated prior to mobilization and periodically at the discretion of the Field Operations Leader (FOL). The remaining instruments will be calibrated daily and/or according to the manufacturer's operation manual.

Calibration will be documented on an Equipment Calibration Log as shown in Appendix B. During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until defective parts are repaired or replaced.

4.11.3 Equipment Maintenance

Measuring equipment used in environmental monitoring or analysis and test equipment used for calibration and maintenance will be controlled by established procedures. Measuring equipment shall have an initial calibration and shall be recalibrated at scheduled intervals against certified standards.

TiNUS and its suppliers maintain a large inventory of sampling and measurement equipment. If failed equipment cannot be repaired, replacement equipment can be shipped to the site by overnight express carrier to minimize downtime.

4.12 FIELD QA/QC PROGRAM

4.12.1 Control Parameters

Field control parameters, which address various field blanks and duplicate samples, are described in Section 4.10, QC Samples. Control checks and their frequency are also presented in Section 4.10.

4.12.2 Control Limits

QA/QC specifications for field measurements are summarized on Table 4-4. This table shows control parameters to be assessed, control limits, and corrective actions to be implemented.

TABLE 4-4

**FIELD QA/QC SPECIFICATIONS
MARINE CORPS RECRUIT DEPOT**

PARRIS ISLAND, SOUTH CAROLINA

Analysis	Control Parameter	Control Limit	Corrective Action
Air monitoring using an photo ionization detector (PID)	Daily check of calibration of PID	Calibration to manufacturer's specifications	Recalibrate. If unable to calibrate, replace.
pH of water	Continuing calibration check of pH 7.0 buffer	PH = 7.0 ± 0.1	Recalibrate. If unable to calibrate, replace electrode.
Specific conductance of water	Continuing calibration check of standard solution	± 1% of standard	Recalibrate. If unable to calibrate, replace electrode.
Temperature of water	Check against NIST precision thermometer	± 0.1°C at two different temperatures	Reset thermistors in accordance with manufacturer's specifications; dispose of inaccurate thermometer.

NIST – National Institute of Standards and Technology

The TtNUS FOL or designee on-site will confirm subcontractor reports of total depth of borings and wells, dimensions and placement of well screens and casings, and the volume and placement of filter pack and grout materials by independent measurement. The FOL will examine field laboratory records and field logbooks on a weekly basis during field activities.

4.12.3 Corrective Actions

The need for corrective actions may become apparent during surveillance of field activities, procurement of services and supplies, or other operations that may affect the quality of work. The identification of significant conditions adverse to quality, the cause of the conditions, and the corrective actions shall be documented and reported to the appropriate levels of management. The TtNUS Task Order Manager (TOM) will have overall responsibility for implementing corrective actions and must initiate corrective action to remedy any effects of the problem.

The corrective action program includes an analysis of the cause of any negative findings and implementing the corrective actions required. This program includes the investigation of significant or repetitious unsatisfactory conditions relating to the quality of sampling, or the failure to implement and adhere to required quality assurance practices such as SOPs.

4.13 RECORD KEEPING

In addition to chain-of-custody records associated with sample handling and packaging and shipping, certain standard forms will be completed for sample description and documentation. These forms will include sample log sheets (for soil and groundwater samples), daily activities record, and logbooks. An example of these forms can be found in Appendix B.

A bound/weatherproof field notebook will be maintained by each sampling event leader. The field team leader, or designee, will record all information related to sampling or field activities. This information may include sampling time, weather conditions, unusual events (e.g., well tampering), field measurements, descriptions of photographs, etc.

A site logbook will be maintained by the FOL. The requirements of the logbook are referenced in SOP SA-6.3 provided in Appendix B. This book will contain a summary of the day's activities and will reference the field notebooks when applicable.

Each field team leader who is supervising a drilling subcontractor activity must complete a Daily Activities Record (DAR). The DAR documents the activities and progress of the daily drilling activities. The information contained within this report is used for billing verification and progress reports. The driller's signature is required at the end of each working day to verify work accomplished, hours worked, standby time, and material used. An example of this form is provided in Appendix B.

At the completion of field activities, the FOL will submit to the TOM all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc.

4.14 SITE MANAGEMENT AND BASE SUPPORT

TtNUS will perform this project with support from the Navy. This section of the Work Plan describes the project contacts, support personnel, project milestones, and time frames of all major events.

Throughout the investigation activities, work at MCRD Parris Island will be coordinated through SOUTHNAVFACENGCOM and MCRD Parris Island personnel. The primary contacts are as follows:

1. SOUTHNAVFACENGCOM Engineer in Charge
Mr. Gabriel Magwood
(843) 820-7307

2. NREAO MCRD Parris Island
Mr. Jim Clark
(843) 228-3102

4.14.1 Support From MCRD Parris Island

The following support functions will be provided by MCRD Parris Island personnel:

- Assist TtNUS in locating underground utilities prior to the commencement of drilling operations.
- Provide existing engineering plans, drawings, diagrams, files, etc., to facilitate evaluation of the sites under investigation.
- Provide all historical data, background geological and hydrogeological information, and initial site investigation documents.

4.14.2 Assistance From MCRD Parris Island

MCRD Parris Island personnel will aid in arranging the following:

- Personnel identification badges, vehicle passes, and/or entry permits.
- A secure staging area for storing equipment and supplies.
- A supply (e.g., fire hydrant, stand pipe, etc.) of large quantities of potable water for equipment cleaning, etc.
- As required, provide escorts for contract personnel working in secured areas (all contract personnel working at MCRD Parris Island will be U.S. citizens).
- Establish a decontamination area and waste staging area located adjacent to or near the study area.

4.14.3 Support From TtNUS

The project will be staffed with personnel from the TtNUS Oak Ridge, Tennessee, office. During field activities, TtNUS will provide a senior level geologist and/or staff geologist, and field technician.

Mr. Bryn Howze, P.G., is the TOM for CTO 0236 and will be the primary point of contact. He is responsible for cost and schedule control as well as technical performance. Mr. Howze is a Registered Professional Geologist, will serve as the TOM, and will provide senior level review and oversight during field activities. Mr. Howze will be the primary point of contact for the FOL.

4.14.4 Contingency Plan

In the event of problems that may be encountered during site activities, the point of contact will be notified immediately, followed by the TOM and the MCRD Parris Island point of contact. The project manager will determine a course of action so as to not interfere with the schedule or budget. All contingency plans will be approved through the SouthDiv point of contact before being enacted.

5.0 PROPOSED LABORATORY ANALYSIS

Soil samples for laboratory analysis will be collected from borings conducted during the soil and groundwater assessment (Phase 1 field investigation). Groundwater samples for laboratory analysis will be collected from newly installed monitoring wells (Phase 2 field investigation). Soil samples will be collected in accordance with EPA Method 5035 prescribed by SW-846 Update III. The groundwater and soil samples will be analyzed in accordance with SCDHEC's May 15, 2001 guidance document, "South Carolina Risk-Based Corrective Action for Petroleum Releases." The specific sampling requirements for soil and groundwater are provided below. A summary of the sample parameters and EPA methods is provided in Table 4-1.

5.1 SOIL INVESTIGATION

Soil samples will be collected from select soil borings installed around the fiber optic vault and surrounding area for submittal to a laboratory for analysis. Samples collected for laboratory analysis will be collected from the interval with the highest BTEX and/or naphthalene screening values observed above the water table. The samples will be analyzed for BTEX, total naphthalenes, PAHs, and lead. One soil sample will also be collected from a background soil boring for laboratory analysis for total organic carbon. In addition, soil samples will be collected from the soil boring with the highest BTEX and/or naphthalene screening value as follows:

1. One soil sample will be collected from the terminus of the boring (above the groundwater table) for laboratory analysis by the grain size/hydrometer method to determine the sand, silt, and clay fractions at 0.074 millimeters (#200) screen and 0.004 millimeters, respectively.
2. One soil sample will be collected from the stratigraphic level exhibiting the highest BTEX and/or DRO screening value (above the water table) for laboratory analysis for TPH.

In addition to the environmental soil analysis described above, soil samples will also be collected from the IDW for submittal to a laboratory for analysis for Toxicity Characteristic Leaching Procedure (TCLP), BTEX, and TCLP lead. The parameters and laboratory methods to be used are summarized in Table 4-1.

5.2 GROUNDWATER INVESTIGATION

Groundwater samples will be collected from each of the newly installed permanent monitoring wells for submittal to a laboratory for analysis. The samples will be analyzed for BTEX, EDB, methyl tert butyl ether

(MTBE), total naphthalenes, PAHs, and total lead. Additionally, four monitoring wells (one upgradient, two in-plume, and one downgradient) will be sampled for the biological indicator parameters, dissolved oxygen, ferrous iron, hydrogen sulfide, carbon dioxide, and alkalinity and laboratory analysis for nitrate, nitrite, sulfate, and methane. The parameters and laboratory methods to be used are summarized in Table 4-1.

6.0 PROPOSED SCHEDULE

Phase 1 of the fieldwork is proposed to begin in June, 2002 and will take approximately 5 days to complete. Phase 2 work is anticipated to begin in early July 2002 and will take approximately 15 days. Phase 2 of the fieldwork will begin following SCDHEC and Navy review and approval of the Phase 1 field screening data and proposed permanent monitoring well locations. Upon completion of Phase 2 field activities, a Tier Assessment Report will be prepared and submitted to the Navy for review within 60 days.

If chemicals of concern concentrations indicate that corrective action is warranted, a Corrective Action Plan (CAP) will be developed upon approval of the Tier Assessment Report by SCDHEC. It is anticipated the CAP will be submitted to the Navy for review approximately 60 days after SCDHEC approval of the Tier Assessment Report. The remedial technology considered for site remediation will be determined based on the findings presented in the Tier Assessment Report.

7.0 REPORT

Upon completion of all fieldwork and laboratory analyses, a Tier Assessment report summarizing the results of the investigation will be submitted to SCDHEC. Basic site information including site facility name and address, and background will be provided. Also included in the report will be graphical presentations of the soil and groundwater screening results, and complete summaries of the soil and groundwater analytical results. The locations of the soil samples and monitoring wells will be presented on scaled figures. Boring logs, chain-of-custody forms, field forms, field screening results, and analytical reports will be included in Appendices of the report.

The report will include a recommendation for no further action, natural attenuation monitoring, or for an active remediation determination if remediation is required in accordance with SCDHEC's May 15, 2001, guidance document "South Carolina Risk-Based Corrective Action for Petroleum Releases." If remediation is deemed appropriate, a recommended remediation technique will be presented with an implementation schedule.

REFERENCES

SCDHEC (South Carolina Department of Health and Environmental Control), 1985. *South Carolina Well Standards and Regulations*. June.

SCDHEC, 1997. *Rapid Assessment*. June.

SCDHEC, 1997. *Standard Limited Assessment*. June.

SCDHEC, 2000. *Tier II Assessment*. March 15.

SCDHEC, 2001. *South Carolina Risk-Based Corrective Action for Petroleum Releases*. May 15.

SOUTHNAVFACENGCOM (Southern Division, Naval Facilities Engineering Command), 1997. *Monitoring Well Design, Installation, Construction and Development Guidelines*. March 27.

U.S. Environmental Protection Agency Region IV, 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*. November.

APPENDIX A
SCDHEC TIER ASSESSMENT PLAN

TIER II ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Conservation

Bureau of Underground Storage Tank Management

Site ID # NA County Beaufort Facility Name Fiber Optic Vault
 Facility Address Marine Corps Recruit Depot (MCRD Parris Island)
 Responsible Party U. S. Navy Address (See address below)
 No. USTs Unknown removed? Unknown replaced? Unknown
 (date) (date)
 Current use of facility/property Recruit Training Depot
 Current property owner name U. S. Navy
 Current property owner address 2155 Eagle Drive Charleston, SC 29406

Field Screening Methodolgy
 Specify the field screening method to be used. The use of field screening methods to optimize the number and location of permanent wells is required.
Grab samples will be collected at 5 ft intervals from DPT borings. A portion of each sample will be placed in a sealed baggie for head space screening with a calibrated PID.
The sample displaying the highest PID/FID reading from each borehole will be submitted to a mobile laboratory and analyzed for BTEX and naphthalene. Groundwater samples will be collected from each of the DPT borings and analyzed for the same parameters as the soil samples. Data from the DPT investigation will be submitted to SCDHEC for review and discussion with the Navy prior to installation of any monitoring wells.

Permanent Monitoring Wells (Estimate the number and completed depth)
 # of shallow wells 10 total depth 18 to 20 feet
 # of deep wells 3 total depth 35 to 40 feet (if necessary)
 Comments, if warranted Exact well depths and numbers will depend on field conditions.

Analyses
 List the analytical parameters (e.g. BTEX, MTBE) and estimated number.
Soil - BTEX + naphthalene (8)
Soil - PAH (8)
Soil - Lead (8)
Soil - TPH (2), TOC (1), and grain size (2)
Water - BTEX+EDB+MTBE+naphthalene (13)
Water - PAH (13)
Water - Lead (13)
Water - Dissolved methane (4), anions (4)

Implementetion Schedule
 Start Up Date 7/8/2002 Completion Date 8/30/2002
 Report Submittal Date 12/12/02

TIER II ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Conservation

Bureau of Underground Storage Tank Management

Site ID # NA Facility Name Fiber Optic Vault (MCRD Parris Island)

Site Maps

1. Attach a copy of the relevent portion of the USGS topographic map showing the site location
2. Prepare a site base map. This map must be accurately scaled, but does not need to be surveyed. The map must include the following:

North Arrow

Legend with facility name and address, Site ID number, date, and a bar scale

Location of property lines

Streets or highways (indicate names and numbers)

Location of buildings

Identification of located buildings

Paved areas on or adjacent to site

Location of all present and former ASTs and USTs

Previous soil sampling locations

Underground and above ground utilities on or adjacent to site

Previous monitoring well locations

Location of any other potential receptor

Aquifer Characterization (Check one and provide explanation for choice)

Pump Test _____ Slug Tests X

The surficial aquifer has been characterized at other locations on base. Slug test will be conducted to ascertain site specific conditions and compare them to existing aquifer data.

Small Volume Disposal Type and Method

Soil Soil cuttings will be containerized in drums and stored at the base drum storage facility until chemical analysis is complete. After the analysis is complete the proper disposal option will be determined.

Purge Water Containerized in drums and stored at the base drum storage facility until chemical analysis is complete. After the analysis is complete the proper disposal option will be determined.

Additional Comments _____

APPENDIX B

TETRA TECHNUS, INC.
STANDARD OPERATING PROCEDURES
STANDARD FIELD FORMS



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	

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.

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Size				FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size				
FIELD IDENTIFICATION PROCEDURES <small>(Excluding Particles Larger Than 3 inches and Heavy Fractions on Extended Weights)</small>			GROUP SYMBOL	TYPICAL NAMES		FIELD IDENTIFICATION PROCEDURES <small>(Excluding Particles Larger Than 3 inches and Heavy Fractions on Extended Weights)</small>		
<small>Identification Procedure on Fraction Smaller than No. 40 Same Size</small>						DAY STRENGTH (Shaking Characteristics)	DILATANCY (Swollen to Shrink)	TOUGHNESS (Commercy - Non Plastic Limit)
GRAVELS (GW)(-)(H)(F)(O)	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and maximum amount of all intermediate particle sizes	GW	Well graded gravel, gravel-sand mixture, etc. or no fines	SANDS AND CLAYS Liquid Limit < 50	None to Slight	Quick to Slow	None
	GRAVELS WITH FINES (High % Fines)	Predominantly one size or a range of sizes with some intermediate size missing	GP	Poorly graded gravel, gravel-sand mixture, etc. or no fines		Medium to High	None to Very Slow	Medium
	GRAVELS WITH FINES (High % Fines)	Non-plastic limit (for identification procedure, see ML)	GM	Silty gravel, poorly graded gravel-sand mixture		Slight to Medium	Slow	Slight
SANDS (SW)(-)(H)(F)(O)	CLEAN SANDS (Low % Fines)	Wide range in grain size and maximum amount of all intermediate particle sizes	SW	Well graded sand, gravelly sand, etc. or no fines	SANDS AND CLAYS Liquid Limit > 50	Slight to Medium	Slow to None	Slight to Medium
	SANDS WITH FINES (High % Fines)	Predominantly one size or a range of sizes with some intermediate size missing	SP	Poorly graded sand, gravelly sand, etc. or no fines		High to Very High	None	High
	SANDS WITH FINES (High % Fines)	Non-plastic limit (for identification procedure, see ML)	SM	Silty sand, poorly graded sand-silt mixture		HIGHLY ORGANIC SOILS	Medium to High	None to Very Slow
SANDS WITH FINES (High % Fines)	Plastic limit (for identification procedure, see CL)	SC	Clayey sand, poorly graded sand-clay mixture	Routinely identified by color, odor, strength and frequency by laboratory methods				

Boundary characteristics: Soil governing characteristics of two groups are designated by combining group symbols. For example GW-GC, well graded gravel-sand mixture with clay fines. All notes refer to this chart and U.S. Standards.

DENSITY OF GRANULAR SOILS	
DESIGNATION	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Density	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS			
CONSISTENCY	UNCORRECTED COMPRESSIVE STRENGTH (TENSILE FT.)	STANDARD PENETRATION RESISTANCE - BLOWS/FOOT	REMARKS
Very Soft	Less than 0.25	0 to 2	Empty penetrometer
Soft	0.25 to 0.50	2 to 4	Empty penetrometer
Medium SW	0.50 to 1.0	4 to 8	One blow penetrometer
Stiff	1.0 to 2.0	8 to 15	Readily indented
Very Stiff	2.0 to 4.0	15 to 30	Readily indented
Hard	More than 4.0	Over 30	Indented with

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENNESS		
Descriptive Terms	Spoon/Power or Lyle Effect	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gauged	Crushes when struck with hammer	Very Broken	(V) (B)	0-2'
Medium - Soft	Can be Gauged	Breaks (into tabs), rounded edges	Broken	(B)	2'-10'
Medium - Hard	Can be scratched	Breaks (into tabs) sharp edges	Blocky	(B)	10-20'
Hard	Cannot be scratched	Breaks conchoidal (smooth tabs), sharp edges	Massive	(M)	20-100'

LEGEND

<p>SOIL SAMPLES - TYPES</p> <p>S-2 Soil Borehole Sample</p> <p>S1-2 O.D. Undisturbed Sample</p> <p>O - Other Samples, Specify in Remarks</p>	<p>ROCK SAMPLES - TYPES</p> <p>X-1X (Common) Core (-2.0" O.D.)</p> <p>O-1X (Weak) Core (-1.75" O.D.)</p> <p>Z - Other Core Sizes, Specify in Remarks</p>	<p>WATER LEVELS</p> <p>V-12.8 Water Level</p> <p>W-12.8 Water & Depth</p> <p>V-12.8 Subsidence Level</p> <p>W-12.8 Subsidence & Depth</p>
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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:

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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

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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 (CaCO₃). 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 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	YI - 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.

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**FIGURE 5
COMPLETED BORING LOG (EXAMPLE)**



BORING LOG

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PROJECT NAME:	<u>NSB- SITE</u>	BORING NUMBER:	<u>SB/MW 1</u>
PROJECT NUMBER:	<u>9594</u>	DATE:	<u>3/8/96</u>
DRILLING COMPANY:	<u>SOILTEST CO.</u>	GEOLOGIST:	<u>SJ CONTI</u>
DRILLING RIG:	<u>CME-55</u>	DRILLER:	<u>R. ROCK</u>

Sample No. and Type or RQD	Depth (FT) 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/ROD 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 9 6 10	1.5/2.0		M DENSE	BRN TO BK	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	2.7/2.0	4.0	M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE SBOI-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	-	-
95 ①	15.0 19.0	4.0/5.0		15.0 16	M HARD	BRN	SILTSTONE	VER	WEATHERED LO + JNTS @ 15.5 WATER STAINS @ 16.5, 17.1, 17.5 LOSING SOME	0	0	0	0
4.9 5.0 ②	20.0 25.0	5.0/5.0		19'	HARD	GRAY	SANDSTONE - SOME SILTSTONE	BR	DRILL H ₂ O @ 17'± SET TEMP 6" CAS TO 15.5				
									SET 2" Ø PVC SCREEN 16-25 SAND 14-25 PELLETS 12-14	0	0	0	0

* When rock coring, enter rock brokenness. • 1-20% Drilling Area
 ** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read. 1-80% Background (ppm):

Remarks: CME-55 RIG, 4 1/4" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
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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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

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

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

7.0 RECORDS

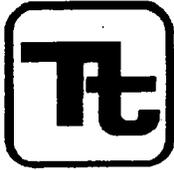
Originals of the boring logs shall be retained in the project files.

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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.



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 DECONTAMINATION OF FIELD EQUIPMENT AND WASTE HANDLING

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1.0 PURPOSE

The purpose of this procedure is to provide guidelines regarding the appropriate procedures to be followed when decontaminating drilling equipment, monitoring well materials, chemical sampling equipment and field analytical equipment.

2.0 SCOPE

This procedure addresses drilling equipment and monitoring well materials decontamination, as well as chemical sampling and field analytical equipment decontamination. This procedure also provides general reference information on the control of contaminated materials.

3.0 GLOSSARY

Acid - For decontamination of equipment when sampling for trace levels of inorganics, a 10% solution of nitric acid in deionized water should be used. Due to the leaching ability of nitric acid, it should not be used on stainless steel.

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Deionized Water - Deionized (analyte free) water is tap water that has been treated by passing through a standard deionizing resin column. Deionized water should contain no detectable heavy metals or other inorganic compounds at or above the analytical detection limits for the project.

Potable Water - Tap water used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Solvent - The solvent of choice is pesticide-grade Isopropanol. Use of other solvents (methanol, acetone, pesticide-grade hexane, or petroleum ether) may be required for particular projects or for a particular purpose (e.g. for the removal of concentrated waste) and must be justified in the project planning documents. As an 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.

4.0 RESPONSIBILITIES

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved Standards Operating Procedures or as otherwise dictated by the approved project plan(s).

5.0 PROCEDURES

To ensure that analytical chemical results reflect actual contaminant concentrations present at sampling locations, the various drilling equipment and chemical sampling and analytical equipment used to acquire the environment sample must be properly decontaminated. Decontamination minimizes the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

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5.1 Drilling Equipment

Prior to the initiation of a drilling program, all drilling equipment involved in field sampling activities shall be decontaminated by steam cleaning at a predetermined area. The steam cleaning procedure shall be performed using a high-pressure spray of heated potable water producing a pressurized stream of steam. This steam shall be sprayed directly onto all surfaces of the various equipment which might contact environmental samples. The decontamination procedure shall be performed until all equipment is free of all visible potential contamination (dirt, grease, oil, noticeable odors, etc.) In addition, this decontamination procedure shall be performed at the completion of each sampling and/or drilling location, including soil borings, installation of monitoring wells, test pits, etc. Such equipment shall include drilling rigs, backhoes, downhole tools, augers, well casings, and screens. Where the drilling rig is set to perform multiple borings at a single area of concern, the steam-cleaning of the drilling rig itself may be waived with proper approval. Downhole equipment, however, must always be steam-cleaned between borings. Where PVC well casings are to be installed, decontamination is not required if the manufacturer provides these casings in factory-sealed, protective, plastic sleeves (so long as the protective packaging is not compromised until immediately before use).

The steam cleaning area shall be designed to contain decontamination wastes and waste waters and can be a lined excavated pit or a bermed concrete or asphalt pad. For the latter, a floor drain must be provided which is connected to a holding facility. A shallow above-ground tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases such an elaborate decontamination pad is not possible. In such cases, a plastic lined gravel bed pad with a collection system may serve as an adequate decontamination area. Alternately, a lined sloped pad with a collection pump installed at the lower end may be permissible. The location of the steam cleaning area shall be onsite in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating drilling equipment shall include:

- As a general rule, any part of the drilling rig which extends over the borehole, shall be steam cleaned.
- All drilling rods, augers, and any other equipment which will be introduced to the hole shall be steam cleaned.
- The drilling rig, all rods and augers, and any other potentially contaminated equipment shall be decontaminated between each well location to prevent cross contamination of potential hazardous substances.

Prior to leaving at the end of each work day and/or at the completion of the drilling program, drilling rigs and transport vehicles used onsite for personnel or equipment transfer shall be steam cleaned, as practicable. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

Error! Bookmark not defined. **5.2 Sampling Equipment**

5.2.1 Bailers and Bailing Line

The potential for cross-contamination between sampling points through the use of a common bailer or its attached line is high unless strict procedures for decontamination are followed. For this reason, it is preferable to dedicate an individual bailer and its line to each sample point, although this does not eliminate the need for decontamination of dedicated bailers. For non-dedicated sampling equipment, the following conditions and/or decontamination procedures must be followed.

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Before the initial sampling and after each successive sampling point, the bailer must be decontaminated. The following steps are to be performed when sampling for organic contaminants. Note: contract-specific requirements may permit alternative procedures.

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush (may be required if the sample point is heavily contaminated with heavy or extremely viscous compounds)
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Pesticide-grade isopropanol (unless otherwise required)
- Pesticide-grade hexane rinse**
- Copious distilled/Deionized water rinse
- Air dry

If sampling for volatile organic compounds (VOCs) only, the nitric acid, isopropanol, and hexane rinses may be omitted. Only reagent grade or purer solvents are to be used for decontamination. When solvents are used, the bailer must be thoroughly dry before using to acquire the next sample.

In general, specially purchased pre-cleaned disposable sampling equipment is not decontaminated (nor is an equipment rinsate blank collected) so long as the supplier has provided certification of cleanliness. If decontamination is performed on several bailers at once (i.e., in batches), bailers not immediately used may be completely wrapped in aluminum foil (shiny-side toward equipment) and stored for future use. When batch decontamination is performed, one equipment rinsate is generally collected from one of the bailers belonging to the batch before it is used for sampling.

It is recommended that clean, dedicated braided nylon or polypropylene line be employed with each bailer use.

5.2.2 Sampling Pumps

Most sampling pumps are low volume (less than 2 gpm) pumps. These include peristaltic, diaphragm, air-lift, pitcher and bladder pumps, to name a few. If these pumps are used for sampling from more than one sampling point, they must be decontaminated prior to initial use and after each use.

The procedures to be used for decontamination of sampling pumps compare to those used for a bailer except that the 10 percent nitric acid solution is omitted. Each of the liquid fractions is to be pumped through the system. The amount of pumping is dependent upon the size of the pump and the length of the intake and discharge hoses. Certain types of pumps are unacceptable for sampling purposes. For peristaltic pumps, the tubing is replaced rather than cleaned.

An additional problem is introduced when the pump relies on absorption of water via an inlet or outlet hose. For organic sampling, this hose should be Teflon. Other types of hoses leach organics (especially phthalate esters) into the water being sampled or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (listed in order of preference).

* Due to the leaching ability of nitric acid on stainless steel, this step is to be omitted if a stainless steel sampling device is being used and metals analysis is required with detection limits less than approximately 50 ppb.

** If sampling for pesticides, PCBs, or fuels.

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Whenever possible, dedicated hoses should be used. It is preferable that these types of pumps not be used for sampling, only for purging.

5.2.3 Filtering Equipment

On occasion, the sampling plan may require acquisition of filtered groundwater samples. Field-filtering is addressed in SOP SA-6.1 and should be conducted as soon after sample acquisition as possible. To this end, three basic filtration systems are most commonly used: the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

For the in-line filter, decontamination is not required since the filter cartridge is disposable, however, the cartridge must be disposed of in an approved receptacle and the intake and discharge lines must still be decontaminated or replaced before each use.

For the over-pressure and the vacuum filtration systems, the portions of the apparatus which come in contact with the sample must be decontaminated as outlined in the paragraphs describing the decontamination of bailers. (Note: Varieties of both of these systems come equipped from the manufacturer with Teflon-lined surfaces for those that would come into contact with the sample. These filtration systems are preferred when decontamination procedures must be employed.)

5.2.4 Other Sampling Equipment

Field tools such as trowels and mixing bowls are to be decontaminated in the same manner as described above.

5.3 Field Analytical Equipment

5.3.1 Water Level Indicators

Water level indicators that come into contact with groundwater must be decontaminated using the following steps:

- Rinse with potable water
- Rinse with deionized water

Water level indicators that do not come in contact with the groundwater but may encounter incidental contact during installation or retrieval need only undergo the first and last steps stated above.

5.3.2 Probes

Probes (e.g., pH or specific-ion electrodes, geophysical probes, or thermometers) which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise (e.g., dissolved oxygen probes). Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, (e.g., OVA equipment) the probe is self-cleaning when exposure to uncontaminated air is allowed and the housing can be wiped clean with paper-towels or cloth wetted with alcohol.

5.4 Waste Handling

For the purposes of these procedures, contaminated materials are defined as any byproducts of field activities that are suspected or known to be contaminated with hazardous substances. These byproducts

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include such materials as decontamination solutions, disposable equipment, drilling muds, well-development fluids, and spill-contaminated materials and Personal Protection Equipment (PPE).

The procedures for obtaining permits for investigations of sites containing hazardous substances are not clearly defined at present. In the absence of a clear directive to the contrary by the EPA and the states, it must be assumed that hazardous wastes generated during field activities will require compliance with Federal agency requirements for generation, storage, transportation, or disposal. In addition, there may be state regulations that govern the disposal action. This procedure exclusively describes the technical methods used to control contaminated materials.

The plan documents for site activities must include a description of control procedures for contaminated materials. This planning strategy must assess the type of contamination, estimate the amounts that would be produced, describe containment equipment and procedures, and delineate storage or disposal methods. As a general policy, it is wise to select investigation methods that minimize the generation of contaminated spoils. Handling and disposing of potentially hazardous materials can be dangerous and expensive. Until sample analysis is complete, it is assumed that all produced materials are suspected of contamination from hazardous chemicals and require containment.

5.5 Sources of Contaminated Materials and Containment Methods

5.5.1 Decontamination Solutions

All waste decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

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. Larger equipment such as backhoes and tractors must be decontaminated in an area provided with an impermeable liner and a liquid collection system. A decontamination area for large equipment could consist of a bermed concrete pad with a floor drain leading to a buried holding tank.

5.5.2 Disposable Equipment

Disposable equipment that could become contaminated during use typically includes PPE, rubber gloves, boots, broken sample containers, and cleaning-wipes. These items are small and can easily be contained in 55-gallon drums with lids. These containers should be closed at the end of each work day and upon project completion to provide secure containment until disposed.

5.5.3 Drilling Muds and Well-Development Fluids

Drilling muds and well-development fluids are materials that may be used in groundwater monitoring well installations. Their proper use could result in the surface accumulation of contaminated liquids and muds that require containment. The volumes of drilling muds and well-development fluids used depend on well diameter and depth, groundwater characteristics, and geologic formations. There are no simple mathematical formulas available for accurately predicting these volumes. It is best to rely on the experience of reputable well drillers familiar with local conditions and the well installation techniques selected. These individuals should be able to estimate the sizes (or number) of containment structures required. Since guesswork is involved, it is recommended that an slight excess of the estimated amount of containers required will be available.

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Drilling muds are mixed and stored in what is commonly referred to as a mud pit. This mud pit consists of a suction section from which drilling mud is withdrawn and pumped through hoses, down the drill pipe to the bit, and back up the hole to the settling section of the mud pit. In the settling section, the mud's velocity is reduced by a screen and several flow-restriction devices, thereby allowing the well cuttings to settle out of the mud/fluid.

The mud pit may be either portable above-ground tanks commonly made of steel (which is preferred) or stationary in-ground pits as depicted in Attachment A. The above-ground tanks have a major advantage over the in-ground pits because the above-ground tanks isolate the natural soils from the contaminated fluids within the drilling system. These tanks are also portable and can usually be cleaned easily.

As the well is drilled, the cuttings that accumulate in the settling section must be removed. This is best done by shoveling them into drums or other similar containers. When the drilling is complete, the contents of the above-ground tank are likewise shoveled or pumped into drums, and the tank is cleaned and made available for its next use.

If in-ground pits are used, they should not extend into the natural water table. They should also be lined with a bentonite-cement mixture followed by a layer of flexible impermeable material such as plastic sheeting. Of course, to maintain its impermeable seal, the lining material used would have to be nonreactive with the wastes. An advantage of the in-ground pits is that well cuttings do not necessarily have to be removed periodically during drilling because the pit can be made deep enough to contain them. Depending on site conditions, the in-ground pit may have to be totally excavated and refilled with uncontaminated natural soils when the drilling operation is complete.

When the above-ground tank or the in-ground pit is used, a reserve tank or pit should be located at the site as a backup system for leaks, spills, and overflows. In either case, surface drainage should be such that any excess fluid could be controlled within the immediate area of the drill site.

The containment procedure for well-development fluids is similar to that for drilling muds. The volume and weight of contaminated fluid will be determined by the method used for development. When a new well is pumped or bailed to produce clear water, substantially less volume and weight of fluid result than when backwashing or high-velocity jetting is used.

5.5.4 Spill-Contaminated Materials

A spill is always possible when containers of liquids are opened or moved. Contaminated sorbents and soils resulting from spills must be contained. Small quantities of spill-contaminated materials are usually best contained in drums, while larger quantities can be placed in lined pits or in other impermeable structures. In some cases, onsite containment may not be feasible and immediate transport to an approved disposal site will be required.

5.6 Disposal of Contaminated Materials

Actual disposal techniques for contaminated materials are the same as those for any hazardous substance, that is, incineration, landfilling, treatment, and so on. The problem centers around the assignment of responsibility for disposal. The responsibility must be determined and agreed upon by all involved parties before the field work starts. If the site owner or manager was involved in activities that precipitated the investigation, it seems reasonable to encourage his acceptance of the disposal obligation. In instances where a responsible party cannot be identified, this responsibility may fall on the public agency or private organization investigating the site.

Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable

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onsite disposal structure is expected, contaminated materials generated during the investigation should be stored at the site for disposal with other site materials. In this case, the initial containment structures should be evaluated for use as long-term storage structures. Also, other site conditions such as drainage control, security, and soil type must be considered so that proper storage is provided. If onsite storage is expected, then the containment structures should be specifically designed for that purpose.

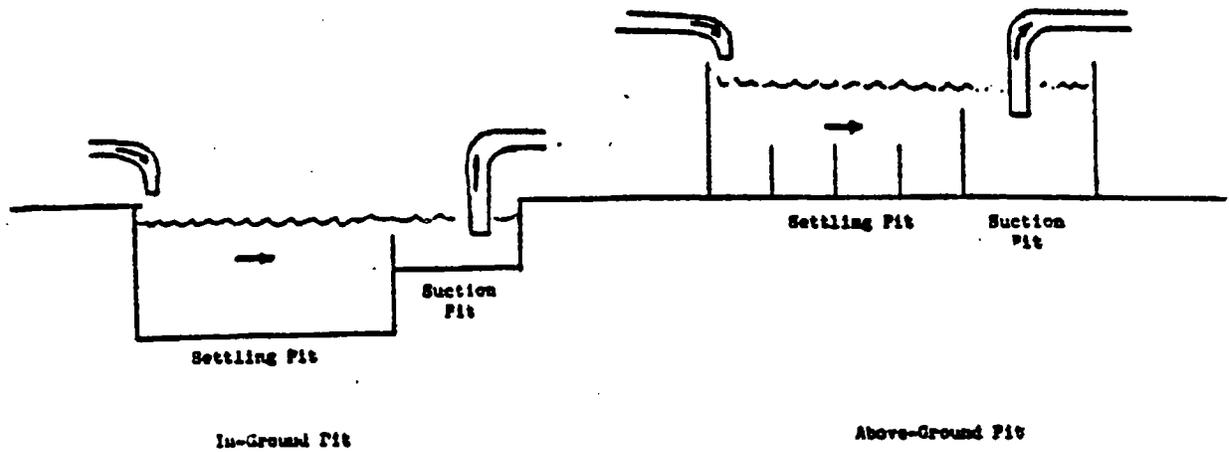
6.0 REFERENCES

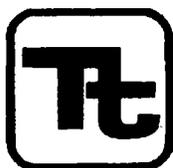
Brown & Root Environmental: Standard Operating Procedure No. 4.33, Control of Contaminated Material.

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ATTACHMENT A

TWO TYPES OF MUD PITS USED IN WELL DRILLING





TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Effective Date	06/99	Revision	4
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>ds</i>		

Subject
GROUNDWATER SAMPLE ACQUISITION AND
ONSITE WATER QUALITY TESTING

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. 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 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, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

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 standard hydrogen electrode.

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.

Salinity – Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

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Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. 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 the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. 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.
2. For wells that can be purged dry, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.
3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:
 - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.
 - The intake line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e.,

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floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed 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, ice, labels and chain-of-custody documents.
- Field tools and instrumentation - Multi-parameters water quality meter 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), engineer's rule, water level indicator.
- Pumps
 - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, 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 and inert line with tripod-pulley assembly (if necessary).
- Pails - Plastic, graduated.
- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), 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.

5.3 Calculations of Well Volume

To insure 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. 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 (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).
- Determine well or casing diameter.
- Measure and record static water level (depth below ground level or top of casing reference point).

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- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.
- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)1$

where: V = Static volume of well in gallons.
T= Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r = Inside radius of well casing in inches.
0.163 = A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection 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 that 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 the 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, field notebook, or on standardized data sheets.

5.4.2 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. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.

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- There is minimal outgassing of volatile organics while the sample is in the bailer.
- 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.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

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 a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These 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 significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water 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, leading to 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. The operation principles vary and the 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:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

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5.5 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
- Dissolved Oxygen (DO)
- Oxidation Reduction Potential (ORP)
- Certain Dissolved Constituents Using Specific Ion Elements
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

5.5.1 Measurement of pH

5.5.1.1 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.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and 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, 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.

5.5.1.2 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 pH range hydron paper.

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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 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.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- 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.
- pH indicator paper, to cover the pH range 2 through 12.
- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.
- 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.
- 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).
- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.
- Immerse the electrode(s) in the sample, slowly stirring the probe until the pH stabilizes. 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. This must be clearly noted in the logbook.
- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.
- Rinse the electrode(s) with deionized water.
- Store the electrode(s) in an appropriate manner when not in use.

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Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

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 adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 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 the 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, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.5.2.2 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, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or 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 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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13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes 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 near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 2 inches or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The 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 5 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 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 may be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, 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, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies.
- Interface probe, if needed.

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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.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 **Measurement of Dissolved Oxygen**

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration 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 dissolved oxygen meters only. 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, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen 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 current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since 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, while leaving the surface of the solution undisturbed.

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Dissolved oxygen 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, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 610).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned 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.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment C).
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- 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 can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

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Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or if a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds 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 oxidized to reduced species in the sample.

5.5.5.2 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 dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.
- Thoroughly rinse the electrode with deionized water.
- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases, and the ORP

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will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating 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. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of deionized water from a wash bottle. Place the sample in a clean container and insert the electrodes. Set temperature compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook or sample logsheet, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.5.6 Measurement of Turbidity

5.5.6.1 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, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method 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 (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Stand alone portable turbidity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 61).

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- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the probe in the sample and measure the turbidity. The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode with deionized water.

5.5.7 **Measurement of Salinity**

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 610).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

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5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the probes in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are 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 degrees of contamination between wells is unknown or insignificant, a sampling sequence which 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 as a result of the sampling procedures.
- 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, requirement for split samples, access problems, location of keys, etc.

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5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.
2. 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 (see SOP SA-6.3); then calculate the fluid volume in the well pipe (as previously described in this SOP).
3. Calculate well volume to be removed as stated in Section 5.3.
4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.
5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.
6. Measure the rate of discharge frequently. A graduated bucket and stopwatch are most commonly used; other techniques include use of pipe trajectory methods, weir boxes or flow meters.
7. Observe the peristaltic pump 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.
8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.
9. If sampling using a pump, lower the pump intake to midscreen (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.
10. (For pump and packer assembly 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.
11. In the event that 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 occurrence in the site logbook.
12. Fill sample containers (preserve and label as described in SOP SA-6.1).

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13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.
14. Process sample containers as described in SOP SA-6.1.
15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes 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 near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 2 inches or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The 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 5 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 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 may be used to check for and obtain samples of LNAPLs or DNAPLs.
- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, 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, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies.
- Interface probe, if needed.

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- 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 and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s), and other forms (e.g., well purging forms).
- 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.
- Field Sampling Plan.
- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Use a submersible pump to purge and sample monitoring wells which have a 2.0 inch or greater well casing diameter.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump, safety cable, tubing and electrical lines 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 two 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 three feet or less of standing water in the well.

When starting the pump, slowly increase the pump speed until a discharge occurs. Check water level. Adjust pump speed to maintain little or no water level drawdown. The target drawdown should be less than 0.3 feet and it should stabilize. If the target of less than 0.3 feet cannot be achieved or maintained, the sampling is acceptable if remaining criteria in the procedure are met. Subsequent sampling rounds will probably have intake settings and extraction rates that are comparable to those used in the initial sampling rounds.

Monitor water level and pumping rate every five to ten minutes (or as appropriate) during purging. Record pumping rate adjustments and depths to water. Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (e.g., 0.1-0.2 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During initial pump start-up, drawdown may exceed the 0.3 feet target and then recover as pump flow adjustments are made (minimum purge volume calculations should utilize stabilized drawdown values, not the initial drawdown). If the recharge rate of the well is less than minimum capability of the pump do not

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allow the water level to fall to the intake level (if the static water level is above the screen, avoid lowering the water level into the screen). Shut off the pump if either of the above is about to occur and allow the water level to recover. Repeat the process until field indicator parameters stabilize and the minimum purge volume is removed. The minimum purge volume with negligible drawdown (0.3 feet or less) is two saturated screen length volumes. In situations where the drawdown is greater than 0.3 feet and has stabilized, the minimum purge volume is two times the saturated screen volume plus the stabilized drawdown volume. After the minimum purge volume is attained (and field parameters have stabilized) begin sampling. For low yields wells, commence sampling as soon as the well has recovered sufficiently to collect the appropriate volume for all anticipated samples.

During well purging, monitor field indicator parameters (turbidity, temperature, specific conductance, pH, etc.) every five to ten minutes (or as appropriate). Purging is complete and sampling may begin when all field indicator parameters have stabilized (variations in values are within ten percent of each other, pH +/- 0.2 units, for three consecutive readings taken at five to ten minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every five to ten minutes. If pumping rate cannot be decreased any further and stabilized turbidity values remain above 5 NTU goal record this information. Measurements of field parameters should be obtained (as per Section 5.5) and recorded.

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.

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: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) 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; (3) 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, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

6.0 REFERENCES

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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			
	Water Level >25 feet				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®, Tetzel®	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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ATTACHMENT A
PURGING EQUIPMENT SELECTION
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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L ength (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 dependant 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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ATTACHMENT B

**SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT
VARIOUS TEMPERATURES¹**

Temperature (°C)	Specific Conductance (umhos/cm)
15	1,147
16	1,173
17	1,199
18	1,225
19	1,251
20	1,278
21	1,305
22	1,332
23	1,359
24	1,368
25	1,413
26	1,441
27	1,468
28	1,496
29	1,524
30	1,552

¹ Data derived from the International Critical Tables 1-3-8.

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ATTACHMENT C

**VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER
AS A FUNCTION OF TEMPERATURE AND SALINITY**

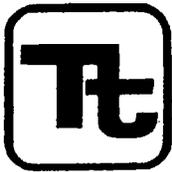
Temperature (°C)	Dissolved Oxygen (mg/L)						Difference/ 100 mg Chloride
	Chloride Concentration in Water						
	0	5,000	10,000	15,000	20,000		
0	14.6	13.8	13.0	12.1	11.3	0.017	
1	14.2	13.4	12.6	11.8	11.0	0.016	
2	13.8	13.1	12.3	11.5	10.8	0.015	
3	13.5	12.7	12.0	11.2	10.5	0.015	
4	13.1	12.4	11.7	11.0	10.3	0.014	
5	12.8	12.1	11.4	10.7	10.0	0.014	
6	12.5	11.8	11.1	10.5	9.8	0.014	
7	12.2	11.5	10.9	10.2	9.6	0.013	
8	11.9	11.2	10.6	10.0	9.4	0.013	
9	11.6	11.0	10.4	9.8	9.2	0.012	
10	11.3	10.7	10.1	9.6	9.0	0.012	
11	11.1	10.5	9.9	9.4	8.8	0.011	
12	10.8	10.3	9.7	9.2	8.6	0.011	
13	10.6	10.1	9.5	9.0	8.5	0.011	
14	10.4	9.9	9.3	8.8	8.3	0.010	
15	10.2	9.7	9.1	8.6	8.1	0.010	
16	10.0	9.5	9.0	8.5	8.0	0.010	
17	9.7	9.3	8.8	8.3	7.8	0.010	
18	9.5	9.1	8.6	8.2	7.7	0.009	
19	9.4	8.9	8.5	8.0	7.6	0.009	
20	9.2	8.7	8.3	7.9	7.4	0.009	
21	9.0	8.6	8.1	7.7	7.3	0.009	
22	8.8	8.4	8.0	7.6	7.1	0.008	
23	8.7	8.3	7.9	7.4	7.0	0.008	
24	8.5	8.1	7.7	7.3	6.9	0.008	
25	8.4	8.0	7.6	7.2	6.7	0.008	

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**ATTACHMENT C
 VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER
 AS A FUNCTION OF TEMPERATURE AND SALINITY
 PAGE TWO**

Temperature (°C)	Dissolved Oxygen (mg/L)						Difference/ 100 mg Chloride
	Chloride Concentration in Water						
	0	5,000	10,000	15,000	20,000		
26	8.2	7.8	7.4	7.0	6.6	0.008	
27	8.1	7.7	7.3	6.9	6.5	0.008	
28	7.9	7.5	7.1	6.8	6.4	0.008	
29	7.8	7.4	7.0	6.6	6.3	0.008	
30	7.6	7.3	6.9	6.5	6.1	0.008	
31	7.5						
32	7.4						
33	7.3						
34	7.2						
35	7.1						
36	7.0						
37	6.9						
38	6.8						
39	6.7						
40	6.6						
41	6.5						
42	6.4						
43	6.3						
44	6.2						
45	6.1						
46	6.0						
47	5.9						
48	5.8						
49	5.7						
50	5.6						

Note: In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore, used to correct measured D.O. concentration) using Attachment B.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>[Signature]</i>		

Subject
FIELD SCREENING

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1.0 PURPOSE

This Standard Operating Procedure (SOP) provides an overview of current techniques used to rapidly determine the presence or absence of various target organic compounds at hazardous waste sites. This SOP also describes the functions and capabilities of available instrumentation and provides suggestions of adapted methods suitable to the use and constraints of mobile laboratories. The purpose of this SOP is not to establish standardized analytical procedures, but to describe the concepts employed in field screening analyses. The purpose also is to provide guidance in the application of the best methodology practicable, based upon site-specific requirements, with consideration given to native interferences, specific data quality objectives, and variances in available instrumentation.

2.0 SCOPE

Field screening techniques provide for quantitative analysis of specified compounds by use of portable or transportable instruments based at, or near, a sampling site. As such, field screening provides unique information, and it is therefore important to understand the usability of the data generated. Because of the sophistication of the instruments used and their ability to identify specific compounds, field screening analysis should not be confused with non-specific techniques (for example, the process of obtaining total organic vapor readings from portable meters). However, because field screening results are not typically confirmed (i.e., are generated by non-confirmatory columns and detectors) and are supported by only moderate control criteria, field screening data may not be suitable for assessing risk.

The main asset of field screening lies in quick turn-around time and specific (though typically not confirmed) data, which are suitable for support in field decisions involving, for example, the best placement of well screens, the optimal positioning of monitoring wells, the focusing of sample submissions to fixed-base laboratories (i.e., the selection of samples that will yield the most important information), the delineation of contaminant plumes, the evaluation of unexpected exposures to the field crew, and fundamental regulatory/remedial support. In this manner, field screening allows for decisions to be made on a real-time basis while the field team is mobilized, thus avoiding the lag time which occurs when waiting for fixed-base laboratory results.

Field screening techniques are applicable to the analysis of air, soil gas, water and solid matrices for various volatile, semi-volatile, pesticide, and PCB compounds. For correlative and quality control purposes, field screening is usually performed in conjunction with a previously established percentage of sample submissions sent to a fixed-base laboratory as split-sample analyses.

3.0 GLOSSARY

Affinity - Molecular attraction

Inert Gas - Non-reactive gas, such as nitrogen or helium, which are commonly used as purge/carrier gas.

Isothermal - At constant temperature.

Neat - Undiluted.

Suspect - Estimated; of questionable accuracy.

Target Compound - Of the host of plausible compounds (i.e., compounds that would be recognized by the methodology used), the specific compounds chosen for analysis that are felt to be representative of site contamination. Typically, a few compounds are selected and monitored, thus facilitating the analytical effort.

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4.0 RESPONSIBILITIES

Personnel and assigned duties essential to the accomplishment of the above two tasks are outlined below:

- Project Manager - Responsible for developing, in consultation with other project personnel (e.g., geologists, chemists, engineers, toxicologists, client), a comprehensive work plan in which field screening activities are defined.
- Field Operation Leader - Responsible for the direct supervision of site activities.
- Sampler - Responsible for conducting sampling for submission to the mobile laboratory and fixed-base laboratory, packaging and shipment of samples to the fixed-base laboratory, and the preparation of all necessary paper work associated with sampling and shipment.
- Site Chemist - Responsible for the receipt and analysis of samples submitted to the mobile laboratory for targeted analysis. Responsible for giving guidance in conjunction with the interpretation and appropriate use of the field screening data. Responsible for the oversight of analytical QA/QC.

5.0 PROCEDURES

The following subsections discuss methodologies that have been applied successfully in the field screening of environmental samples obtained from hazardous waste sites. These methodologies are not stand-alone protocols and are not intended to serve as standardized analytical procedures. These methodologies are presented as formats within which analytical approaches, based on the referenced established methods, may be developed to fit site specific needs and data quality objectives. It is necessary for the site chemist and the project manager to address the specific modifications to the procedures that will be employed and to obtain the necessary approval prior to the commencement of site activities.

5.1 Field Screening of Target Purgeable Volatile Organic Compounds (Aqueous Matrix)

5.1.1 Overview

The following methodology describes a modification of EPA 600 series purge and trap gas chromatographic procedures suitable for the determination of volatile organic contaminants in aqueous matrix samples.¹ Via this methodology, a portion of neat sample or dilution is placed into a glass sparging vessel which is sealed onto a purging device. The contained sample aliquot is subjected to a stream of inert gas which is allowed to bubble through the matrix. This mechanical bubbling action effectively strips the contaminants (now volatilized) from the aqueous matrix and sweeps them onto a packed sorbent tube (i.e., trap), where they are subsequently desorbed (by the action of heat and reverse gas flow) onto a suitable column, housed in a pre-programmed gas chromatograph (GC). The contaminants become separated and resolved as they travel through the GC column. Eventually, the contaminants elute through an appropriate detector. The detector signals are processed and interpreted via a previously programmed integrator. Figure 1 provides a list of Potential Volatile Target Compounds.

¹ (EPA Methods 601, 602, 612, and 624).

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FIGURE 1

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Volatile Organics Analysis)
Acetone
Benzene
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chloroform
Ethylbenzene
Methylene chloride
1,1-Dichloroethene
total 1,2-Dichloroethenes
1,1-Dichloroethane
1,2-Dichloroethane
1,1,1-Trichloroethane
Tetrachloroethene
Toluene
Trichloroethene
Total Dichlorobenzenes
Total Xylenes
2-Butanone (MEK)
4-Methyl-2-pentanone (MIBK)

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5.1.2 Summary of Methods

Low Level Analysis - Use of 20 mL neat sample aliquot is suggested in order to achieve reportable detection limits of approximately 5 µg/L. Sample aliquots should be introduced into the sparger using a 10 mL GC syringe. Sample aliquots should not be pipetted, as the action of pipetting may compromise sample integrity due to mechanical stripping.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot plus a complementary portion of organic-free water for sparging. For example, a four-fold dilution can be simulated by injecting 5 mL of neat sample plus 15 mL of organic-free water. Similarly, extremely high concentration samples may be analyzed by spiking µL aliquots of neat sample in 19+ mL of organic-free water.

5.1.3 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the purging mechanism. Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

Samples can become contaminated by the diffusion of high concentration contaminants to lower concentrated samples through container seals during shipping and storage. If opted as part of the analysis plan, organic-free trip blanks may be developed and carried by the sampling team together with field samples to assess the existence and the magnitude of this phenomenon.

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this from occurring, the sample line and sparge vessel are thoroughly rinsed with organic-free water prior to the bake cycle of each highly contaminated sample run.

5.1.4 Major Apparatus and Materials

Purge and Trap Device - Tekmar Company Model LSC-2 or equivalent complete with a 25 mL glass sparge vessel and a 1/8-inch-O.D. x 25-cm-long stainless steel trap. The trap may be packed solely with Tenax. Alternately, trap packing may consist of 1.0 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph (GC) - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis, and direct-column injection.

Detector - PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivities of the target compounds being analyzed.

Analytical Column - Glass or stainless steel column packed with 1 percent SP-1000 on 60/80 mesh Carboxpack B. Alternatively a suitable capillary column may be used.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 mL, 10 mL.

Volumetric Flasks - 10 mL, 25 mL, 100 mL.

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Analytical Balance - Capable of accurately weighing 0.0001 g.

Oven - Constant temperature for the regeneration of contaminated apparatus.

Refrigerators - One dedicated refrigerator each for separate sample and standard storage. Each should be capable of maintaining a stable temperature of 4°C.

5.1.5 Reagents

Methanol - Pesticide grade or equivalent.

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity, or better, for each compound of interest.

5.1.6 Calibration

Standards - Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or by creating in-house standards from pure solvents. In-house calibration standards are prepared gravimetrically, in that an appropriate μL aliquot of each target compound is introduced into a known volume of methanol. The appropriate μL aliquot of compound is based upon the compound's density and response to the selected detector. Calibration standards are created at a level such that a 2-5 μL spike of standard into 20 mL of organic-free water is suitable for continuing calibration purposes.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component, thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 μL spike into organic-free water yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 μL , 5 μL , and 10 μL aliquot spikes. The linearity study for field screening is conducted in such a way as to substantiate the performance of the detector at the level of the reportable limits. It is not performed to demonstrate the entire range of detector capability.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily, using the mid-concentration standard: (1) preceding the daily analysis, (2) mid-day and (3) after the daily analyses.

5.1.7 Gas Chromatography

Preconcentration of sample contaminants is achieved through the purge-and-trap process in which stripped volatile contaminants are adsorbed onto a sorbent trap. The affinity the volatilized organic

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contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing), while other inert components pass through the tube. The purge and trap process consists of a prepurge cycle (optional), a purge cycle (during which contaminants are stripped away from the sample matrix and are trapped within the sorbent tube), a dry purge cycle (optional), a desorb cycle (in which the contaminants are backflushed off the sorbent tube and onto the GC column), and a bake cycle in which the sorbent tube (trap) is heated (with flow) to a high temperature, regenerating the trap. The selection of the appropriate temperature, options, and duration of the purge and trap processes are contingent upon the target compounds being analyzed. Generally, the following range of conditions apply:

Cycle	Temperature	Duration
Purge	Ambient	8 - 10 minutes
Desorb	180°C	2 - 4 minutes
Bake	215°C	7 - 10 minutes

Desorption of the adsorbed contents of the sorbent trap onto the head of a previously conditioned GC analytical column allows for subsequent analysis by temperature-programmed gas chromatography. The desorbed contaminants are first held at constant temperature (usually in the range of 45-55°C) at the head of the analytical column for a period of 3 to 5 minutes. After this initial time period, the GC oven temperature is raised at a constant rate (usually 8-15°C/minute) until a final temperature of 200-225°C is reached. The final temperature is customarily held for a period of 3 to 10 minutes.

The affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature, and the action of the carrier gas flow through the column cause the volatile contaminants to become separated and resolved, allowing them to elute in bands through the selected detector. As long as the analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of a standard mix containing known compounds and concentrations.

Quantitation of volatile contaminants in aqueous matrix samples is calculated based upon the following formula:

$$\text{Concentration sample } (\mu\text{g/L}) = \text{target peak response (sample)} \times \text{RF} \times \text{DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu\text{g/L})}{\text{Target Peak Response Std.}}$$

DF (Dilution Factor) is used when applicable

5.2 Field Screening of Target Purgeable Volatile Organic Compounds (Solid Matrix)

5.2.1 Overview

The following methodology describes a modification of SW846 analytical procedures suitable for the determination of volatile organic contaminants in solid matrix samples.² Via this methodology a portion of sample matrix, or extract, is placed into a glass sparging vessel along with 5-10 mL of organic-free water. The sparge vessel is then sealed onto a purging device. The contained sample (or extract) aliquot is heated while a stream of inert gas is bubbled through the slurry. The mechanical bubbling action effectively strips the contaminants (now volatilized) from the matrix slurry and sweeps them onto a packed sorbent tube (i.e., trap) where they are subsequently desorbed (by action of heat and reverse gas flow)

² (SW846 Methods 5030B/5035, 8015B, 8021B, 8121, 8260B, and 3580A).

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onto a suitable column, housed by a pre-programmed gas chromatograph (GC). The volatile contaminants become separated and resolved as they travel through the GC column. Eventually the contaminants elute through an appropriate detector. The detector signals are processed and interpreted by a previously programmed integrator (see Figure 1 for a list of Potential Volatile Target Compounds).

5.2.2 Summary of Methods

Low Level Analysis. Use of a 5 gram sample is suggested to achieve reportable detection limits of approximately 5 µg/kg. The solid matrix (free of obvious pebbles and unrepresentative organic matter) should be quickly measured directly into a tared sparge vessel. After the exact weight of sample is recorded, 5 mL of organic-free water is introduced into the sparger. A heated purge is required.

Medium Level Analysis. Simple dilutions may be achieved by using a reduced portion of the solid matrix (i.e., 1-<5 grams) and a complementary portion of 9 to 5 mL organic-free water. For example, a 2.5X dilution can be simulated by adding 8 mL of organic-free water to 2 grams of weighed matrix. Moderate to high concentration samples are prepared by extracting a 5 gram portion of solid matrix with 10 mL methanol. A suitable aliquot of the methanol extract (usually 10 µL to 200 µL) is then spiked into a sparge vessel containing 10 mL organic-free water. Note that the 1:2 ratio of sample to solvent has introduced a two-fold dilution. The additional dilution factor based upon the µL injection used must also be taken into consideration.

5.2.3 Interferences

The analysis of volatile organic contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.1.3. Additionally, some chromatographic artifacts may occur due to impurities present in the methanol used to extract medium/high concentration samples.

5.2.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.1.4, the following devices and materials are required:

Spurge Heater - Tekmar Model 4100 or equivalent. Must be capable of maintaining constant temperature during the purge process.

Pipettes - Assorted glass disposable: 1 mL, 5 mL, 10 mL.

Vials - 15 mL septum-seal for storage of sample extracts.

Vials - 40 mL septum-seal for use in extracting contaminants from sample matrix.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Aluminum Weighing Pans - For use in determining moisture content of the sample matrix.

5.2.5 Reagents

Reagents are as outlined in Subsection 5.1.5.

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5.2.6 Calibration

Standard preparation, peak identification, initial linearity, integration, and continuing calibration are accomplished as outlined in Subsection 5.1.6.

5.2.7 Sample Preparation

Medium to high concentration samples are extracted in methanol prior to chromatographic analysis. The following extraction protocol is suggested:

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial; record weight.
- Pipet a 10 mL volume of methanol into the vial. Assuming 100 percent transference of contaminants from matrix to methanol, note that a 2X dilution factor has been introduced.
- Remove the vial from the analytical balance, cap and shake vigorously for 2 full minutes (alternatively, vial contents may be sonicated).
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 15 mL vial.
- Perform a gas chromatographic analysis by spiking 10 μ L-200 μ L of the methanol extract into approximately 10 mL organic-free water. Calculate total dilution (deviation) from the original 5 gram sample base.

5.2.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.1.7 are applicable to the volatile organic analysis of solid matrix samples with the following additions:

Prepurge and dry-purge options of the purge and trap process are recommended; a heated purge is required. Sample prepurge enhances subsequent chromatography by allowing air molecules present in the sparge vessel to be replaced by inert purge gas molecules prior to the actual purge cycle. The dry-purge option follows the purge cycle. Dry-purge removes water vapor from the trap tube prior to the desorb cycle. The selection of appropriate purge and trap conditions are contingent upon the target compounds being analyzed. Generally, the following range of conditions apply:

Cycle	Temperature	Duration
Prepurge/Preheat	Ambient/to 40°C	2 minutes/1 minute
Purge	40°C	8 - 10 minutes
Dry-Purge	40°C	2 minutes
Desorb	180°C	3 - 5 minutes
Bake	215°C	7 - 10 minutes

Due to the extraction process and the need to correct the final value for moisture content, the quantitation of volatile contaminants in solid matrix samples is calculated based upon the following formula:

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Concentration (ug/kg) = Sample Peak Response (Area or Height) x RF x 1/wt. of sample extract(g) x
final volume (mL) x 1/ % solids

$$\text{where : RF (Response Factor)} = \frac{\text{Target Conc. Std. } (\mu\text{g/L})}{\text{Target Peak Response Std.}}$$

% solids = 100 - % moisture

$$\% \text{ moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.3 Field Screening of Target Semivolatile Organic Compounds (Aqueous Matrix)

5.3.1 Overview

The following methodology describes a modification of SW846 preparative and EPA 600 series analytical gas chromatographic procedures suitable for the determination of semi-volatile contaminants in aqueous matrix samples.³ Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed by a previously calibrated gas chromatograph (GC). The semi-volatile compounds are resolved by temperature-programmed gas chromatography and are detected by an FID (Flame Ionization Detector). The detector signals are processed and interpreted via a previously programmed integrator. Figure 2 provides a list of Potential Target Compounds.

5.3.2 Summary of Method

Low Level Analysis - Use of 25 mL neat sample aliquot is suggested. Detection limits vary per each compound sensitivity to the detector. Detection limits of approximately 100 µg/L to 800 µg/L are achievable.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 5 mL neat sample while retaining the same volume of extraction solvent.

5.3.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

³ (SW846 Methods 3550B and 3580A; EPA Methods 604, 605, 610, 611, and 625).

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FIGURE 2

SUMMARY OF POTENTIAL TARGET COMPOUNDS

(Semivolatile Organics Analysis)	
Acenaphthene	Hexachloroethane
Acenaphthylene	Naphthalene
Anthracene	2-Chloronaphthalene
Benzo(a)anthracene	2-Methylnaphthalene
Benzo(a)pyrene	Phenanthrene
total Benzofluoranthenes	Pyrene
Butyl benzyl phthalate	1,2,4-Trichlorobenzene
Chrysene	total Dichlorobenzenes
Diethyl phthalate	Phenol
Dimethyl phthalate	2-Chlorophenol
Di-n-butyl phthalate	2,4-Dichlorophenol
Di-n-octyl phthalate	2,4,5-Trichlorophenol
Fluoranthene	2,4,6-Trichlorophenol
Fluorene	2-Methylphenol
Hexachlorobenzene	4-Methylphenol
Hexachlorobutadiene	2,4-Dimethylphenol
Hexachlorocyclopentadiene	4-Chloro-3-methylphenol

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Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this from occurring, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.3.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with a temperature programmable oven and on-column injection capabilities.

Detector - Flame Ionization Detector (FID).

Analytical Column - Better resolution is achieved through use of a capillary column (such a DB-5 or equivalent). However, a packed column, such as 3 percent SP-2250 on 100/120 mesh Supelcoport, is more practical for field use.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 mL.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vials - 40 mL septum-seal for extraction.

Vials - 2 dram septum-seal for extract storage.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Hydrion Paper - To measure pH.

5.3.5 Reagents

Methanol - Pesticide grade or equivalent.

Methylene Chloride - Pesticide grade or equivalent.

Sulfuric Acid - 1N, reagent grade.

Neat Standards - 96 percent purity or better for each compound of interest.

5.3.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared from commercially purchased standard mixes or pure compound. All standards are made and/or diluted using a 1:1 mixture of methylene chloride: methanol and are created for use via a 2 µL direct injection.

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Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 µL spike yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 µL, 5 µL and 10 µL aliquot spikes.

Calibration. Calibration of the analytical system is achieved via the external standard method, in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF and known concentration. The RF for each peak is determined by dividing the known concentration by the peak response (area or height units) of the associated peak. For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analyses, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.3.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. The suggested protocol follows:

- Pipet 25 mL of aqueous sample matrix each into two 40 mL septum-seal vials; discard pipet.
- Add exactly 2.5 mL of methylene chloride to one of the vial's contents.
- Adjust the pH of the other vial's contents to pH<2 using sulfuric acid.
- Add exactly 2.5 mL methylene chloride to the adjusted contents of the second vial.
- Cap the vials and shake vigorously for 2 minutes.
- Set the vials aside and allow the contents to settle for 5 minutes.
- Combine the extracts by pipetting 1.5 mL each of the supernatant extracts into a 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 µL of combined sample extract onto the GC's analytical column.

5.3.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of methylene chloride extraction (see Subsection 5.3.7). A 2-5 µL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The semi-volatile contaminants are then resolved by temperature-programmed gas chromatography in which the action of carrier gas flow, elevated temperatures and the affinity each semi-volatile compound has for the phases of the column packing cause the contaminants to separate into bands. As the bands of contaminants elute from the column, they are recognized by an FID (Flame Ionization Detector). Detector signals are then processed

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by a previously programmed integrator. As long as analytical conditions remain constant, each semivolatile compound will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of a standard with known concentrations.

Under the following run conditions, most compounds of interest will elute within 32 minutes:

Run Parameter	Setting
Initial Column Temperature	100°C
Initial Hold Time	1 minute
Rate	10°C/minute
Final Column Temperature	300°C
Carrier Gas Flow	20 mL/minute

These conditions will need to be adjusted as necessary in order to optimize the resolution of the specific compounds of interest.

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration } (\mu\text{g/L}) = \text{Target peak response (sample)} \times \text{RF} \times \text{DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu\text{g/L})}{\text{Target Peak Response}}$$

DF (Dilution Factor) is used when applicable

5.4 **Field Screening of Target Semivolatile Organic Compounds (Solid Matrix)**

5.4.1 **Overview**

The following methodology describes a modification of SW846 analytical gas chromatographic procedures suitable for the determination of semi-volatile organic contaminants in solid matrix samples.⁴ Via this methodology, a 2 gram portion of a solid sample is extracted using rapid field techniques. An aliquot of the sample extract is then directly injected onto an analytical column for analyses by temperature-programmed gas chromatography. The semi-volatile contaminants are subsequently analyzed by a flame ionization detector (FID). The detector signals are processed by a previously programmed integrator (see Figure 2 for a list of Potential Target Compounds).

5.4.2 **Summary of Methods**

Low Level Analysis - The extraction of a 2 gram sample portion is suggested to achieve analytical results comparable to approximately 50 mg/kg reportable detection limits.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of methylene chloride.

⁴ (SW846 Methods 3550B and 3580A; 8041; 8061A; 8100; 8270C; and 8310).

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5.4.3 Interferences

The analysis of semi-volatile contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.3.3.

5.4.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.3.4, the following device is required:

Oven - Constant temperature; for use in the determination of moisture content.

5.4.5 Reagents

Methanol - Pesticide grade or equivalent.

Methylene Chloride - Pesticide grade or equivalent.

Sulfuric Acid - 1N, reagent grade.

Neat Standards - 96 percent purity or better for each compound of interest.

Anhydrous Sodium Sulfate - Used to remove moisture from the sample matrix.

5.4.6 Calibration

Standard preparation, peak identification, initial linearity, integration and continuing calibration are accomplished as outlined in Subsection 5.3.6.

5.4.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol follows:

- Weigh and tare two 40 mL septum-seal vials using an analytical balance.
- Add 2.0 grams of sample matrix (each) to the two vials. Record both sample weights.
- Add approximately 2 grams of anhydrous sodium sulfate to each vial. Mix the vial contents thoroughly using a clean spatula.
- Add exactly 10 mL of methylene chloride to each vial.
- Invert one vial several times to mix. Adjust the pH of this vial's contents to pH<2 using sulfuric acid.
- Cap the vial and shake vigorously for 2 full minutes (alternately, vial contents may be sonicated).
- Set the vials aside and allow the contents to settle for 5 minutes.
- Combine the extracts by pipetting off exactly 1.5 mL each of the supernatant extracts into a labeled 2-dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting a 2-5 µL aliquot of the combined sample extract onto the GC's analytical column.

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5.4.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.3.8 are applicable to the semivolatile analysis of solid matrix samples, with one addition:

Due to the extraction process and the need to correct the final value for moisture content, the quantitation of semi-volatile contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration } (\mu\text{g/kg}) = \frac{\text{Sample Peak Response (Area or Height)} \times \text{RF} \times 1/\text{wt. of sample extract(g)} \times \text{final volume (mL)} \times 1/\% \text{ solids}}{\text{Target Conc. Std. } (\mu\text{g/L})}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Conc. Std. } (\mu\text{g/L})}{\text{Target Peak Response Std.}}$$

$$\% \text{ solids} = 100 - \% \text{ moisture}$$

$$\% \text{ moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.5 Field Screening of Organochlorine Pesticides (Aqueous Matrix)

5.5.1 Overview

The following methodology describes a modification of EPA Method 608. This methodology is suitable for the determination of organochlorine pesticide contaminants in aqueous matrix samples. Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed in a previously calibrated gas chromatograph (GC). The pesticide contaminants are resolved isothermally and are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator. Figure 3 provides a list of Potential Target Compounds.

5.5.2 Summary of Methods

Low Level Analysis. A 20 mL neat sample aliquot is suggested to achieve method detection limits of approximately 0.5 µg/L.

Medium Level Analysis. Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 4 mL neat sample while retaining the same volume of extraction solvent.

5.5.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning, (3) residual contamination remaining on improperly cleaned glassware, and (4) matrix interferences caused by co-extracted organic matter.

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FIGURE 3

**SUMMARY OF POTENTIAL TARGET
COMPOUNDS**

(Organochlorine Pesticide Analysis)
Alpha-BHC
Beta-BHC
Delta-BHC
Gamma-BHC (Lindane)
Aldrin
Chlordane
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan sulfate
Endrin
Heptachlor
Heptachlor epoxide
4,4-DDD
4,4-DDE
4,4-DDT

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Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts, which manifest themselves as carryover in the next analytical run, can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.5.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with isothermal oven and on-column injection capabilities.

Detector - Electron Capture Detector (ECD)

Analytical Column - Glass or stainless steel packed with 1.5 percent SP-2250/1.95 percent SP-2401 on 100/120 mesh Supelcoport. Alternately, a 3 percent OV-1 on 80/100 mesh Supelcoport packed column or a suitable capillary column may be used.

Syringes - Assorted: 5 μ L, 25 μ L, 100 μ L, 1 mL.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vials - 40 mL septum-seal for extraction.

Vials - 2 dram septum-seal for extract storage.

Glass Marking Pen - For labeling vials.

Laboratory Timer - To use during the extraction process.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

5.5.5 Reagents

Hexane - Pesticide grade or equivalent.

Iso-octane - Distilled in glass.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.5.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared from commercially purchased standard mixes or pure compound. All standards are made and/or diluted using iso-octane and are created for use via a 2 μ L injection. An example of a working calibration standard within a practical concentration range follows:

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Compound	Concentration
Lindane	0.0125 ng/ μ L
Aldrin	0.0250 ng/ μ L
4,4'-DDT	0.0625 ng/ μ L

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the analysis of multiple-aliquot injections of calibration standard. For example, if the calibration standard is created such that a 2 μ L spike yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 2 μ L, 5 μ L, and 10 μ L aliquot spikes.

Calibration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each peak is determined by dividing the known concentration by the peak response (area or height units) of the associated peak. For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day, and (3) after the daily analysis. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.5.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. Samples are extracted in hexane according to the following suggested protocol:

- Pipet 20 mL aqueous sample matrix into a 40 mL septum-seal vial; discard pipet.
- Add 2.0 mL hexane to the measured matrix aliquot.
- Cap the vial and shake vigorously for 2 minutes.
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μ L of sample extract onto the GC's analytical column.

5.5.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of hexane extraction (see Subsection 5.5.7). A 2-5 μ L aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The organochlorine pesticide compounds are resolved isothermally due to the affinity each compound has for the phases of the column packing as they migrate (under flow) through the analytical column. As the contaminants elute from the column, they are recognized by an electron capture detector (ECD). Detector signals are then processed by a previously programmed integrator. As long as analytical conditions remain constant, each type of organochlorine compound will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard mix of known concentration.

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Under the following run conditions all commonly targeted organochlorine pesticides will elute within 15 minutes:

Injection Port Temperature	300°C
Isothermal Oven Temperature	215°C
Detector Temperature	350°C
Carrier Gas Flow	70 mL/minute

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration } (\mu\text{g/L}) = \text{Target Peak Response (Sample)} \times \text{RF} \times \text{DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Concentration Std. } (\mu\text{g/L})}{\text{Target Peak Response Std.}}$$

DF (Dilution Factor) is used when applicable

5.6 **Field Screening of Organochlorine Pesticides (Solid Matrix)**

5.6.1 **Overview**

The following methodology describes a modification of SW846 analytical gas chromatographic procedures suitable for the determination of organochlorine pesticide contaminants in solid matrix samples.⁵ Via this methodology, a 5 gram portion of solid sample is extracted using rapid field techniques. A 2-5 μL aliquot of sample extract is then directly injected onto an analytical column for the isothermal resolution of target compounds. The organochlorine pesticide contaminants are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator.

5.6.2 **Summary of Method**

Low Level Analysis - Use of a 5 gram portion of sample is suggested to achieve method detection limits of approximately 25 $\mu\text{g/kg}$.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of iso-octane.

5.6.3 **Interferences**

The analysis of organochlorine pesticide contaminants in solid matrix samples is susceptible to the same interferences discussed in Subsection 5.5.3.

5.6.4 **Major Apparatus and Materials**

In addition to the equipment listed in Subsection 5.5.4, the following device is required:

Oven - Constant temperature; for use in the determination of moisture content.

⁵ (SW846 Methods 3550B, 3580A, and 8081A).

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5.6.5 Reagents

Hexane - Pesticide grade or equivalent.

Iso-Octane - Distilled in glass.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

Anhydrous Sodium Sulfate - Used to remove moisture from the portion of soil prior to extraction.

5.6.6 Calibration

Standard preparation, peak identification, initial linearity, integration, and continuing calibration are accomplished as outlined in Subsection 5.5.6.

5.6.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested extraction protocol follows:

- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial; record weight.
- Add approximately 3 grams of anhydrous sodium sulfate; mix thoroughly using a clean spatula.
- Pipet 8.0 mL of hexane into the vial.
- Cap the vial and shake vigorously for 2 minutes (alternately, vial contents may be sonicated).
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μ L of sample extract onto the GC's analytical column.

5.6.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.5.8 are applicable to the pesticide analysis of solid matrix samples, with one modification:

Due to the need to correct the final value for moisture content, the quantitation of pesticide contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration } (\mu\text{g/kg}) = \frac{\text{Sample Peak Response (Area or Height)} \times \text{RF} \times 1/\text{wt. of sample extract(g)} \times \text{final volume (mL)} \times 1/\% \text{ solids}}{1}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target Conc. Std. } (\mu\text{g/L})}{\text{Target Peak Response Std.}}$$

$$\% \text{ solids} = 100 - \% \text{ moisture}$$

$$\% \text{ moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

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5.7 Field Screening of Polychlorinated Biphenyl (PCB) Compounds (Aqueous Matrix)

5.7.1 Overview

The following methodology describes a modification of EPA Methods 608 and 625. This methodology is suitable for the determination of polychlorinated biphenyl (PCB) contaminants in aqueous matrix samples. Via this methodology, a portion of neat sample is extracted using rapid field techniques. An aliquot of sample extract is then directly injected onto an analytical column housed by a previously calibrated gas chromatograph (GC). The PCB contaminants are resolved isothermally and are detected by an electron capture detector (ECD). Detector signals are processed and interpreted via a previously programmed integrator (see Figure 4 for a list of Potential Target Compounds).

5.7.2 Summary of Method

Low Level Analysis - A 20 mL neat sample aliquot is suggested to achieve method detection limits of approximately 15 µg/L.

Medium Level Analysis - Proportioned dilutions may be achieved by using a reduced sample aliquot. For example, a five-fold dilution can be simulated by extracting only 4 mL neat sample while retaining the same volume of extraction solvent.

5.7.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analyses of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts (which manifest themselves as carryover in the next analytical run) can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.7.4 Major Apparatus and Materials

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for packed or capillary column analysis with isothermal oven and on-column injection capabilities.

Detector - Electron Capture Detector (ECD).

Analytical Column - Glass or stainless steel packed with 1.5 percent SP-2250/1.95 percent SP-2401 on 100/120 mesh Supelcoport or equivalent. Alternately, a suitable capillary column may be used.

Syringes - Assorted: 5 µL, 25 µL, 100 µL, 1 ml.

Analytical Balance - Capable of accurately weighing 0.0001 g.

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FIGURE 4

**SUMMARY OF POTENTIAL TARGET
COMPOUNDS**

(PCB Analysis)
Aroclor-1016
Aroclor-1221
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

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Vials - 40 mL septum-seal for sample extraction.

Glass Marking Pen - For labeling vials.

Laboratory Timer - For use during the extraction process.

Vials - 2 dram septum-seal for extract storage.

Pipets - Assorted: 1 mL, 5 mL, 10 mL; disposable glass.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

5.7.5 Reagents

Hexane - Pesticide grade or equivalent.

Neat Standards - 96 percent purity or better for each compound of interest.

Zero-Grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.7.6 Calibration

Standards. A singular calibration standard for each PCB compound is prepared from commercially purchased standards or pure compound. All standards are made and/or diluted using hexane and are created for use via a 2 µL injection. A working calibration standard concentration of 0.375 ng/µL for each Aroclor is usually practical.

Peak Identification. Each PCB compound is identified by its unique pattern (fingerprint). The identity of each target Aroclor is substantiated by the singular analysis of each individual Aroclor.

Calibration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each individual Aroclor are obtained by the analysis of a standard of known concentration. For each Aroclor analyzed, the responses of several peaks characteristic to that particular Aroclor are summated. Following the analysis of this known standard, a file is created noting each Aroclor's pattern (i.e., the retention times of each characteristic peak), the appropriate RF and known concentration. The RF for each Aroclor is determined by dividing the Aroclor's known concentration by the summated peak responses (area or height units) which were taken from the associated pattern. The concentration of PCB contaminants in samples is usually hand calculated by manually summating the responses of the characteristic peaks and comparing them to the analogous summated peaks designated in the Aroclor standard.

Continuing Calibration - Calibration of the analytical system is performed three times daily: (1) preceding the daily analyses, (2) mid-day, and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.7.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol for hexane extraction follows:

- Pipet 20 mL aqueous sample matrix into a 40 mL septum-seal vial; discard pipet.

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- Add 2.0 mL hexane to the measured matrix aliquot.
- Cap the vial and shake vigorously for 2 minutes.
- Set the vial aside and allow the contents to settle for 5 minutes.
- Pipet off the supernatant extract into a labeled 2-dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μL of sample extract onto the GC's analytical column.

5.7.8 Gas Chromatography

Sample contaminants are first stripped from the matrix by means of hexane extraction (see Subsection 5.7.7). A 2-5 μL aliquot of the sample extract is introduced onto the head of a previously conditioned analytical column by means of direct injection technique. The PCB compounds are resolved isothermally due to the affinity the PCB components have for the phases of the column's packing as they migrate (under flow) through the analytical column. As the contaminants elute from the column, they are recognized by an electron capture detector (ECD). Detector signals are then processed by an integrator. As long as analytical conditions remain constant, each PCB pattern will elute at characteristic retention times (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standards of known concentration.

The following run conditions have been found to be practical for the analysis of PCB compounds analyzed by field screening techniques:

Run Parameter	Setting
Injection Port Temperature	280°C
Isothermal Oven Temperature	215°C
Detector Temperature	300°C
Carrier Gas Flow	30 mL/minute

Under these conditions, Aroclor-1260 will elute within 35 minutes.

Appropriate quantitation of sample contaminants is based upon the following formula:

$$\text{Concentration } (\mu\text{g/L}) = \Sigma \text{ designated peak responses (sample)} \times \text{RF} \times \text{DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Concentration standard}}{\Sigma \text{ designated peak responses std.}}$$

DF (Dilution Factor) is used when applicable

5.8 Field Screening of Polychlorinated Biphenyl (PCB) Compounds (Solid Matrix)

5.8.1 Overview

The following methodology describes a modification of SW846 Methods suitable for the determination of polychlorinated biphenyl (PCB) contaminants in solid matrix samples.⁶ Via this methodology, a 5 gram portion of solid sample is extracted using rapid field techniques. A μL aliquot of sample extract is then directly injected onto an analytical column for the isothermal resolution of target components. The PCB pattern is recognized by an electron capture detector (ECD) with detector signals processed by a previously programmed integrator (see Figure 4 for a list of Potential Target Compounds).

⁶ (SW846 Methods 3550B, 3580A, and 8082).

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5.8.2 Summary of Methods

Low Level Analysis - Use of a 5 gram portion of sample matrix is suggested to achieve method detection limits of approximately 100 µg/kg.

Medium Level Analysis - Sample dilutions are achieved by diluting a portion of the sample extract (as above) in an appropriate volume of hexane.

5.8.3 Interferences

Interferences inherent to this procedure stem from four major sources: (1) impurities present in the solvents used for extraction, (2) system artifacts caused by insufficient column conditioning (3) residual contamination remaining on improperly cleaned glassware and (4) matrix interferences caused by co-extracted organic matter.

Interferences in the analytical system are monitored by the analysis of method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, in order to establish average background response.

Artifacts (which manifest themselves as carryover in the next analytical run) can also occur within the analytical apparatus whenever a highly contaminated sample is introduced. To preclude this, injection syringes are repeatedly flushed with solvent and the analytical column is baked for a short period of time following each direct injection analysis.

5.8.4 Major Apparatus and Materials

In addition to the equipment listed in Subsection 5.7.4, the following device is required:

Oven - Constant temperature for use in the determination of moisture content.

5.8.5 Reagents

Methanol - Pesticide grade or equivalent.

Hexane - Pesticide grade or equivalent.

Neat Compounds - 96 percent purity or better for each Aroclor of interest.

Organic-Free Water - Laboratory supplied or purchased.

Zero-grade Nitrogen - As carrier gas for the gas chromatograph (GC).

5.8.6 Calibration

Standard preparation, compound identification, integration and continuing calibration are accomplished as outlined in Subsection 5.7.6.

5.8.7 Sample Preparation

All samples must be extracted prior to chromatographic analysis. A suggested protocol for hexane extraction follows:

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- Weigh and tare a 40 mL septum-seal vial using an analytical balance.
- Add 5.0 grams of sample matrix to the vial; record weight.
- Pipet approximately 1.5 mL of organic-free water into the vial. (The water serves as a wetting agent thus facilitating the transference of the PCB compounds from the soil matrix into the methanol.)
- Pipet approximately 2 mL of methanol into the vial.
- Pipet 2.5 mL of hexane into the vial. (By preference, the PCB compounds almost exclusively partition into the hexane.)
- Cap the vial and shake vigorously for 2 minutes (alternately, vial contents may be sonicated).
- Pipet off the supernatant extract into a labeled 2 dram septum-seal vial.
- Gas chromatographic analysis is performed by directly injecting 2-5 μ L of sample extract onto the GC's analytical column.

5.8.8 Gas Chromatography

The same chromatographic theory and GC run conditions outlined in Subsection 5.7.8 are applicable to the PCB analysis of solid matrix samples, with one modification.

Due to the need to correct the final value for moisture content, the quantitation of PCB contaminants in solid matrix samples is calculated based upon the following formula:

$$\text{Concentration } (\mu\text{g/kg}) = \frac{\Sigma \text{ designated peak responses (sample)} \times \text{RF} \times 1/\text{wt. of sample extract(g)} \times \text{final volume (mL)} \times 1/\% \text{ solids}}{\Sigma \text{ designated peak responses std.}}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Concentration Standard}}{\Sigma \text{ designated peak responses std.}}$$

$$\% \text{ solids} = 100 - \% \text{ moisture}$$

$$\% \text{ moisture} = \frac{\text{Wet wt.} - \text{Dry wt.}}{\text{Wet wt.}} \times 100$$

The protocol for determining percent moisture is presented in Subsection 5.12.

5.9 Field Screening Analysis of Ambient Air

5.9.1 Overview

The following methodology describes a modification of EPA Compendium methods suitable for the determination of volatile organic contaminants in ambient air.⁷ Via this methodology, an aliquot of gaseous sample is routed through a packed sorbent tube. Volatile contaminants present in the gaseous

⁷ (EPA Compendium Methods TO-1, TO-2, TO-3, and TO-12).

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sample are adsorbed onto the packing within the sorbent tube. The contents of the sorbent tube are subsequently desorbed (by action of heat and reverse gas flow) onto a suitable column housed by a pre-programmed gas chromatograph (GC). The contaminants become separated and resolved as they travel through the GC's column. Eventually, the contaminants elute through an appropriate detector. Detector signals are processed and interpreted via a previously programmed integrator (see Figure 1 for a list of Potential Target Compounds).

5.9.2 Summary of Method

The procedure described here is based upon the analysis of whole air samples collected in canisters or Tedlar bags. However, this procedure can easily be adapted for the analysis of samples collected directly on sorbent tubes or for source sample analysis using aliquot introduction into the GC via direct gaseous injection or an appropriate size commercial sample loop.

5.9.3 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the trapping/desorption device. Interferences in the analytical system are monitored by the analysis of inert gas method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

5.9.4 Major Apparatus and Materials

Purge and Trap Device - Tekmar Model LSC-2 or Model 5000. Traps may be packed solely with Tenax or alternately, trap packing may consist of 1.0 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis and on-column injection.

Detector - PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivities of the target compounds being analyzed.

Analytical Column - Glass or stainless steel packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternately a suitable capillary column may be used.

Syringes - Assorted: 5 μ L, 25 μ L, 100 μ L, 1 mL, 10 mL.

Volumetric Flasks - 10 mL, 25 mL, 100 mL.

Tedlar Bag - For making gaseous standards.

Flow Meter - For use in measuring the exact volume of gas introduced to the Tedlar.

Analytical Balance - Capable of accurately weighing 0.0001 g.

Vacuum Pump - Low draw, positive seal.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

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5.9.5 Reagents

Methanol - Pesticide grade or equivalent.

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity or better for each compound of interest.

Ultra-high Purity Nitrogen - For use in generating standards and method blanks.

5.9.6 Calibration

Standards. Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or by creating in-house standards from pure solvents. In-house calibration standards are prepared gravimetrically, in that an appropriate μL aliquot of each target compound is introduced into a known volume of methanol. The appropriate μL aliquot of compound is based upon the compound's density and response to the selected detector. The calibration standards should be created at such a level that a 5-10 μL spike into a 1 liter Tedlar bag filled with nitrogen yields a concentration of 10 $\mu\text{g/L}$ based upon the analysis of a 500 mL aliquot. Aliquots are evacuated onto a clean trap. Alternately, commercially prepared stock calibration gases may be used.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

Initial Linearity. An initial three-point calibration curve is generated by the trapping and analysis of multiple aliquots of calibration standard. For example, if the calibration standard is created such that analysis of a 500 mL aliquot of standard yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 500, 700 and 1,000 mL aliquots.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.9.7 Gas Chromatography

Preconcentration of sample contaminants is achieved through the trapping process in which the volatile contaminants are adsorbed on to a sorbent trap. The affinity that the volatilized organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing) while other components of the gaseous aliquot pass through the tube.

Desorption of the adsorbed contents of the sorbent trap onto the head of a previously conditioned GC analytical column allows for subsequent analysis by temperature-programmed gas chromatography. The

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desorbed contaminants are first held at constant temperature (usually in the range of 45-55°C) at the head of the analytical column for a period of 3-5 minutes. After this initial time period, the GC oven temperature is raised at a constant rate (usually 8-15°C/minute) until a final temperature of 200-225°C is reached. The final temperature is customarily held for a period of 3-10 minutes.

The preferential affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature and the action of carrier gas flow through the column cause the volatile contaminants to become separated and resolved allowing them to elute in bands through the selected detector. As long as analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard of known concentration.

The quantitation of volatile contaminants is calculated based upon the following formula:

$$\text{Concentration sample } (\mu\text{g/L}) = \text{Target peak response (sample)} \times \text{RF} \times \text{DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target concentration standard } (\mu\text{g/L})}{\text{Target peak response std.}}$$

DF (Dilution Factor) is used when applicable

5.10 Field Screening Analysis of Volatile Contaminants in Soil Gas Matrix

5.10.1 Overview

The following methodology describes a modification of SW846 and EPA Compendium methods as applied to the determination of volatile organic contaminants in soil gas.⁸ Via this methodology, a sorbent tube containing previously trapped volatile organic contaminants obtained via the sampling of soil gas matrix, is subsequently desorbed (by action of heat and reverse gas flow) onto a suitable analytical column housed by a pre-programmed gas chromatograph (GC). The volatile organic contaminants become separated and resolved as they travel through the GC's column. Eventually, the contaminants elute through an appropriate detector. Detector signals are processed and interpreted via a previously programmed integrator. Figure 1 provides a list of Potential Target Compounds.

5.10.2 Interferences

Interferences can result from many sources, considering the environmental settings of most hazardous waste sites. However, most interfering impurities are artifacts originating from organic compounds within the specialty gases and the plumbing within the trapping/desorption device. The presence of air molecules and excessive water vapor and/or the degradation of the trap packing can also account for many artifacts.

Interferences in the analytical system are monitored by the analysis of inert gas method blanks. Method blanks are analyzed under the same conditions and at the same time as standards and samples, to establish an average background response.

⁸ (SW846 Method 5041A; EPA Compendium Methods TO-1, TO-2, TO-3, and TO-12).

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5.10.3 Major Apparatus and Materials

Purge and Trap Device - Tekmar Model LSC-2 or Model 5000. Traps may be packed solely with Tenax or, alternately, trap packing may consist of 10 cm of 3 percent OV-1, 15 cm of Tenax and 8 cm of silica gel. Appropriate trap selection is contingent upon the target compounds being analyzed.

Gas Chromatograph - Hewlett Packard 5890 or equivalent. The analytical system should be equipped for temperature programming, packed and/or capillary column analysis, and on-column injection.

Detector. PID/FID or PID/HECD in series; FID only. Optimum detector selection should be based upon the sensitivity to the detector for the target compounds being analyzed.

Analytical Column. Glass or stainless steel packed with 1 percent SP-1000 on 60/80 mesh Carbopack B. Alternately a suitable capillary column may be used.

Syringes - Assorted gas tight 5 μ L, 25 μ L, 100 μ L, 1 mL, 10 mL.

Volumetric Flasks - 10 mL, 25 mL, 100 mL.

Tedlar Bags - For making gaseous standards.

Flow Meter - For use in measuring the exact volume of gas introduced to the Tedlar bag.

Analytical Balance - Capable of accurately weighting 0.0001 g.

Vacuum Pump - Low draw, positive seal.

Refrigerator - Separate for sample and standard storage. Capable of maintaining a stable temperature of 4°C.

5.10.4 Reagents

Methanol - Pesticide grade or equivalent

Organic-Free Water - Supplied by laboratory or purchased.

Neat Solvents - 96 percent purity or better for each compound of interest.

Ultra-high Purity Nitrogen - For use in generating standards and method blanks.

5.10.5 Calibration

Standard. Calibration standards containing the compounds of interest are prepared in methanol by either diluting commercially purchased stock standard mixes or pure solvents. In-house calibration standards are prepared gravimetrically in that a μ L aliquot of each target compound is introduced into a known volume of methanol. The appropriate μ L aliquot of compound is based upon the compounds density and response to the selected detector. The calibration standards should be created at such a level that a 5-10 μ L spike into a 1-liter Tedlar bag filled with nitrogen yields a concentration of 10 μ g/L based upon the analysis of a 500 mL aliquot. Aliquots are evacuated onto a clean trap. Alternately, commercially prepared stock calibration gases may be used.

Peak Identification. Compound identities may be substantiated by the analysis of each individual component thereby documenting compound retention time.

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Initial Linearity. An initial three-point calibration curve is generated by the trapping and analysis of multiple aliquots of calibration standard. For example, if the calibration standard is created such that analysis of a 500 mL aliquot of standard yields results at the level of the reported detection limits, a three-point calibration curve may be achieved by the analysis of 500, 700 and 1,000 mL aliquots.

Integration. Calibration of the analytical system is achieved via the external standard method in which response factors (RF) for each compound are obtained by the analysis of a standard mix of known concentration. Following the analysis of this known standard mix, an electronic file is created establishing each peak's identity, retention time, RF, and known concentration. The RF for each target compound is determined by dividing the known concentration by the associated peak response (area or height units). For initial calibration, each compound's average response factor is determined by averaging the peak response results generated for the initial linearity study. These average response factors are programmed into the integrator to allow for direct concentration reading of contaminants found in subsequent sample analyses.

Continuing Calibration. Calibration of the analytical system should be updated three times daily: (1) preceding the daily analysis, (2) mid-day, and (3) after the daily analyses. Continuing calibration should be conducted at a concentration level equal to the reported detection limits.

5.10.6 Sample Preparation

Prior to the desorption and analysis of previously trapped soil gas contaminant tubes, the introduction of a surrogate spike compound via a short purge is recommended. In addition to enhancing quality assurance, this short purge cycle allows inert gas molecules to replace potentially destructive air molecules still entrained within the trap tube. The surrogate spike compound should be introduced to the trap via the following procedure:

- Program the Tekmar LSC-2 device for a 3 minute purge, 3 minute desorb and 8 minute bake cycle.
- Insert a previously trapped soil gas contaminant tube.
- Spike 2 μ L of an appropriate surrogate spike solution (such as 1 μ g/ μ L 2-bromo-1-chloropropane) into a glass sparge vessel containing 20 mL organic-free water.
- Purge the surrogate spike onto the trap. Desorb and analyze.

5.10.7 Gas Chromatography

Preconcentration of soil gas matrix contaminants is achieved through the sampling process in which the volatile contaminants are adsorbed onto the sorbent trap. The affinity that the volatile organic contaminants have for the special packing inside the sorbent tube cause them to be retained within the tube (i.e., adsorbed onto the packing) while other components of the gaseous matrix pass through the tube.

Following the addition of a surrogate spike compound, the adsorbed contents of the sorbent trap are desorbed (by action of heat and reverse gas flow) onto the head of a previously conditioned GC analytical column. The desorbed contaminants are first held at constant temperature (usually between 45-55°C) for an initial time period of 3-5 minutes. The desorbed contaminants are subsequently analyzed by temperature-programmed gas chromatography in which, following the initial hold, the GC oven temperature is raised at a constant rate (usually 8-15°C/minute) until a final temperature of 200-225°C is reached. The final temperature is customarily held for a period of 3-10 minutes.

The preferential affinity of the volatile contaminants to either the analytical column's mobile or stationary phase, the effect of elevated temperature and the action of carrier gas flow through the column cause the volatile contaminants to become separated and resolved allowing them to elute in bands through the

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selected detector. As long as analytical conditions remain constant, each type of volatile component will elute at a characteristic retention time (RT). In this manner, sample contaminants are identified and quantified by comparison to a run of standard of known concentration.

The quantitation of volatile contaminants is calculated based upon the following formula:

$$\text{Concentration sample } (\mu\text{g/L}) = \text{Target peak response (sample)} \times \text{RF} \times \text{DF}$$

$$\text{where : RF (Response Factor)} = \frac{\text{Target concentration standard } (\mu\text{g/L})}{\text{Target peak response std.}}$$

DF (Dilution Factor) is used when applicable

5.11 Quality Assurance/Quality Control (QA/QC)

5.11.1 Overview

Field screening generates Level II data. As Level II data, the concurrent analysis of laboratory duplicates and matrix spike analyses and the use of surrogate spike compounds is not required. However, beyond the maintenance of practical Standard Operating Procedures (SOPs), certain elements of quality control (if opted) can greatly enhance the interpretation of and the confidence in the data generated. These traditional elements of quality control are discussed here with respect to how they are adapted to meet the demands of a successfully applied field screening QA/QC program.

The primary purposes of an appropriate QA/QC program are to: (1) substantiate system performance and give credence to the accuracy of the results generated, (2) to define aberrations and give guidance to the interpretation of data, and (3) to achieve these goals through realistic efforts that do not impede the forward progress of the analytical set.

The discussion presented here deals with only direct analytical quality control. Additional elements of QA/QC, such as field duplicate sample submissions, blind spike analysis and external audits are not discussed. Also not discussed are elements of QA/QC that are inherent to good chromatographic technique. Examples of these accepted laboratory practices include (but are not limited to) the following:

- The proper conditioning of analytical columns and traps.
- Use of the solvent flush technique for the creation of standards and for direct injections.
- The appropriate maintenance of selected detectors.

Details regarding these accepted practices are given in the referenced methodologies.

5.11.2 Holding Times

The primary purpose of field screening is to provide cost-effective, specific data on a near- to real-time turn-around basis. For this reason, samples submitted to the mobile laboratory should be analyzed as soon as possible. Samples awaiting analysis are stored at 4°C in a dedicated refrigerator. If, because of loading, it is not possible to analyze all samples taken daily, the following holding times are suggested:

Type of Sample	Holding Time
VOA (aqueous matrix)	7 days prior to analysis
VOX (soil matrix)	10 days prior to analysis
SEMI, PEST, and PCB (aqueous matrix)	5 days prior to extraction; analysis within 30 days
SEMI, PEST, and PCB (soil matrix)	5 days prior to extraction; analysis within 30 days

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5.11.3 Sample Sets

Analyses should be conducted in sets of ten, whenever possible, with one laboratory duplicate spike analysis run per set. Each set of sample analyses should be bracketed by the analysis of a standard, with a method blank analysis following each standard run.

The number of analyses per sample set and the associated QA/QC varies per contract. The project work plan/QAPP should be consulted to verify that all contractual obligations are met.

5.11.4 Continuing Calibration

Standards run for continuing calibration purposes should be analyzed at a level equal to the reported detection limits. Continuing calibration response factors for each parameter should fall within 25 percent difference (D) of the average response factor calculated for that particular compound during the initial linearity study (see Figure 5). Data associated with individual parameter not meeting the 25 percent D criteria should be flagged as suspect.

5.11.5 Laboratory Duplicates

One laboratory duplicate should be analyzed per sample set. Laboratory duplicate analyses should generate results within 30 percent RPD (see Figure 5).

5.11.6 Matrix Spike Analyses

Matrix spikes should be conducted at a level of 1-4 times the concentration of the reported detection limits. One matrix spike analysis should be run per every 20 samples. Advised recovery ranges vary with respect to the compound being analyzed. Recoveries of 35-150 percent are generally acceptable (see Figure 5).

5.11.7 Surrogate Spikes

The use of at least one surrogate spike compound is highly recommended. The identity, concentration and addition of the appropriate surrogate spike varies with the procedure being used. Each associated referenced methodology should be consulted for guidance. Surrogate spike recoveries should fall within ± 30 percent (see Figure 5). Sample analyses yielding recoveries outside this 30 percent window should be reanalyzed or the associated data should be flagged as suspect.

5.11.8 Initial Linearity

An initial linearity study is performed as described in each adapted methodology. The associated response factors should all fall within <20 percent RSD (see Figure 5). Standard runs yielding data that does not meet the <20 percent RSD criteria should be reanalyzed.

5.11.9 Method Blanks

Method blanks are prepared and analyzed in exactly the same manner as sample matrices. A method blank analysis should follow every standard run and sample of high concentration. Ideally, method blank results should yield no interferences to the chromatographic analysis and interpretation of target compounds. If interferences are present, associated data should be qualified as suspect and/or target detection limits should be adjusted accordingly.

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5.11.10 Detection Limits

The appropriate method detection limit (MDL) for an adapted methodology may be statistically calculated using results generated for the initial linearity study and continuing calibrations, or, method detection limits may be substantiated by the analysis of a low standard at the level of the anticipated MDL.

5.12 Supplemental Protocol: Percent Moisture Determination

A moisture correction factor (MCF) is used to adjust the value generated for the amount of contaminant present in a solid matrix sample, so that the value reflects the true (dry weight) concentration of contaminant. Moisture content is determined gravimetrically. The following protocol is suggested for determining percent moisture:

- Mark and weigh an aluminum tare using an analytical balance. Record weight; tare balance.
- Place 5-10 grams of matrix (free from unrepresentative pebbles and organic matter) into the pan; record weight.
- Place the pan and its contents into a drying oven heated to 103°C.
- Dry the matrix for a period of 4-6 hours (or until weight is constant).
- Remove the pan from the oven and allow to cool to room temperature.
- Weigh the pan and record the weight.
- Calculate percent moisture and the MCF.

5.13 Supplemental Protocol: Field Screening Validation

The validation process serves as an independent check thus ensuring the proper performance of all QA/QC measures. Figures 6 and 7 illustrate a validation protocol that is suitable for the evaluation of field screening data.

6.0 REFERENCES

"Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," EPA-600/4-82-057. (EPA 600 Series methods):

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FIGURE 5

QC COMPUTATIONS

$$\% \text{ RSD (Relative Standard Deviation)} = \frac{SD}{X} \times 100$$

$$\text{where: } SD = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1}}$$

X = mean of initial four response factors (per compound)

$$\% \text{ RPD (Relative Percent Difference)} = \frac{D_1 - D_2}{(D_1 + D_2) / 2} \times 100$$

where: D₁ = First Sample Value

D₂ = Second Sample Value

$$\% \text{ D (Percent Difference)} = \frac{X_1 - X_2}{X_1} \times 100$$

where: X₁ = RF (Response Factor) of first result

X₂ = RF of Second Result

$$\% \text{ R (Percent Recovery)} = \frac{SSR - SR}{S} \times 100$$

where: SSR = Spike Sample Results

SR = Sample Result

S = Amount of Spike Added

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FIGURE 6
TtNUS/FIELD SCREENING
VALIDATION PROTOCOL

1. Verify that samples were handled in sets of ten or less.
2. Verify that at least one laboratory duplicate was run once every ten samples.
3. Verify that one matrix spike analysis was performed once every 20 samples.
4. Ensure that at least one surrogate spike compound was used.
5. Substantiate daily initial calibration table.
6. Determine if at least one standard was run every 8 hours and that a calibration standard was run after every set of ten samples (plus QC runs).
7. Check standard tracking form to ensure that parameter response factors fall within 25 percent of the initial calibration. If parameters exceed 25 percent value, check to see how problem was corrected and verify all reported results for that parameter were flagged as suspect.
8. Check that method blanks were run after every calibration and every sample of high concentration. Verify that any system artifacts were tracked and reported.
9. Verify that reported detection levels have been properly substantiated.
10. Evaluate chromatograms of target compound peaks for proper identification. (Check peak shapes and shoulders.)
11. Check quantitations of approximately 20 percent of samples.
12. Verify if statistics have been calculated for the data package.
13. Verify retention time window.
14. Determine if each chromatogram reports the following information:
 - a. Sample name/number
 - b. Date/time of analysis
 - c. Laboratory duplicate designation (if applicable)
 - d. Matrix spike designation (if applicable)
 - e. Concentration/dilution value recorded (if applicable)
 - f. Retention time reported at apex of each peak
 - g. Chromatographic report generated includes peak name, retention time, peak area or peak height.

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FIGURE 6
TtNUS/FIELD SCREENING
VALIDATION PROTOCOL
PAGE TWO

15. Verify that package Operations Record contains the following information:
 - a. Purge, desorb, and bake time of sample concentrator
 - b. GC flow rate, attenuation, range, initial temperature, initial time, ramp, final temperature, final time; injection temperature and detector temperature.
16. Verify that chain of custody was maintained.
17. Verify that package narrative relates all pertinent information necessary to properly interpret results.

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FIGURE 7
TtNUS/FIELD SCREENING
VALIDATION RECORD

Project Name/Number: _____ Sample Matrix: _____
 Dates Samples Received: _____ Data Reviewer: _____
 Dates Samples Analyzed: _____ Data Reviewed: _____

Evaluation Checklist:

_____ Data Completeness	_____ Duplicate Analyses Results
_____ Calibration Records	_____ Matrix Spike Recoveries
_____ Method Blank Analyses	_____ Compound Identification
_____ Surrogate Spike Results	_____ Detection Limits Achieved

Reviewer's Evaluation	Volatiles	Acids	Base/Neutrals	PCBs/Pesticides
Acceptable				
Acceptable with Exception(s)				
Questionable				
Unacceptable				

Validator's Comments:

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Method	Title
601	Purgeable Halocarbons
601	Purgeable Aromatics
604	Phenols
606	Phthalate esters
608	Pesticides and PCBs
610	Polynuclear Aromatic Hydrocarbons
612	Chlorinated Hydrocarbons
624	Purgeables
625	Base/Neutrals, Acids, and Pesticides

"Test Methods for the Evaluation of Solid Waste," SW-846, EPA Publication No. 955-001-00000-1. (SW846 preparative methods):

Method	Title
5030B	Purge and Trap Technique for Aqueous Samples
5041A	Protocol for Analysis of Sorbent Cartridges
3580A	Waste Dilution
5035	Purge and Trap and Extraction for VOCs in Soil and Waste Samples

"Test Methods for the Evaluation of Solid Waste," SW846, EPA Publication No. 955-001-00000-1. (SW846 analytical methods):

Method	Title
8015	Non-halogenated Volatile Organics
8021B	Aromatic and Halogenated Volatile Organics
8041	Phenols
8061	Phthalate Esters
8081A	Organochlorine Pesticides
8100	Polynuclear Aromatic Hydrocarbons
8121	Chlorinated Hydrocarbons
8260B	GC/MS for Volatile Organics
8270C	GC/MS for Semi-volatile Organics (Capillary Column)
8310	Polynuclear Aromatic Hydrocarbons
8082	Polychlorinated Biphenyls

"Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," EPA-600/4-84-041.

Method	Title
TO-1	Tenax GC Adsorption
TO-2	Carbon Molecular Sieve Adsorption
TO-3	Cryogenic Trapping
TO-12	NMOC in Ambient Air Using Preconcentration and FID

"Field Measurement of PCBs in Soil and Sediment Using a Portable Gas Chromatograph," Spittler, Dr. Thomas. U.S. EPA Region I.

"Comparability of Field Screening Data to Fixed-base Laboratory Results," Scheib, Debra A., Dr. H. Roffman and C. Kieda. NUS Corporation.

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"Manual of Field Analytical Technique," Scheib, Debra A. NUS Corporation.

7.0 RECORDS

A formalized system for tracking and reporting information is essential to appropriately document the specific analytical approach used to support the investigation of a hazardous waste site. Sound record keeping practices serve to:

- Document the QA/QC measures performed.
- Substantiate sample integrity.
- Present data in a usable form.
- Organize and record the occurrences pertinent to the interpretation of the data generated.
- Function as the historical record leading to the development of new methodologies and for the improvement of existing methods.

In light of the advances in laboratory automation and computer technology, record keeping can take the form of either electronic file or bench data sheets. Regardless of the method of record keeping employed while in the field, the submission (to the Project Manager) of a formalized, hard-copy data package upon conclusion of the field screening activity is strongly recommended. Examples of useful bench data sheets not already presented in this text follow as Figures 8 through 20. A suggested Table of Contents (Figure 21) and data package Cover Sheet (Figure 22) are also presented.

Mobile laboratory facilities vary greatly in design. Consequently, in addition to the maintenance of pertinent records, a site-specific S.O.P. (Standard Operating Procedure) should be developed to provide the following:

- Specific information regarding the operation and maintenance of the particular affiliated instrumentation.
- Guidance regarding the hook-up of power and other necessary services.
- Procedures addressing the disposal of laboratory waste.
- Materials and supply resources.
- Towing and transport considerations.
- Housekeeping requirements.

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FIGURE 9
TINUS/FIELD SCREENING

DATA QUALIFIERS

- B - found in blank
- DL - detection limit
- DNI - peak "did not integrate;" quantitation is not possible
- J - estimated quantity
- u - compound analyzed for but value generated is below reported DL
- r - GC peak over range. Peak exceeds linear range of detector and is not quantifiable
- () - compound present, but detected at levels below the reported DL

CHROMATOGRAM NOTATIONS

- ART - artifact; peak produced by chromatographic system, not caused by sample content
- au - area units
- D - laboratory duplicate
- hu - height units
- MB - method blank
- MS - matrix spike
- NEAT - sample is not diluted
- FD - field duplicate

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FIGURE 10

**TtNUS/FIELD SCREENING
OPERATIONS RECORD**

General Information:

Date(s) _____	Task Name _____	Std Used _____
Site Name _____	Task No. _____	Analyst _____
Site No. _____	Matrix _____	

Chromatographic Programming:

Flow _____	In. Temp. _____	Inj. Temp. _____
Attn _____	In. Time _____	Det. Temp. _____
Range _____	Rate _____	Other _____
Col. _____	Fin. Temp. _____	
Detector _____	Fin. Time _____	

Integration System:

File _____	Speed _____	<u>Other</u> _____
Attn _____	Zero/Slope _____	_____
Range _____	Min. Area _____	_____
Method _____	Stop Time _____	_____
Format _____		_____

Purge/Desorption System:

Purge Time _____	SP-2 _____	Prepurge _____
Desorb _____	SP-3 _____	Preheat _____
Bake Time _____	SP-4 _____	Purge Temp. _____
SP-1 _____	SP-5 _____	Line Temp. _____

Comments:

FIGURE 11

TtNUS/FIELD SCREENING
ANALYTICAL STANDARDS LOG

Target Compound	Desired Final Concentration*	Matrix Amount	Required Dose	Desired Standard Injection	Required Standard Concentration	Volume of Standard	Compound Density	Calculation	Amount Neat Compound
Example: Trichloroethene	3 ppb	20 mL	0.06 µg/L	2 µL	0.03 µg/µL	50,000 µL	1,465 µg/µL	$\mu\text{L} = \{0.03 \mu\text{g}/\mu\text{L} \times 50,000 \mu\text{L}\} \div 1,465 \mu\text{g}/\mu\text{L}$	1.02

*Example: $\frac{3 \mu\text{g}}{\text{L}} = \frac{3 \mu\text{g}}{1,000 \text{ mL}} = 0.06 \mu\text{g per 20 mL}$

Therefore, 0.06 µg per 2 µL injection of standard.

Therefore, standard concentration must equal 0.03 µg/µL.

Formula: Neat Solvent (µL) = $\frac{\text{Required Std. Concentration } (\mu\text{g/L}) \times \text{Volume of Std. } (\mu\text{L})}{\text{Compound Density } (\mu\text{g}/\mu\text{L})}$

Check: $1.02 (\mu\text{L}) \times \frac{1,494 \mu\text{g}}{\mu\text{L}} = \frac{1,494 \mu\text{g}}{5,000 \mu\text{L}} \times 2 \mu\text{L} = \frac{0.0598 \mu\text{g}}{20 \text{ mL}} \times \frac{1,000 \text{ mL}}{\text{L}} = 2.99 \text{ ppb}$

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**FIGURE 14
TtNUS/FIELD SCREENING**

METHOD BLANK SUMMARY (OVERVIEW)

By definition, method blanks consist of an equal aliquot of like matrix + surrogate spike. For quality control/troubleshooting purposes, it sometimes becomes necessary to exclude the surrogate spike or run variations of the matrix. In order to avoid confusion, distinctions of various types of blanks are clarified here:

Trip Blank - previously prepared VOA vials filled with organic-free water, sealed and transported with sample containers. These sealed vials are not opened until analysis; their purpose is to ensure no cross contamination (migration of contaminants through the container's seal) has occurred during transit.

Rinsate Blank - a containerized aliquot of bailer or sampler washwater. Ensures appropriate cleaning and rinsing of the sampling equipment.

Prepared Soil Matrix Blank - a laboratory soil matrix blank is prepared by obtaining an amount of soil and baking it in the drying oven overnight at 105°C to drive off volatile organic compounds. An aliquot of prepared matrix is run without surrogate spike to ensure the matrix is free of contaminants.

Aqueous Method Blank - an aliquot of organic-free water + surrogate spike.

Solid Method Blank - an aliquot of prepared soil matrix + surrogate spike.

Water Purge (System Blank) - an aliquot of organic-free water only; no surrogate spike.

Repurge - repurging, trapping and analysis of material run previously in sparging apparatus.

Desorption/Redesorption - desorb and analysis of trap without any additional purging.

GC Column Only - analysis of GC column response without any prior desorption onto the GC.

Comments regarding the various blank analyses performed for this site appear on the following summary sheets:

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**FIGURE 20
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C. Data qualifiers		C. Run roster
		D. Supplemental support data
		- Quantitations
		- Surrogate
		recoveries
<u>SECTION II</u>		<u>SECTION V</u>
A. Sample chromatograms		A. Shipping data
B. Operations record		B. Communications notes
C. Percent moisture determinations		C. Analytical methodology
<u>SECTION III</u>		<u>SECTION VI</u>
A. Standard chromatogram		A. Validation procedure
B. Analytical standards log		B. Validation record
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F. Method blank chromatograms		

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**FIGURE 21
COVER SHEET**

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Project Number/Name: _____

Analysis/Matrix: _____

Dates: _____

File _____ of _____