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SITE ASSESSMENT PLAN UNDERGROUND STORAGE TANK (UST) FOR ZONE C CNC CHARLESTON SC
03/01/1999
TETRA TECH INC

SITE ASSESSMENT PLAN
ZONE C - UST

Charleston Naval Complex
Charleston, South Carolina

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO-0093

MARCH 1999

SITE ASSESSMENT PLAN
ZONE C - UST

CHARLESTON NAVAL COMPLEX
CHARLESTON, SOUTH CAROLINA

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1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) has prepared this Site Assessment Plan (SAP) for Zone C at the Charleston Naval Complex, Charleston, South Carolina. This SAP was prepared for the U.S. Navy (Navy) Southern Division (SouthDiv) Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0093, for the Comprehensive Long-term Environmental Action Navy (CLEAN III) Contract Number N62467-94-D-0888.

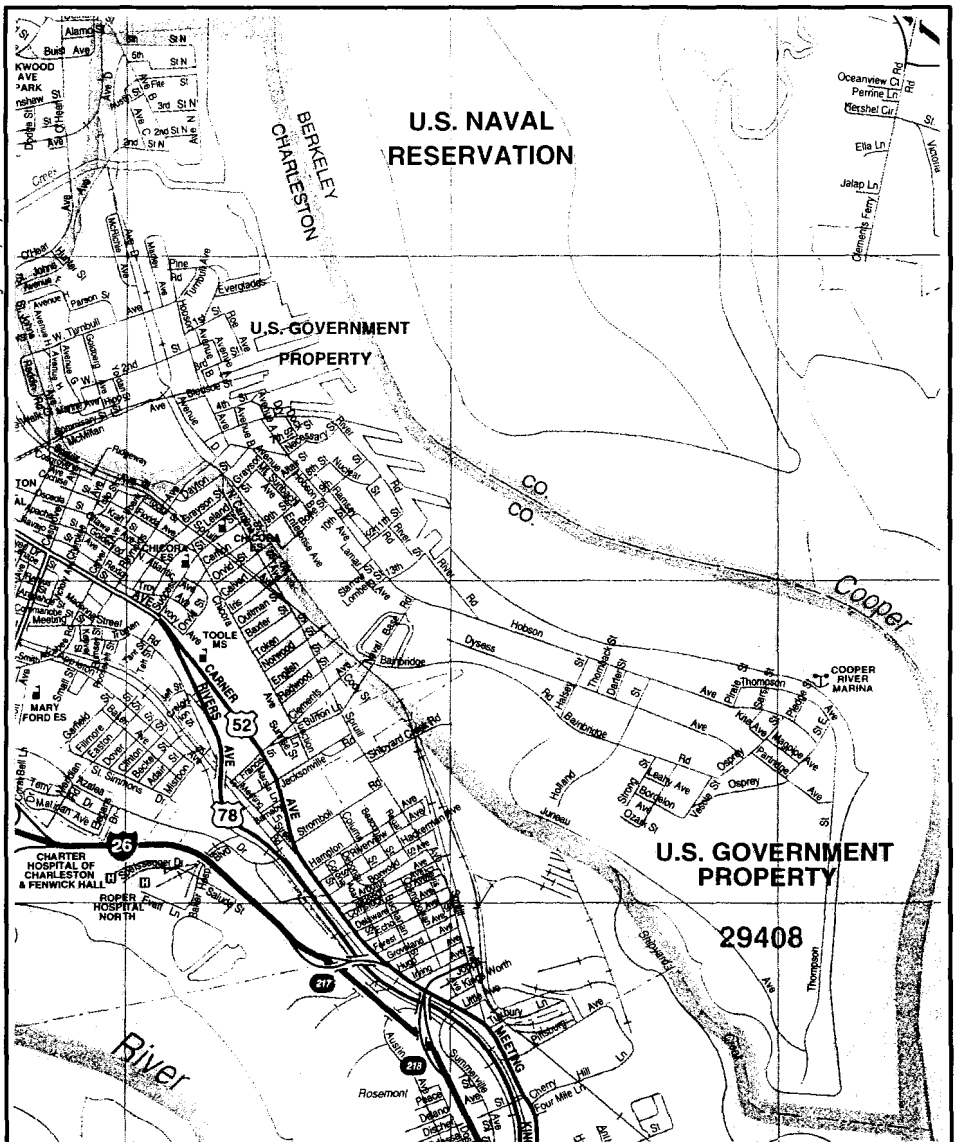
The SAP provides the rationale for performing field activities associated with collecting data to evaluate the impact of petroleum products on the subsurface at the referenced site. Data collected during the investigations will be used to prepare Rapid Assessment Reports (RAR) in accordance with South Carolina Department of Health and Environmental Control (SDHEC) Underground Storage Tank Control Regulations R.61-92. In accordance with SCDHEC's June 1995 guidance document, "Rapid Assessment", TtNUS has prepared a Rapid Assessment Plan (RAP) for each site included in this investigation. The RAPs are provided in Appendix A.

1.1 GENERAL SITE DESCRIPTION

The Charleston Naval Complex (CNC) is located on the western shore of the Cooper River in Charleston County, about five miles north of the city of Charleston, South Carolina. The CNC comprises approximately 2,879 acres. All Naval commands at CNC are closed. Operational closure of the commands was completed on 01 April 1996. A facility location map is provided as Figure 1-1.

1.2 OBJECTIVE

As indicated in the Statement of Work (SOW), the objective of this investigation is to determine the extent of petroleum contamination and assess if further action is required to remediate the sites. The results of the investigation will be submitted in a Rapid Assessment Report (RAR) for each site. If the RAR concludes that active remediation is required, an Active Corrective Action Plan will be prepared. An Intrinsic Corrective Action Plan recommending "monitoring only" or "no further action" will be submitted if the RAR concludes that active remediation is not required.



DRAWN BY RO DATE 2/4/99	DEPARTMENT OF THE NAVY SOUTHERN DIV FACILITIES ENGINEERING COMD	FACILITY LOCATION MAP CHARLESTON NAVAL COMPLEX - ZONE C CHARLESTON, SOUTH CAROLINA	CONTRACT NO.
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2.0 SITE DESCRIPTION

The Naval facilities that comprised the former base are located on the western bank of the Cooper River. The topography at CNC, which is generally flat, consists of average land surface elevations of less than 5 feet above mean sea level. Much of the base is situated on dredge spoils that were used as fill in low lying tidal marsh areas. Commercial, industrial, and residential areas surround the complex. Due to its location on the river's edge, it is also surrounded by diverse ecosystems. There are many wetlands and tidal marsh areas with a great variety of aquatic life as well as plants, birds, and animals.

All surface drainage flows directly into the Cooper River. The water table occurs within 3 to 6 feet of the ground surface. The shallow aquifers are very low yield and are not a practical source of drinking water due to the high levels of dissolved solids and chlorides. However, one of the shallow aquifers is used as an industrial water source. The shallow aquifers in the vicinity of the CNC drain to the Cooper River. Pathways exist for contaminants to migrate via surface water runoff and via infiltration into the shallow aquifer to sensitive ecosystems downstream.

3.0 TANK CLOSURE ASSESSMENTS

Zone C is predominantly an industrial area located in the southern portion of CNC. Zone C had a combination of heating fuel and waste oil tanks. A total of 47 underground storage tanks (USTs) and aboveground storage tanks (ASTs) were permanently closed at CNC Zone C. As a result of the tank removal activities, petroleum contamination was discovered at 12 tank locations within CNC Zone C. One of these locations will not be investigated under the petroleum program. The remaining 11 tank locations wil be addressed in the proposed program. Tank locations in close proximity will be assessed as a single site. Therefore, a total of six sites willl be included in this investigation, the sites are as follows:

Site 29 UST NH46-5
Site 30 USTs NH46-1, NH46-2, NH46-3, NH46-4
Site 31 UST 760
Site 32 UST 54
Site 33 UST NH62-1, AST NH62-2
Site 34 UST NH1137-2, AST NH1137-1

As per SCDHEC requirements, Rapid Assessment Plans (RAP) have been prepared for these six sites and are included in Appendix A.

4.0 SCOPE OF PROPOSED ASSESSMENTS

The proposed scope of work for assessment activities will take place in two phases. The first phase (Phase 1) will consist of performing a soil and groundwater assessment using direct push technology (DPT), such as a geoprobe, to install soil borings. This technique will be used to delineate the horizontal and vertical extent of vadose zone soil contamination. In conjunction with the DPT soil boring installation, Organic Vapor Analyzer (OVA) screening will be performed on the soil samples and a mobile laboratory will be utilized to screen soil and groundwater samples for benzene, toluene, ethyl-benzene, xylenes (BTEX), and Diesel Range Organics (DRO). The soil and groundwater data will be used to determine the optimum location and number of permanent monitoring wells. Three soil borings at each site will be converted to piezometers where necessary to determine groundwater flow direction. 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 those sites where utilities prevent the installation of a conventional monitoring well.

The second phase (Phase 2) will involve permanent well installation, sampling and surveying of monitoring wells, pump tests and tidal studies. The placement of the monitoring wells will be based on ground water flow gradients and water quality data collected during the Phase 1 field investigation. If any existing site monitoring wells are screened in the surficial aquifer, groundwater from these wells will also be sampled during Phase 2. Specific capacity tests will be performed on three shallow monitoring wells, and a tidal survey will be conducted to measure tidal influence on the water table at the site locality.

In accordance with the "Rapid Assessment" guidance, a South Carolina registered surveyor will survey each site after the Phase II investigation activities have been completed. The survey will include: the locations of all structures, aboveground and underground utilities, potential receptors, and existing or former underground storage tanks and associated piping.

4.1 SOIL INVESTIGATION

The soil vapor assessment will be conducted using DPT. This method of drilling is preferred due to the subsurface lithology, which is predominantly silts and silty sands, the presence of a shallow water table, and to minimize the amount of investigation derived waste generated during boring activities. The rationale for soil boring locations will be based on the results of the tank closure reports for each site.

Soil samples will be collected continuously 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 soils will be screened for vapors with an OVA, using the headspace analysis method. The soil borings will be advanced until the water table is encountered. It is anticipated that groundwater will be encountered within 3 to 6 feet of the ground surface. Prior to beginning each bore hole, the drilling crew will hand auger or post hole from the surface to four feet bls to ensure that no underground utilities are present. Soil borings will initially be advanced on a 10 by 10-foot grid until the areal extent of soil contamination is determined. An average of 20 soil borings per site is anticipated. One soil boring from each site will be advanced to a depth of approximately 30 feet bls to characterize the site geology. Soil samples for lithologic description will be collected continuously from this boring to determine if a confining unit is present at the site. The number and spacing of the soil borings will be adjusted in the field as necessary based on field screening data and site conditions.

Each soil boring will be abandoned by grouting the annulus to land surface with Type 1 Portland Cement. Boring locations drilled through asphalt or concrete will be completed with similar material and finished flush to existing grade. All soil samples obtained from the borehole will be screened with an OVA and then used for lithologic and/or chemical analysis as described in Section 5.1 of this plan.

A lithologic description will be made of each sample collected. The site geologist will maintain a completed log of each boring 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 should be included on each log, as well as any other pertinent observations.

4.2 GROUNDWATER FIELD SCREENING FOR BTEX AND DIESEL RANGE ORGANICS (DRO) AND PIEZOMETER INSTALLATIONS

During the Phase 1 soil vapor survey, a groundwater sample will be collected from the termination of each soil boring for on-site analysis. The samples will be collected using a peristaltic pump. The samples will be placed into appropriate sample bottles and immediately analyzed for BTEX and DRO constituents using a mobile laboratory equipped with a gas chromatograph (GC). The DPT method of collecting groundwater samples is the preferred method for field screening groundwater because many groundwater samples can be collected over a short period of time without installing temporary and/or permanent monitoring wells.

At each site, three borings installed during the soil vapor survey will be converted into piezometers and completed with a screened monitoring interval that intersects the water table. Relative groundwater elevations will be determined from static water level measurements collected from the piezometers. The groundwater elevation data will be used to determine the groundwater flow direction across the site. The locations of the piezometers will be determined in the field.

The results from the preliminary investigation will be tabulated and plotted. The summarized data will be sent to the Navy and SCDHEC for review. After the data has been reviewed, a conference call will be scheduled to discuss the preliminary data and reach consensus on the optimum number and placement of permanent monitoring wells.

4.3 GROUNDWATER INVESTIGATION

Monitoring wells will be installed at each site to delineate the horizontal and vertical extent of dissolved hydrocarbons. The installation of the monitoring wells will be completed during the Phase 2 field investigation. The proposed monitoring well locations will be determined based on field screening data obtained during the DPT investigation and the groundwater flow gradient across the site. The Navy and SCDHEC will be contacted to discuss the locations of the proposed monitoring wells prior to mobilizing for Phase 2 activities. The anticipated number of monitoring wells required for each site are included in the Rapid Assessment Plans provided in Appendix A.

4.3.1 Monitoring Well Installation

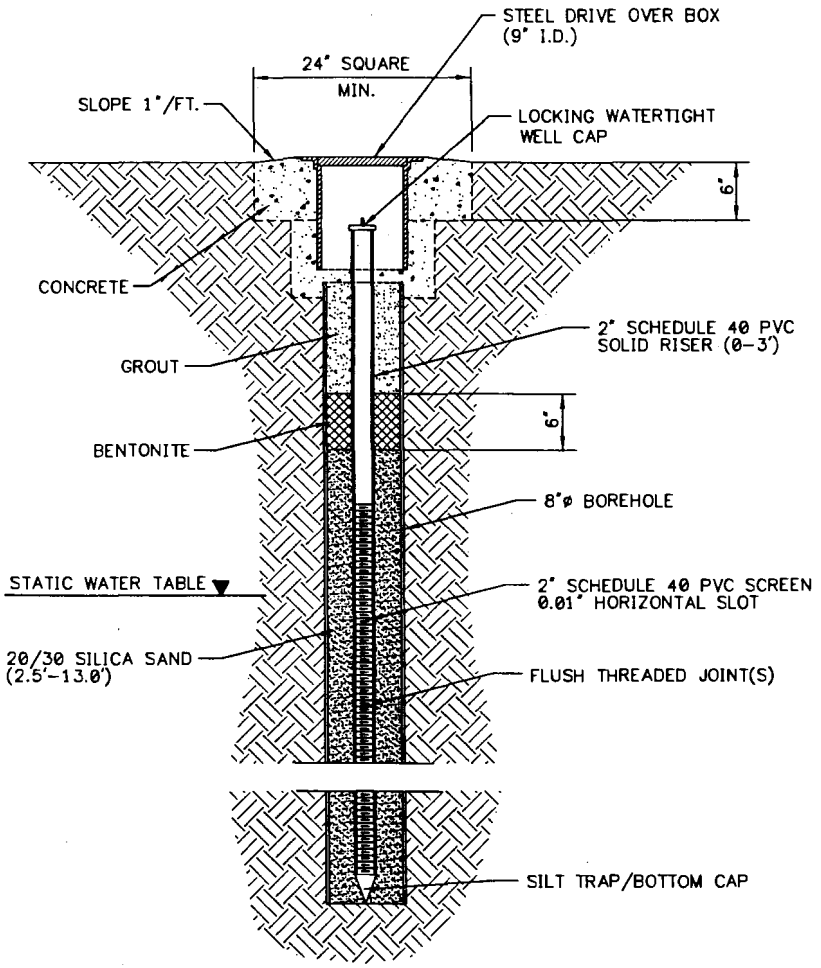
All permanent monitoring wells will be installed in accordance with the South Carolina Well Standards and Regulations, as well as the *Monitoring Well Design, Installation, Construction and Development Guidelines*

(March 27, 1997) provided by SOUTHDIV. Permanent shallow monitoring wells will be installed using hollow stem auger drilling techniques. Vertical extent wells will be installed using a combination of hollow stem auger and mud rotary drilling methods. 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 PVC riser and flush-joint factory slotted well screen. Each section of casing and screen shall be National Sanitation Foundation (NSF) approved. The screen slot size shall be 0.01 inch. Shallow monitoring wells will be constructed with a 10 foot screened interval positioned with approximately 4 feet of screen above the water table. The vertical extent monitoring wells will be constructed with a 5 foot screened interval positioned approximately 15 to 20 feet below the bottom of the shallow wells. Vertical extent monitoring wells will only be installed at those sites where groundwater screening data indicate the presence of petroleum contamination.

Pilot borings for each monitoring well will be at least 6-inches in diameter to accommodate the monitoring well, filter pack, and seal. After the pilot borings are advanced to the desired depth, the monitoring well will be installed through the augers. Clean silica sand of U.S. Standard Sieve Size No. 20/30 will be installed into the boring annulus around the well screen using tremie pipe as the augers are withdrawn from the boring. This filter pack will be set from the bottom of the hole to approximately 1-foot above the top of the well screen. At shallow monitoring well locations, the seal will be comprised of a U.S. Standard Sieve Size No. 30/65 silica sand. The seal for vertical extent monitoring wells will be composed of bentonite pellets. The thickness of all seals will be 0.5 to 1 foot and the bentonite seal will be allowed to hydrate prior to completing the monitoring well. The remainder of the boring anulus 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 or fiberglass tape. The position of the top of the screen interval, sand pack and bentonite seal may be adjusted as site conditions warrant (elevated water table, etc.)

Flush mounted steel well covers and manholes will be installed around each monitoring well. The manhole will consist of 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 shall be completed 1 inch above existing grade and the apron tapered to be flush with the existing grade at the edges such that water will run off of the apron. A detail of a typical flush-mounted well is provided as Figure 4-1. All locks supplied for the wells will be keyed alike.

Once monitoring well installation has been completed; the ground surface, the top of casing (TOC), structures, and other pertinent site features will be surveyed for location and elevation. Monitoring well TOC and ground surface will be measured within 0.01-foot vertical accuracy using datum points as



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CHECKED BY DATE		TYPICAL MONITORING WELL DETAIL CHARLESTON NAVAL COMPLEX - ZONE C CHARLESTON, SOUTH CAROLINA	APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 4-1 REV. 0

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discussed previously in Section 4.0. A monitoring well construction diagram will be completed for each well installed. A sample of the monitoring well construction form is provided in Appendix B. Each monitoring well 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 using a pumping method approved by the field geologist. All wells will be developed for up to one hour until development water is free of sediment and visibly clear. If necessary development will continue until a maximum of 10 well volumes have been removed.

For deeper monitoring well installations that will potentially pass through contaminated zones or confining layers, an outer casing will be installed to prevent cross contamination of deeper aquifers. The outer casing will be installed using hollow stem auger drilling techniques to advance the boring through the surficial aquifer. 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 inner casing to the desired depth of the well. Deep monitoring well construction details will be similar to shallow wells except that the deep wells will be completed with a screened interval of 5 feet.

4.3.2 Permanent Piezometer Installation

Permanent piezometers will be constructed with 1.25-inch ID schedule 40 PVC riser and 10 feet of 0.01-inch slotted screen. Each screened section will be pre-packed with a 20/30 silica sand filter pack. This filter pack will extend a minimum of 2 feet above the screened section. A fine sand seal will be placed above the filter pack and the remaining borehole annulus will be grouted to the surface. A surface completion similar to the permanent monitoring well completions described above will be placed on each permanent piezometer. No surface completions will be placed on piezometers located outside of suspected source areas.

Permanent piezometers will be developed, purged, and sampled using the exact same methods described in Section 4.3.1.

4.3.3 Groundwater Sampling

Groundwater samples will be obtained from the newly installed monitoring wells, any previously existing monitoring wells with screened intervals within the surficial aquifer, and from piezometers where necessary. All monitoring wells will be sampled in accordance with SCDHEC's January 1998 guidance document "South Carolina Risk-Based Corrective Action for Petroleum Releases". Prior to obtaining

groundwater samples, groundwater levels, product thickness, and total well depths will be measured. The presence and thickness of product will be determined with a clear bailer or an oil water interface probe. No samples will be collected from a well that exhibits measurable free product.

Immediately prior to groundwater sampling, each monitoring the well will be purged with a peristaltic pump using the low flow quiescent purging technique. A total of three to five well volumes will be purged from each well. If a monitoring well is purged dry before three well volumes have been removed, the water level in the well will be allowed to recover at least 80 percent prior to sample collection.

All groundwater samples, except volatiles, will be obtained with a peristaltic pump. Volatiles will be collected using the "gravity flow" method (directly from tubing using thumb or finger to hold the water in the tubing). The samples will be transferred directly into the appropriate (pre-preserved) sample bottles for analysis. Samples to be analyzed for volatile constituents shall be taken first and immediately sealed in a vial so that no headspace exists. The sample constituents to be analyzed are summarized in Table 4-1.

Groundwater samples will also be collected from three select monitoring wells per site for field screening for dissolved oxygen and ferrous iron, and laboratory analysis for nitrate, sulfate, and methane. These parameters will be used to evaluate the sites potential for natural attenuation (intrinsic bioremediation).

All pertinent field and sampling data shall be recorded using a groundwater sample form, attached in Appendix B.

4.3.4 Groundwater Level Measurements

Synoptic water level measurements will be taken from all monitoring wells at each site. Static water level measurements will be measured from the northern rim of the top of the PVC riser pipe using an electronic water level indicator. The newly installed wells shall be notched or 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.

TABLE 4-1

FIELD INVESTIGATION
ENVIRONMENTAL SAMPLE SUMMARY/INVESTIGATIVE DERIVED WASTE (IDW) CHARACTERIZATION AND ANALYSES
CHARLESTON NAVAL COMPLEX, ZONE C
CHARLESTON, SOUTH CAROLINA

Analyte	Proposed Method (1)	Env. Samples (3)	IDW Samples (4)	Duplicates	Rinsate Blanks (Aqueous)	Field Blank (Aqueous)	Trip Blanks (Aqueous)	Total Samples
GROUNDWATER								
BTEX, EDB, MTBE & Naphthalene	SW-846 8260	90	6	6	0	6	12	**120**
PAH	SW-846 8270	90	6	6	0	6	0	**108**
Sulfate	EPA 375.3	18	0	2	0	0	0	**20**
Nitrate	EPA 352.1	18	0	2	0	0	0	**20**
Dissolved Methane	RSK SOPs 147 and 175	18	0	2	0	0	0	**20**
SOIL								
BTEX & Naphthalene	SW-846 8260B	42	6	6	6	0	0	**60**
PAH	SW-846 8270C	42	6	6	6	0	0	**60**
TPH	SW-846 9071A	12	6	6	6	0	0	**30**
FOC	ASTM 2974-87	6	0	0	0	0	0	**6**
TOC	EPA 415.1	6	0	0	0	0	0	**6**
Grain size/Hydrometer	ASTM D422	12	0	0	0	0	0	**12**
Encore Samplers	SW-846 9071A	168	0	0	0	0	0	**168**

BTEX - benzene, ethyl benzene, toluene, and total xylenes
MTBE - methyl tert butyl ether
PAH - polynuclear aromatic hydrocarbons
TPH - total petroleum hydrocarbons
FOC - fraction organic carbon
TOC - total organic carbon

(1) Methods referenced reflect SCDHEC requirements set forth in Tables 3 and 4 of the reference document "Analytical Methodology for Groundwater and Soil Assessment Guidelines." Methods further referenced in Table 1 of the SCDHEC Rapid Assessment guidelines.
(2) Environmental sample numbers are based on collecting one complete round of groundwater samples from all six sites and a second round of sampling at four sites.
(4) IDW sample numbers based upon collection of one composite soil sample and one composite liquid sample for every 10 drums of material produced from the six sites.

All analyses are analyzed using standard 30-day laboratory turn around time.

4.4 AQUIFER TESTS

TtNUS will perform a specific capacity pumping test on selected shallow monitoring wells within Zone C. Each specific capacity test will be performed by pumping the well at a constant rate and measuring drawdown in the pumping well until the drawdown has stabilized. Static water levels in the pumped well will be measured using an electronic data logger. Specific capacity of the aquifer will be calculated from the test data and the aquifer transmissivity value estimated using methodology described by Kasenow and Pare, 1995. A hydraulic conductivity value will be estimated based on the aquifer transmissivity value and estimated aquifer thickness.

A tidal influence survey will also be conducted to assess if tidal fluctuations are apparent in the study area. Static water levels will be measured in three selected wells within the study area during a 24-hour period (or one complete tide cycle) using an electronic data logger.

4.5 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.

4.5.1 Major Equipment

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

These decontamination operations will consist of washing equipment using a high-pressure steam wash from a potable water supply and Alconox. Then the equipment will be rinsed with tap 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.

4.5.2 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:

- Tap water and Alconox or Liquinox detergent rinse.
- Tap water rinse.
- Rinse thoroughly with de-ionized, analyte-free water.
- Rinse with isopropanol
- Rinse thoroughly with de-ionized, analyte-free water
- Air dry and wrap equipment in aluminum foil until use.

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.

4.6 WASTE HANDLING

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

4.7 SAMPLE HANDLING

Sample handling includes the selection of sample containers, preservatives, allowable holding times, and analysis requested. In addition, sample identification, packaging, and shipping will be addressed. All sample handling procedures will be in accordance with SCDHEC and EPA Region IV requirements. A summary of bottle ware requirements, preservation requirements, and sample holding times is provided in Table 4-2.

TABLE 4-2

SUMMARY OF ANALYSES, BOTTLEWARE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CHARLESTON NAVAL COMPLEX, ZONE C
CHARLESTON, SOUTH CAROLINA

Parameter	Analytical Method	Sample Container	Container Volume	Sample Preservation	Maximum Holding Time (1)
Aqueous Samples					
BTEX and MTBE	SW-846 8260B or USEPA 601/602	Glass Vial	2 x 40 mL	Add HCL to pH >2; store at 4° C	14 days
PAHs and Naphthalenes	SW-846 8270C or USEPA 610	Amber Glass	1 L	Store at 4° C	7 days – extraction, 14 days - analysis
Lead (Total and dissolved)	SW-846 6010B (Trace ICP) or USEPA 239.2	High Density Polyethylene	1 L	Add HNO_3 to pH >2; store at 4° C	180 days
Total Petroleum Hydrocarbons	SW-846 9071A	Glass	1 L	Add H_2SO_4 to pH >2; store at 4° C	28 days
Anions (Nitrate, Nitrite, and Sulfate)	EPA 300.0	Glass	250 mL	Store at 4° C	Nitrate: 48 hours Others: 28 days
Dissolved Methane	RSK SOPs 147 and 175	Glass	1 L	Store at 4° C	28 days

BTEX – benzene, toluene, ethylbenzene and xylenes
MTBE – methyl tert butyl ether
PAHs – polynuclear aromatic hydrocarbons
ICP – inductively coupled plasma
HCL – hydrochloric acid
H_2SO_4 – sulfuric acid
C - celcius

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

TABLE 4-2

SUMMARY OF ANALYSES, BOTTLEWARE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CHARLESTON NAVAL COMPLEX, ZONE C
CHARLESTON, SOUTH CAROLINA
PAGE 2 OF 2

Parameter	Analytical Method	Sample Container	Container Volume	Sample Preservation	Maximum Holding Time (1)
Soil Samples					
BTEX	SW-846 8260B	Encore Sampler	4 x 5 gram	Store at 4° C (lab does additional preservation)	48 hours – preservation 14 days - analysis
PAHs and Naphthalenes	SW-846 8270C	Glass, wide mouth	8 oz	Store at 4° C	7 days – extraction, 40 days – analysis
Trace Metals	SW-846 6010B (Trace ICP)	High Density Polyethylene	8 oz	Store at 4° C	180 days
Total Petroleum Hydrocarbons	SW-846 9071A	Glass, wide mouth	4 oz	Store at 4° C	28 days
Total Organic Carbon	EPA 415.1 modified for soil	Glass, wide mouth	4 oz	Store at 4° C	28 days
Grain size distribution including hydrometer	ASTM D422	Glass, wide mouth	8 oz	Store at 4° C	None

BTEX – benzene, toluene, ethylbenzene and xylenes
MTBE – methyl tert butyl ether
PAHs – polynuclear aromatic hydrocarbons
ICP – inductively coupled plasma
C - celcius

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

4.8 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 how these numbers are generated and explains the information each number contains.

4.8.1 Base and Site Designations

The base designation for the Charleston Naval Complex is CNC. Site designations are listed in Section 3.0 of this document.

4.8.2 Soil Boring Identification

Soil boring identification numbers are broken down into three pieces of information: (1) the base identifier, CNC in this case, (2) the site designation, and (3) the discriminator "B" and a consecutive numerical value. Thus, the soil boring identification number for the third soil boring installed at Site 5 would be CNC05-B03.

4.8.3 Piezometer and Monitoring Well Identification

Piezometer and monitoring well identification numbers will be similar to soil boring identification numbers, except that they use a "P" or an "M" as discriminators. For example, the first piezometer installed at Site 2 would be called CNC02-P01. The fifth monitoring well installed at Site 11 would be designated CNC11-M05.

4.8.4 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:

NN	-	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 = 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 analytical soil sample collected from CNC01-B01 at 4 to 6 feet bls would be called 01SLB0104 and its duplicate would be 01SLB0104D.

Example 2: The field laboratory groundwater sample collected from CNC01-B01 at 7 feet bls would be called 01GFB0107.

Example 3: The analytical groundwater sample collected from CNC01-P01 during the first sampling event would be called 01GLP0101. The sample collected during the next event would be 01GLP0102.

Example 4: The analytical groundwater sample and matrix spike collected from CNC01-M01 during the first sampling event would be called 01GLM0101 and 01GLM0101M.

Example 5: The analytical trip blank for the 1st sampling event at Site 1 would be called 01TL00101, the second trip blank during the same event would be 01TL00201. The first trip blank collected for the second event would be 01TL00102.

Information regarding sample labels to be attached before shipment to a laboratory is contained in SOP SA-6.3 included in Appendix B. Examples of sample labels, chain of custody seals, and chain-of-custody forms are included in Appendix B.

4.9 SAMPLE PACKAGING AND SHIPPING

Samples will be packaged and shipped in accordance with SCDHEC and EPA Region IV 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

4.10 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.

4.11 QUALITY CONTROL (QC) SAMPLES

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

Rinsate Blank - Rinsate equipment blanks are obtained under representative field conditions by running organic free water through decontaminated sample collection equipment (bailer, split-spoon, etc.) 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 non-dedicated sampling equipment used and will be submitted as shown in Table 4-1.

Field Blanks – Field blanks are source water sample collected to ensure that the water used to decontaminate sampling equipment is free of contaminants. Typically a field blank is collected at the beginning and end of a sampling event. The field blanks will be analyzed for the parameters listed in Table 4-1.

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

TABLE 4-3

SUMMARY OF QC SAMPLES
CHARLESTON NAVAL COMPLEX, ZONE C
CHARLESTON, SOUTH CAROLINA

Number of Samples	Precleaned Equipment Blank	Field cleaned Equipment Blank	Duplicate Samples	Trip Blanks (VOC only)	Field Blanks
10 or more	1 for every 20 samples (5%)	1 for every 20 samples (5%)	1 for every 10 samples (10%)	1 per VOC cooler	2
5 to 9	1*	1*	1	1 per VOC cooler	1
Less than 5	1*	1*	NR	1 per VOC cooler	NR

NR = Not required
VOC = volatile organic compounds

* Note: For 9 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.

QA/QC samples such as rinsate blanks, source blanks, and trip blanks will have the following site identifers: ZG for Zone G samples, ZF for Zone F samples, and ZB for Zone B samples (for example ZGRL00201 would be the second rinsate sample collected at Zone G during the 1st round of sampling).

4.12 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 this data and additional instruments will be calibrated according to the procedures described below.

4.12.1 Parameters

- Air monitoring - OVA
- Temperature - Temperature probe
- Specific conductance - Specific conductance meter
- pH - pH meter
- Turbidity - Turbidity meter
- Depth to water table - interface probe

4.12.2 Equipment Calibration

The electronic water-level indicator will be calibrated prior to mobilization and periodically at the discretion of the Field Operations Leader. 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.

4.12.3 Equipment Maintenance

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

TtNUS maintains a large inventory of sampling and measurement equipment. In the event that failed equipment cannot be repaired replacement equipment can be shipped to the site by overnight express carrier to minimize downtime.

4.13 FIELD QA/QC PROGRAM

4.13.1 Control Parameters

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

4.13.2 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.

The TtNUS representative on site will confirm measurements of total depth of borings and wells, dimensions and placement of well screens and casings, and volume and placement of filter pack and grout materials by independent measurement. The Field Operations Leader will examine field laboratory records and field logbooks on a weekly basis during field activities.

4.13.3 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

TABLE 4-4

FIELD QA/QC SPECIFICATIONS
CHARLESTON NAVAL COMPLEX, ZONE C
CHARLESTON, SOUTH CAROLINA

Analysis	Control Parameter	Control Limit	Corrective Action
Air monitoring using an OVA equipped with a FID	Daily check of calibration of FID	Calibration to manufacturer's specifications	Recalibrate. If unable to calibrate, replace.
pH of groundwater	Continuing calibration check of pH 7.0 buffer	pH = 7.0 ± 0.1	Recalibrate. If unable to calibrate, replace electrode.
Specific conductance of groundwater	Continuing calibration check of standard solution	± 1% of standard	Recalibrate.
Turbidity of groundwater	Continuing calibration check of standard solutions	± 1% of standard	Recalibrate.
Temperature of groundwater	Check against NIST precision thermometer	± 0.1°C at two different temperatures	Reset in accordance with manufacturer's specifications; dispose of inaccurate thermometer.

OVA – organic vapor analyzer
FID – flame ionization detector
NIST – National Institute of Standards and Technology

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 Project Manager will have overall responsibility for implementing corrective actions.

The corrective action program covers the analysis of the cause of any negative findings and 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 Standard Operating Procedures.

4.14 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 shall 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.

Each sampling event leader shall maintain a bound/weatherproof field notebook. The field team leader or designee, shall 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.

The Field Operations Leader shall maintain a site logbook. The requirements of the logbook are referenced 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 Field Operations Leader shall submit to the Project Manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc.

4.15 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 duration of the investigation activities, work at the CNC will be coordinated through SouthDiv and CNC personnel. The primary contacts are as follows:

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

2. Charleston Naval Complex
   Mr. Gabriel Magwood
   (843) 820-7307

4.15.1 Support From SouthDiv and CNC

SouthDiv or CNC personnel will provide the following support functions:

- Provide existing engineering plans, drawings, diagram, files, etc., to facilitate evaluation of the sites under investigation.
- Provide all historical data, background geologic and hydrogeologic information, and initial site investigation documents.
- A secure staging area (approximately 1,000 square feet) for storing equipment and supplies.
- A supply (e.g., fire hydrant, stand pipe, etc.) of large quantities of potable water for equipment cleaning etc.

4.15.2 Support From TtNUS

The project will be staffed with personnel from the TtNUS' Tallahassee, Florida office. Other TtNUS offices will provide support, as needed. During field activities, TtNUS will provide a senior level geologist and/or staff geologist, and equipment technician.

Mr. Paul Calligan, P.G., is the Task Order Manager (TOM) for CTO 0093 and will be the primary point of contact. He is responsible for cost and schedule control as well as technical performance. Mr. Calligan is a Licensed Professional Geologist and will serve as the TOM and will provide senior level review and oversight during field activities. Mr. Calligan will be the primary point of contact for the Field Operations Leader.

4.15.3 Contingency Plan

In the event of problems, which may be encountered during site activities, the SouthDiv point of contact will be notified immediately, followed by the TtNUS project manager. The project manager will determine a course of action that does 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 hydrocarbon vapor assessment (Phase I 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 January 1998 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

At each site, soil samples will be collected from select soil borings installed around the tank(s) and piping for submittal to a laboratory for analysis. Samples collected for laboratory analysis will be collected from the interval with the highest BTEX and/or DRO screening values observed above the water table. The samples will be analyzed for BTEX, ethylene dibromide (EDB), total naphthalenes, polynuclear aromatic hydrocarbons (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 DRO 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 Total Petroleum Hydrocarbons.

In addition to the environmental soil analysis described above, soil samples will also be collected from the investigative derived waste for submittal to a laboratory for analysis.

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, three monitoring wells from each site will be sampled for the biological parameters ferrous iron, nitrate, and sulfate.

6.0 PROPOSED SCHEDULE

Phase 1 of the fieldwork is proposed to begin in late April and take approximately 35 days to complete. Phase 2 work is anticipated to begin in late May. Phase 2 of the field work will begin immediately upon approval of the permanent monitoring well locations by SCDHEC and the Navy following review of Phase I soil and groundwater quality data. Upon completion of Phase 2 field activities, RARs will be prepared and submitted to the Navy for review within 60 days.

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

7.0 REPORT

Upon completion of all field work and laboratory analyses, a RAR summarizing the results of the investigation will be submitted to SCDHEC. Basic UST system information including site facility name and address, date closed, area, type of system and tank capacity will be provided. Data recorded during tank removal will be included. 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 determination if remediation is required in accordance with SCDHEC's January 1998 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. A Responsibility Assignment Matrix, and meeting with Remedial Action Contractors (RACs) to discuss the results of the contamination assessment will be developed, scheduled, and implemented.

8.0 REFERENCES

South Carolina Department of Health and Environmental Control, January 5, 1998. "South Carolina Risk-Based Corrective Action For Petroleum Releases."

South Carolina Department of Health and Environmental Control, June 1995. "Rapid Assessment".

South Carolina Department of Health and Environmental Control, June 1997. "Standard Limited Assessment".

South Carolina Department of Health and Environmental Control, June 1985. "South Carolina Well Standards and Regulations".

U.S. Environmental Protection Agency Region IV, February 1991. "Standard Operating Procedures and Quality Assurance Manual".

Kasenow, M. and P.Pare, 1995. Using Specific Capacity to Estimate Transmissivity: Field and Computer Methods, Water Resource Publications, pp. 3-11.

APPENDIX A

SCDHEC RAPID ASSESSMENT PLANS

Rapid Assessment Plan
UST NH46-5
Site ID #01206

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 01206 County CHARLESTON Facility Name CNC, UST NH46-5

Facility Address CHARLESTON NAVAL COMPLEX, ZONE C

Responsible party U.S.NAVY Address 2155 EAGLE DRIVE

No. USTs 1 removed? 22 SEPT 98 (date) replaced? N. CHARLESTON, SC (date)

Current use of facility/property CHARLESTON NAVAL COMPLEX

Current property owner name U.S. NAVY

Current property owner address 2155 EAGLE DRIVE, N.CHARLESTON, SC 29406

Field Screening Methodology

Specify the field screening methodology to be used. The use of field screening methods to optimize the number and location of permanent wells is required.

DIRECT PUSH TECHNOLOGY WILL BE UTILIZED TO INSTALL MONITORING POINTS. SOIL AND GROUNDWATER WILL BE COLLECTED FROM EACH POINT AND ANALYSED BY A MOBILE LABORATORY. THE MOBILE LABORATORY WILL ANALYZE THE SAMPLES FOR BTEX AND DIESEL RANGE ORGANICS (DRO). SOILS WILL ALSO BE SCREENED WITH AN ORGANIC VAPOR ANALYZER TO ASSESS VADOSE ZONE SOILS FOR PETROLEUM VAPORS.

Permanent Monitoring wells (Estimate number and total completed depth)

# of shallow wells 7 total depth 20'

# of deep wells 1 total depth 40' (If necessary)

Comments, if warranted

Analyses

List the analytical parameters (e.g., BTEX, MTBE) and estimated number.

GROUNDWATER		SOIL	
BTEX	8	BTEX	7
NAPHTHALENE	8	PAH	7
MTBE	8	TPH	2
PAH	8	TOC/FOC	1
		GRAIN SIZE	2

Implementation Schedule

Start up date _____ Completion date _____

Report submittal date _____

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 01206 Facility Name CNC, UST NH46-5

Site Maps

1. Attach a copy of the relevant 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 X **Slug Tests** _____

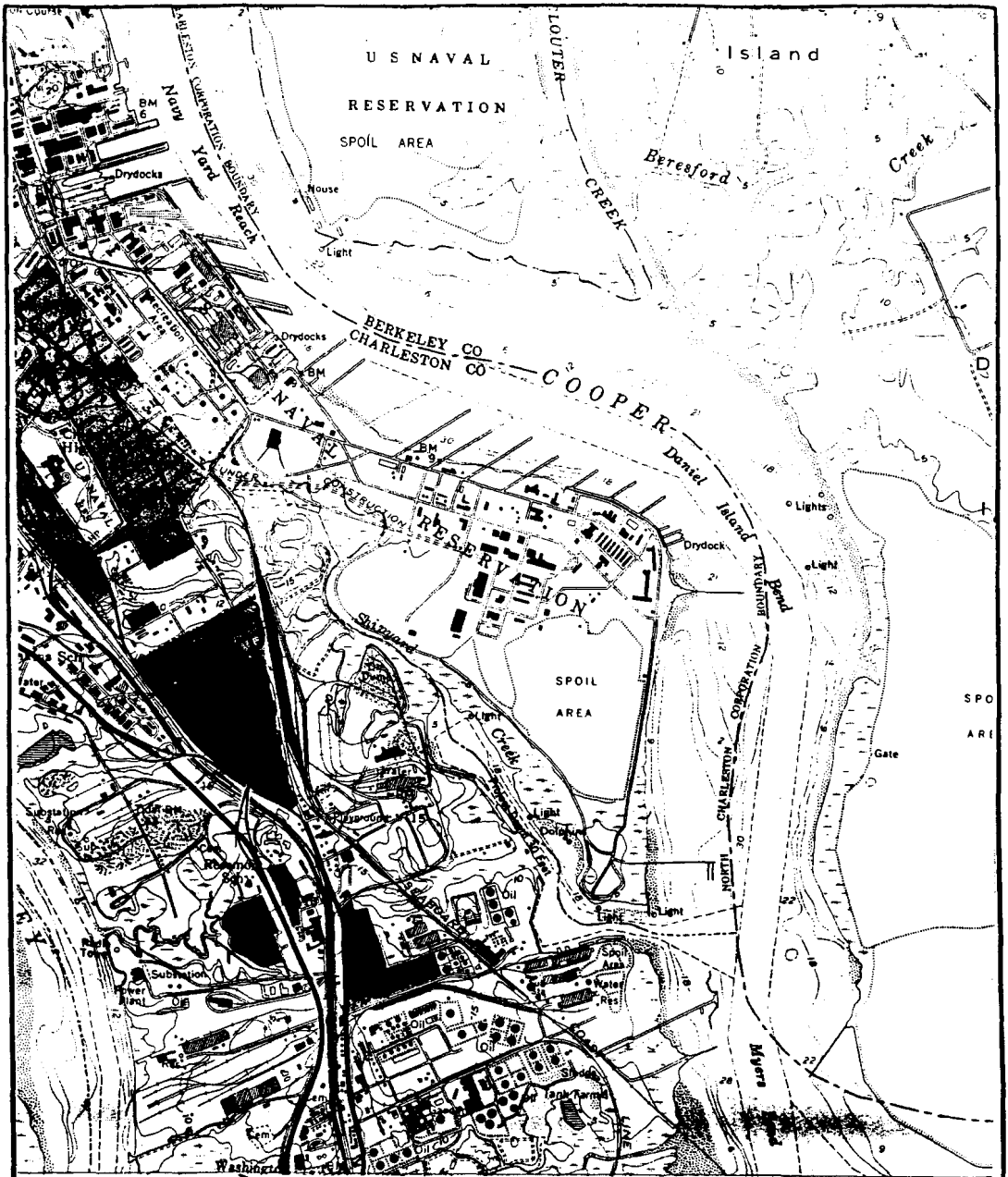
WILL PROVIDE GROUNDWATER FLOW DATA FOR ENTIRE ASSESSMENT AREA

Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WASTE WILL BE CONTAINERIZED IN 55-GALLON DRUMS AND REMAIN AT A STAGING AREA UNTIL CHEMICAL ANALYSIS IS COMPLETE. AFTER ANALYSIS, THE DRUMS WILL BE TRANSFERRED TO THE ENVIRONMENTAL DETACHMENT CHARLESTON FOR DISPOSAL

Purge Water

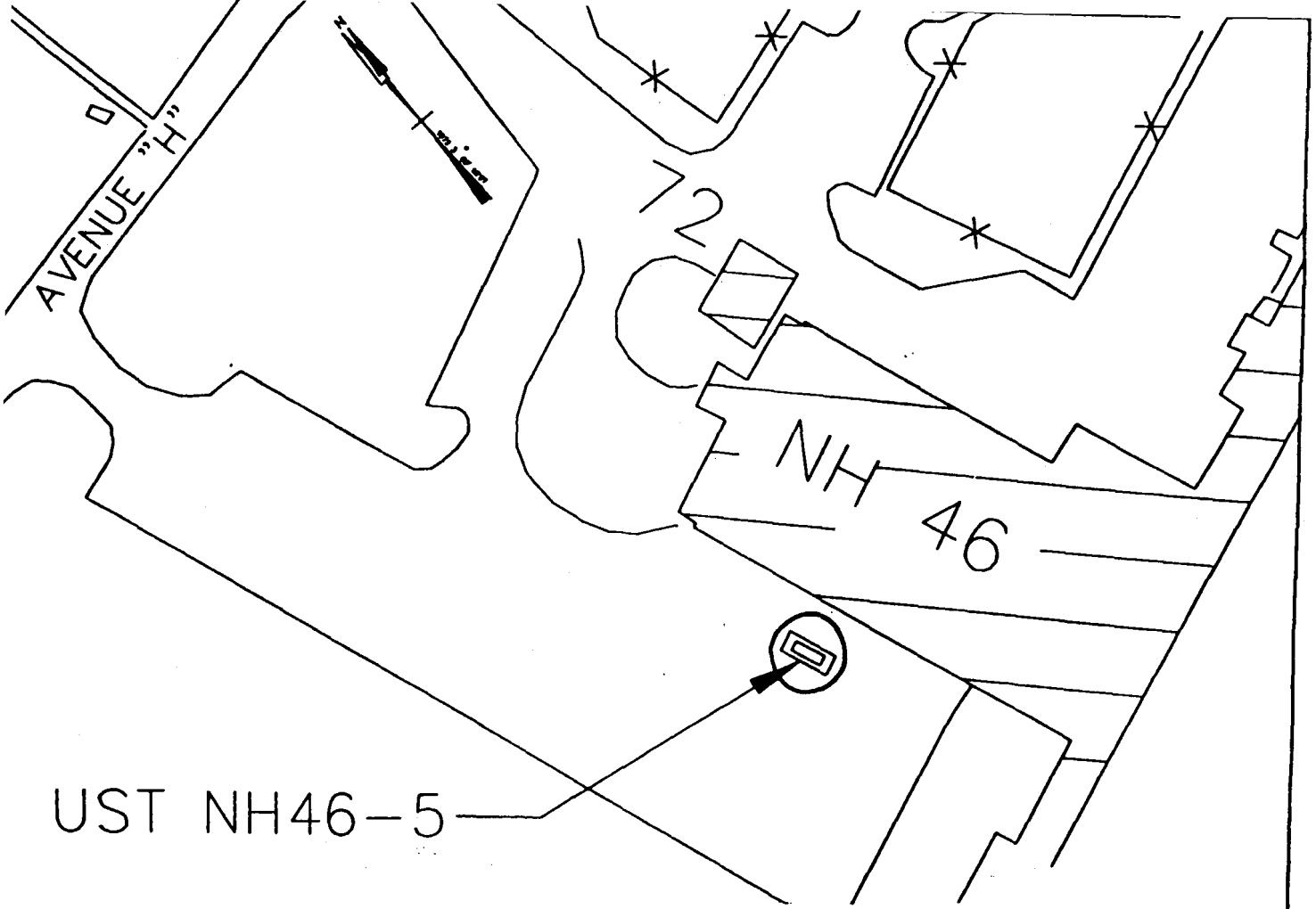
Additional Comments



DRAWN BY MF DATE 8/17/98			CONTRACT NO.
CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

TOPOGRAPHIC MAP



0 50' 100' 150'

GRAPHIC SCALE

DRAWN BY MF	DATE	SITE MAP	CONTRACT NO.
CHECKED BY	DATE		APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. REV 0

Rapid Assessment Plan
UST NH46-1, NH46-2, NH46-3, NH46-4
Site ID #17755

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 17755 County CHARLESTON Facility Name CNC,UST NH46-1,2,3&4

Facility Address CHARLESTON NAVAL COMPLEX, ZONE C

Responsible party U.S.NAVY Address 2155 EAGLE DRIVE N. CHARLESTON, SC

No. USTs 4 removed? 18 SEPT 96 (date) replaced? (date)

Current use of facility/property CHARLESTON NAVAL COMPLEX

Current property owner name U.S. NAVY

Current property owner address 2155 EAGLE DRIVE, N.CHARLESTON, SC 29406

Field Screening Methodology

Specify the field screening methodology to be used. The use of field screening methods to optimize the number and location of permanent wells is required.

DIRECT PUSH TECHNOLOGY WILL BE UTILIZED TO INSTALL MONITORING POINTS. SOIL AND GROUNDWATER WILL BE COLLECTED FROM EACH POINT AND ANALYSED BY A MOBILE LABORATORY. THE MOBILE LABORATORY WILL ANALYZE THE SAMPLES FOR BTEX AND DIESEL RANGE ORGANICS (DRO). SOILS WILL ALSO BE SCREENED WITH AN ORGANIC VAPOR ANALYZER TO ASSESS VADOSE ZONE SOILS FOR PETROLEUM VAPORS.

Permanent Monitoring wells (Estimate number and total completed depth)

# of shallow wells 9 total depth 20'

# of deep wells 1 total depth 40' (If necessary)

Comments, if warranted

Analyses

List the analytical parameters (e.g., BTEX, MTBE) and estimated number.

GROUNDWATER		SOIL	
BTEX	10	BTEX	7
NAPHTHALENE	10	PAH	7
MTBE	10	TPH	2
PAH	10	TOC/FOC	1
		GRAIN SIZE	2

Implementation Schedule

Start up date _____ Completion date _____

Report submittal date _____

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 17755 Facility Name CNC, UST NH46-1,2,3&4

Site Maps

1. Attach a copy of the relevant 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 x **Slug Tests** _____

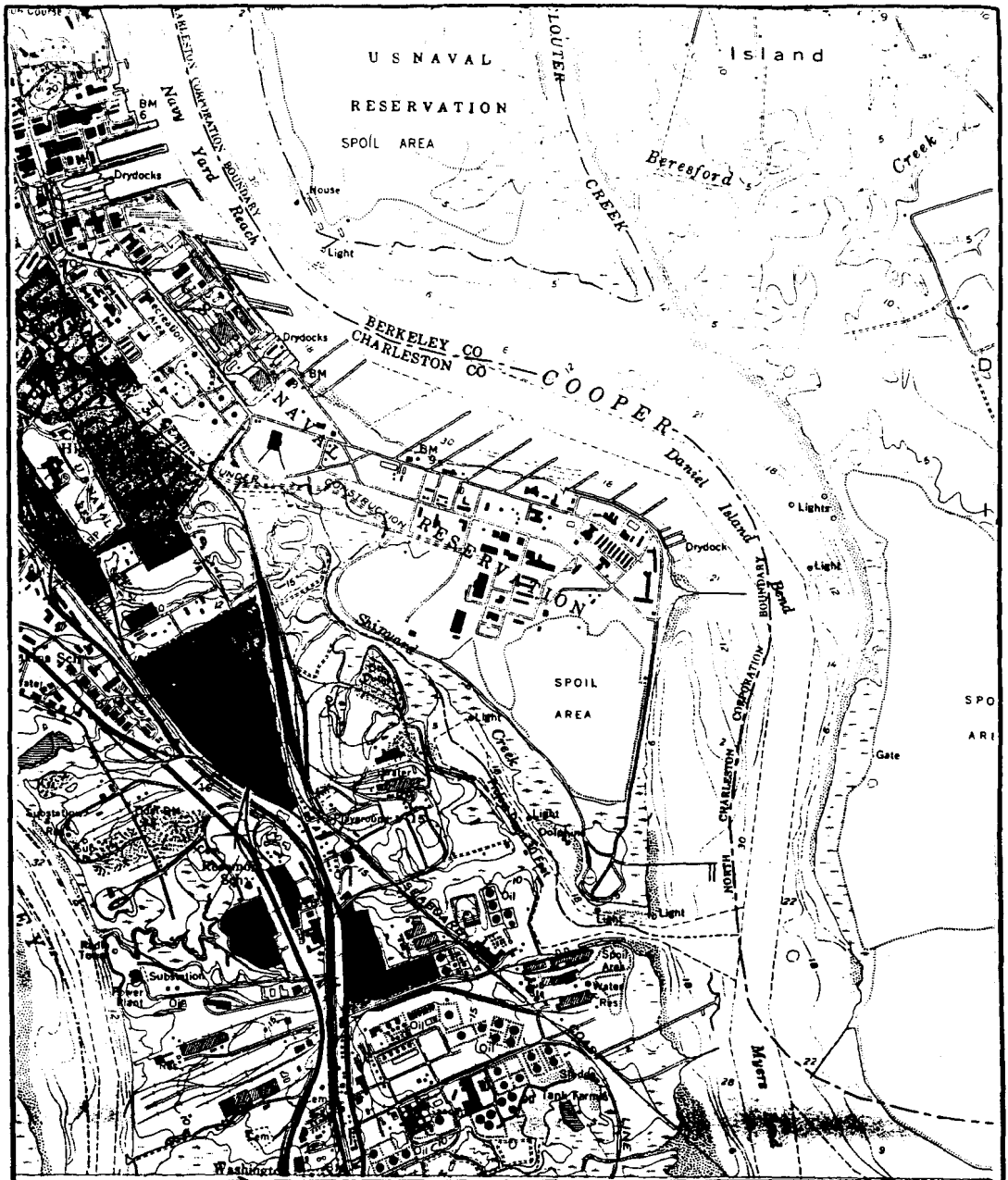
WILL PROVIDE GROUNDWATER FLOW DATA FOR ENTIRE ASSESSMENT AREA

Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WASTE WILL BE CONTAINERIZED IN 55-GALLON DRUMS AND REMAIN AT A STAGING AREA UNTIL CHEMICAL ANALYSIS IS COMPLETE. AFTER ANALYSIS, THE DRUMS WILL BE TRANSFERRED TO THE ENVIRONMENTAL DETACHMENT CHARLESTON FOR DISPOSAL

Purge Water

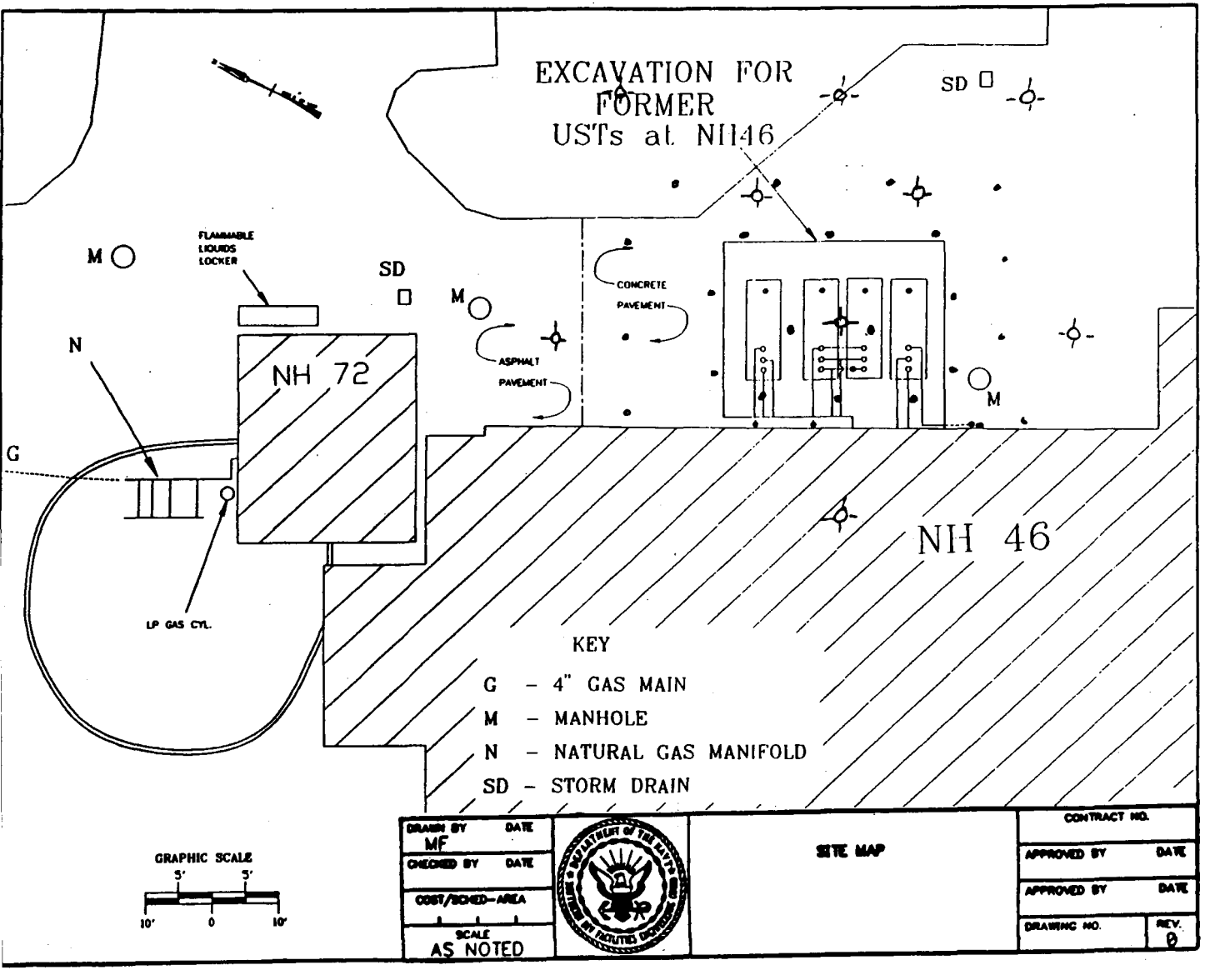
Additional Comments



DRAWN BY MF DATE 8/17/98			CONTRACT NO.
CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

TOPOGRAPHIC MAP


EXCAVATION FOR
FORMER
USTs at NH46
SD
M
FLAMMABLE
LIQUIDS
LOCKER
SD
M
CONCRETE
PAVEMENT
N
NH 72
ASPHALT
PAVEMENT
M
G
NH 46
LP GAS CYL.
KEY
G - 4" GAS MAIN
M - MANHOLE
N - NATURAL GAS MANIFOLD
SD - STORM DRAIN
GRAPHIC SCALE
5'
5'
10'
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DRAWN BY
DATE
MF
CHECKED BY
DATE
COST/SCHED-AREA
SCALE
AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
DATE
APPROVED BY
DATE
DRAWING NO.
REV.
0

Rapid Assessment Plan
UST 760
Site ID #01118

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 01118 County CHARLESTON Facility Name CNC, UST 760

Facility Address CHARLESTON NAVAL COMPLEX, ZONE C

Responsible party U.S.NAVY Address 2155 EAGLE DRIVE

No. USTs 1 removed? 29 MAY 98 (date) replaced? N. CHARLESTON, SC (date)

Current use of facility/property CHARLESTON NAVAL COMPLEX

Current property owner name U.S. NAVY

Current property owner address 2155 EAGLE DRIVE, N.CHARLESTON, SC 29406

Field Screening Methodology

Specify the field screening methodology to be used. The use of field screening methods to optimize the number and location of permanent wells is required.

DIRECT PUSH TECHNOLOGY WILL BE UTILIZED TO INSTALL MONITORING POINTS. SOIL AND GROUNDWATER WILL BE COLLECTED FROM EACH POINT AND ANALYSED BY A MOBILE LABORATORY. THE MOBILE LABORATORY WILL ANALYZE THE SAMPLES FOR BTEX AND DIESEL RANGE ORGANICS (DRO). SOILS WILL ALSO BE SCREENED WITH AN ORGANIC VAPOR ANALYZER TO ASSESS VADOSE ZONE SOILS FOR PETROLEUM VAPORS.

Permanent Monitoring wells (Estimate number and total completed depth)

# of shallow wells 5 total depth 20'

# of deep wells 1 total depth 40' (If necessary)

Comments, if warranted

Analyses

List the analytical parameters (e.g., BTEX, MTBE) and estimated number.

GROUNDWATER		SOIL	
BTEX	6	BTEX	7
NAPHTHALENE	6	PAH	7
MTBE	6	TPH	2
PAH	6	TOC/FOC	1
		GRAIN SIZE	2

Implementation Schedule

Start up date _____ Completion date _____

Report submittal date _____

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 01118 Facility Name CNC, UST 760

Site Maps

1. Attach a copy of the relevant 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 x **Slug Tests** _____

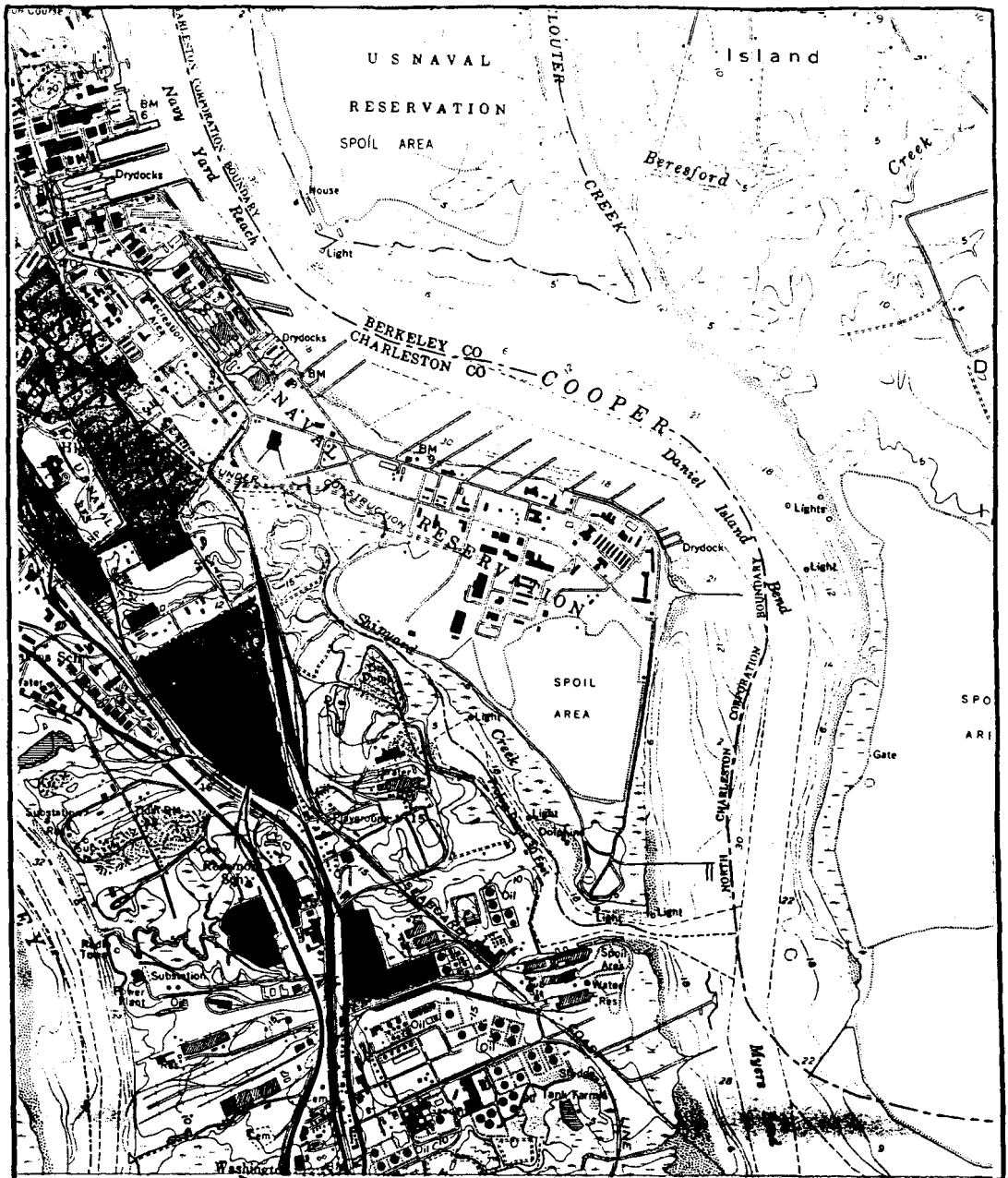
WILL PROVIDE GROUNDWATER FLOW DATA FOR ENTIRE ASSESSMENT AREA

Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WASTE WILL BE CONTAINERIZED IN 55-GALLON DRUMS AND REMAIN AT A STAGING AREA UNTIL CHEMICAL ANALYSIS IS COMPLETE. AFTER ANALYSIS, THE DRUMS WILL BE TRANSFERRED TO THE ENVIRONMENTAL DETACHMENT CHARLESTON FOR DISPOSAL

Purge Water

Additional Comments



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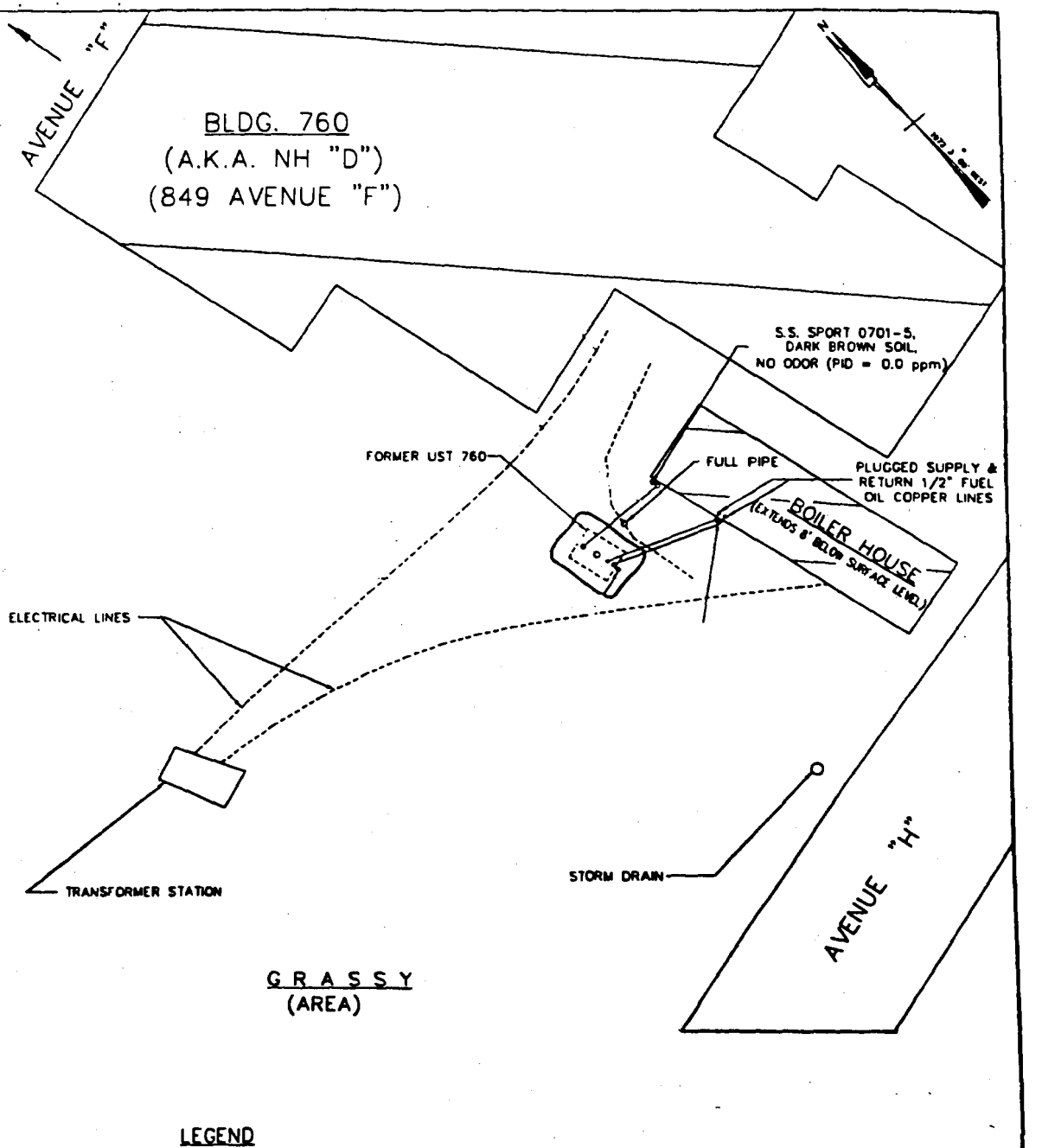
SCALE AS NOTED			



LEGEND

S.S. - SOIL SAMPLE

10 0 10 20 30

GRAPHIC SCALE

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CHECKED BY	DATE		APPROVED BY DATE
COST/BOXED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. REV. 0

Rapid Assessment Plan
UST 54
Site ID #12094

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 12094 County CHARLESTON Facility Name CNC, UST 54

Facility Address CHARLESTON NAVAL COMPLEX, ZONE C

Responsible party U.S.NAVY Address 2155 EAGLE DRIVE

No. USTs 1 removed? 12 JUNE 96 (date) replaced? N. CHARLESTON, SC (date)

Current use of facility/property CHARLESTON NAVAL COMPLEX

Current property owner name U.S. NAVY

Current property owner address 2155 EAGLE DRIVE, N.CHARLESTON, SC 29406

Field Screening Methodology

Specify the field screening methodology to be used. The use of field screening methods to optimize the number and location of permanent wells is required.

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Permanent Monitoring wells (Estimate number and total completed depth)

# of shallow wells 7 total depth 20'

# of deep wells 1 total depth 40' (If necessary)

Comments, if warranted

Analyses

List the analytical parameters (e.g., BTEX, MTBE) and estimated number.

GROUNDWATER		SOIL	
BTEX	8	BTEX	7
NAPHTHALENE	8	PAH	7
MTBE	8	TPH	2
PAH	8	TOC/FOC	1
		GRAIN SIZE	2

Implementation Schedule

Start up date _____ Completion date _____

Report submittal date _____

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 12094 Facility Name CNC, UST 54

Site Maps

1. Attach a copy of the relevant 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 x **Slug Tests** _____

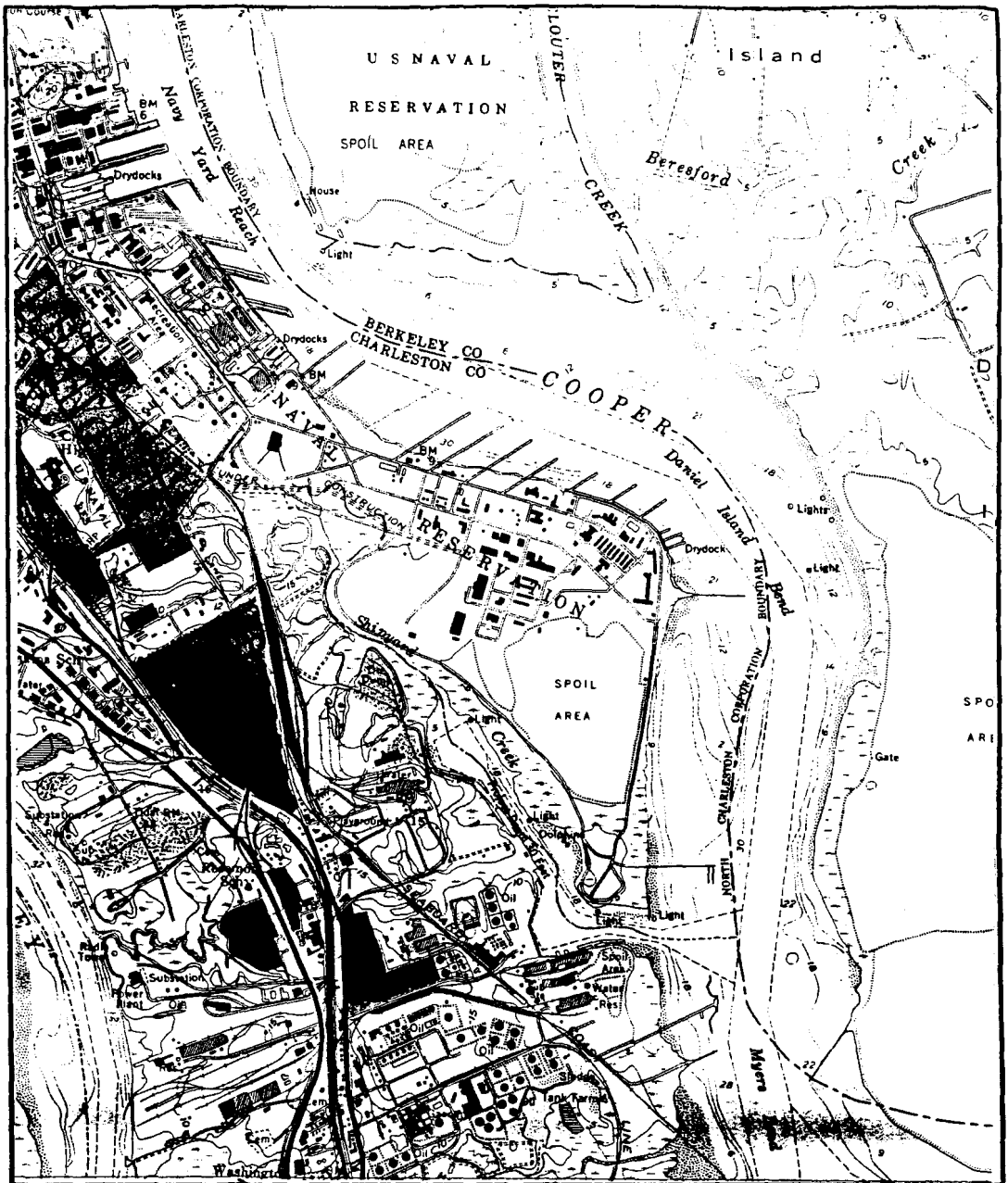
WILL PROVIDE GROUNDWATER FLOW DATA FOR ENTIRE ASSESSMENT AREA

Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WASTE WILL BE CONTAINERIZED IN 55-GALLON DRUMS AND REMAIN AT A STAGING AREA UNTIL CHEMICAL ANALYSIS IS COMPLETE. AFTER ANALYSIS, THE DRUMS WILL BE TRANSFERRED TO THE ENVIRONMENTAL DETACHMENT CHARLESTON

Purge Water FOR DISPOSAL

Additional Comments



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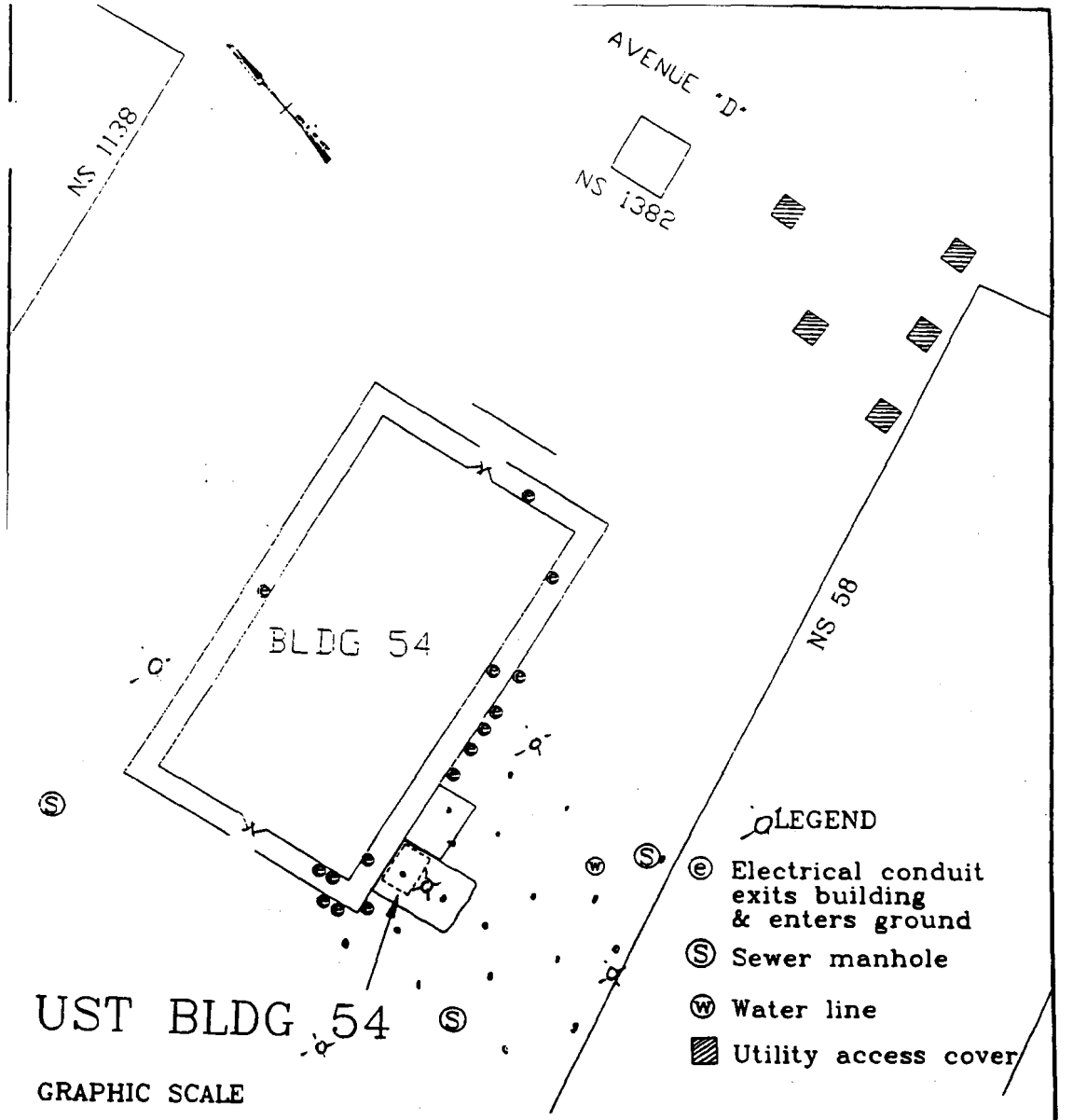
COST/SCHED-AREA		TOPOGRAPHIC MAP	APPROVED BY DATE
SCALE AS NOTED			



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CHECKED BY	DATE		APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. REV 0

Rapid Assessment Plan
UST NH62-1, AST NH62-2
Site ID #00946

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 00946 County CHARLESTON Facility Name CNC, UST NH 62-1 AST NH62-2

Facility Address CHARLESTON NAVAL COMPLEX, ZONE C

Responsible party U.S.NAVY Address 2155 EAGLE DRIVE

No. USTs 1 AST 1 removed? 25 NOV 96 (date) replaced? N. CHARLESTON, SC (date)

Current use of facility/property CHARLESTON NAVAL COMPLEX

Current property owner name U.S. NAVY

Current property owner address 2155 EAGLE DRIVE, N.CHARLESTON, SC 29406

Field Screening Methodology

Specify the field screening methodology to be used. The use of field screening methods to optimize the number and location of permanent wells is required.

DIRECT PUSH TECHNOLOGY WILL BE UTILIZED TO INSTALL MONITORING POINTS. SOIL AND GROUNDWATER WILL BE COLLECTED FROM EACH POINT AND ANALYSED BY A MOBILE LABORATORY. THE MOBILE LABORATORY WILL ANALYZE THE SAMPLES FOR BTEX AND DIESEL RANGE ORGANICS (DRO). SOILS WILL ALSO BE SCREENED WITH AN ORGANIC VAPOR ANALYZER TO ASSESS VADOSE ZONE SOILS FOR PETROLEUM VAPORS.

Permanent Monitoring wells (Estimate number and total completed depth)

# of shallow wells 7 total depth 20'

# of deep wells 1 total depth 40' (If necessary)

Comments, if warranted

Analyses

List the analytical parameters (e.g., BTEX, MTBE) and estimated number.

GROUNDWATER		SOIL	
BTEX	8	BTEX	7
NAPHTHALENE	8	PAH	7
MTBE	8	TPH	2
PAH	8	TOC/FOC	1
		GRAIN SIZE	2

Implementation Schedule

Start up date _____ Completion date _____

Report submittal date _____

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 00946 Facility Name CNC, UST NH62-1 & AST NH62-2

Site Maps

1. Attach a copy of the relevant 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:

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Location of property lines	Streets or highways (indicate names and numbers)
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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 x **Slug Tests** _____

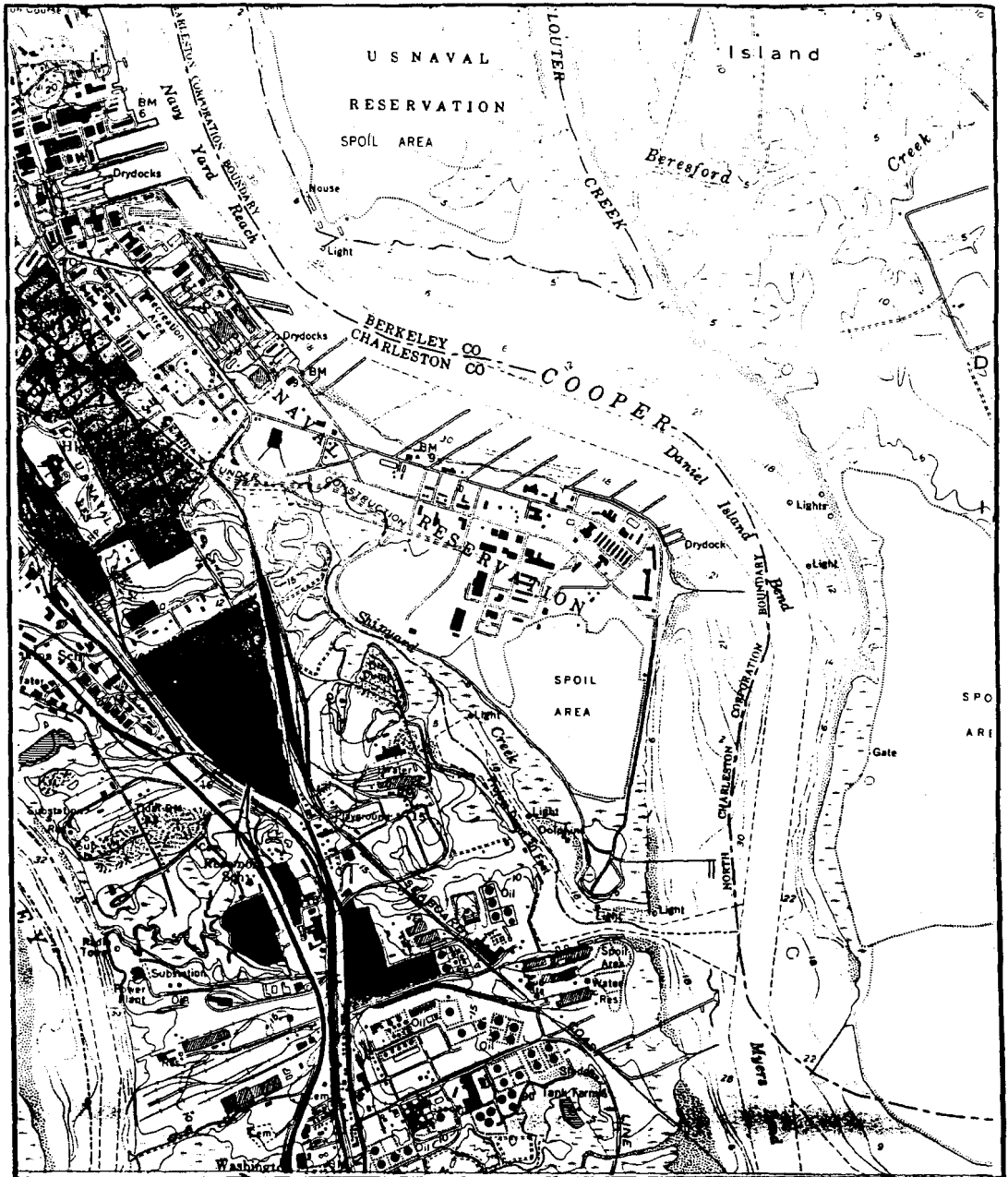
WILL PROVIDE GROUNDWATER FLOW DATA FOR ENTIRE ASSESSMENT AREA

Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WASTE WILL BE CONTAINERIZED IN 55-GALLON DRUMS AND REMAIN AT A STAGING AREA UNTIL CHEMICAL ANALYSIS IS COMPLETE. AFTER ANALYSIS, THE DRUMS WILL BE TRANSFERRED TO THE ENVIRONMENTAL DETACHMENT CHARLESTON FOR DISPOSAL

Purge Water

Additional Comments



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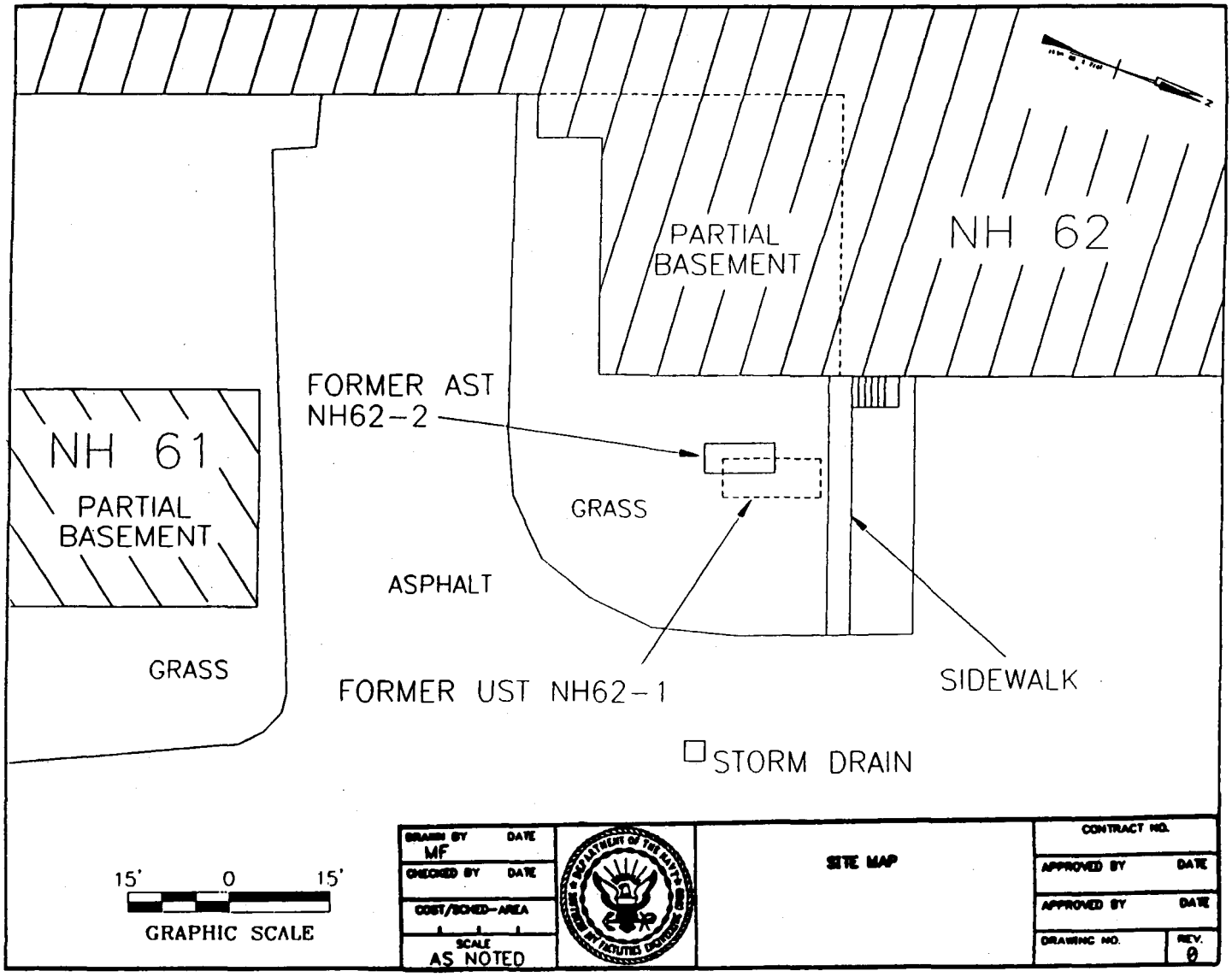
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

TOPOGRAPHIC MAP


PARTIAL BASEMENT
NH 62
FORMER AST NH62-2
NH 61
PARTIAL BASEMENT
GRASS
ASPHALT
GRASS
FORMER UST NH62-1
SIDEWALK
STORM DRAIN
15' 0 15'
GRAPHIC SCALE
DRAWN BY MF
DATE
CHECKED BY
DATE
COST/SCHED-AREA
SCALE AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
DATE
APPROVED BY
DATE
DRAWING NO.
REV. 0

Rapid Assessment Plan
UST NH1137-2, AST NH1137-1
Site ID #17754

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 17754 County CHARLESTON Facility Name CNC, UST NH1137-2 & AST NH1137-1

Facility Address CHARLESTON NAVAL COMPLEX, ZONE C

Responsible party U.S.NAVY Address 2155 EAGLE DRIVE N. CHARLESTON, SC

No. USTs 1 AST 1 removed? 19 AUG 96 (date) replaced? (date)

Current use of facility/property CHARLESTON NAVAL COMPLEX

Current property owner name U.S. NAVY

Current property owner address 2155 EAGLE DRIVE, N.CHARLESTON, SC 29406

Field Screening Methodology

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Permanent Monitoring wells (Estimate number and total completed depth)

# of shallow wells 8 total depth 20'

# of deep wells 1 total depth 40' (If necessary)

Comments, if warranted

Analyses

List the analytical parameters (e.g., BTEX, MTBE) and estimated number.

GROUNDWATER		SOIL	
BTEX	9	BTEX	7
NAPHTHALENE	9	PAH	7
MTBE	9	TPH	2
PAH	9	TOC/FOC	1
		GRAIN SIZE	2

Implementation Schedule

Start up date _____ Completion date _____

Report submittal date _____

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 17754 Facility Name CNC, UST NH1137-2 & AST NH1137-1

Site Maps

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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 X Slug Tests _____

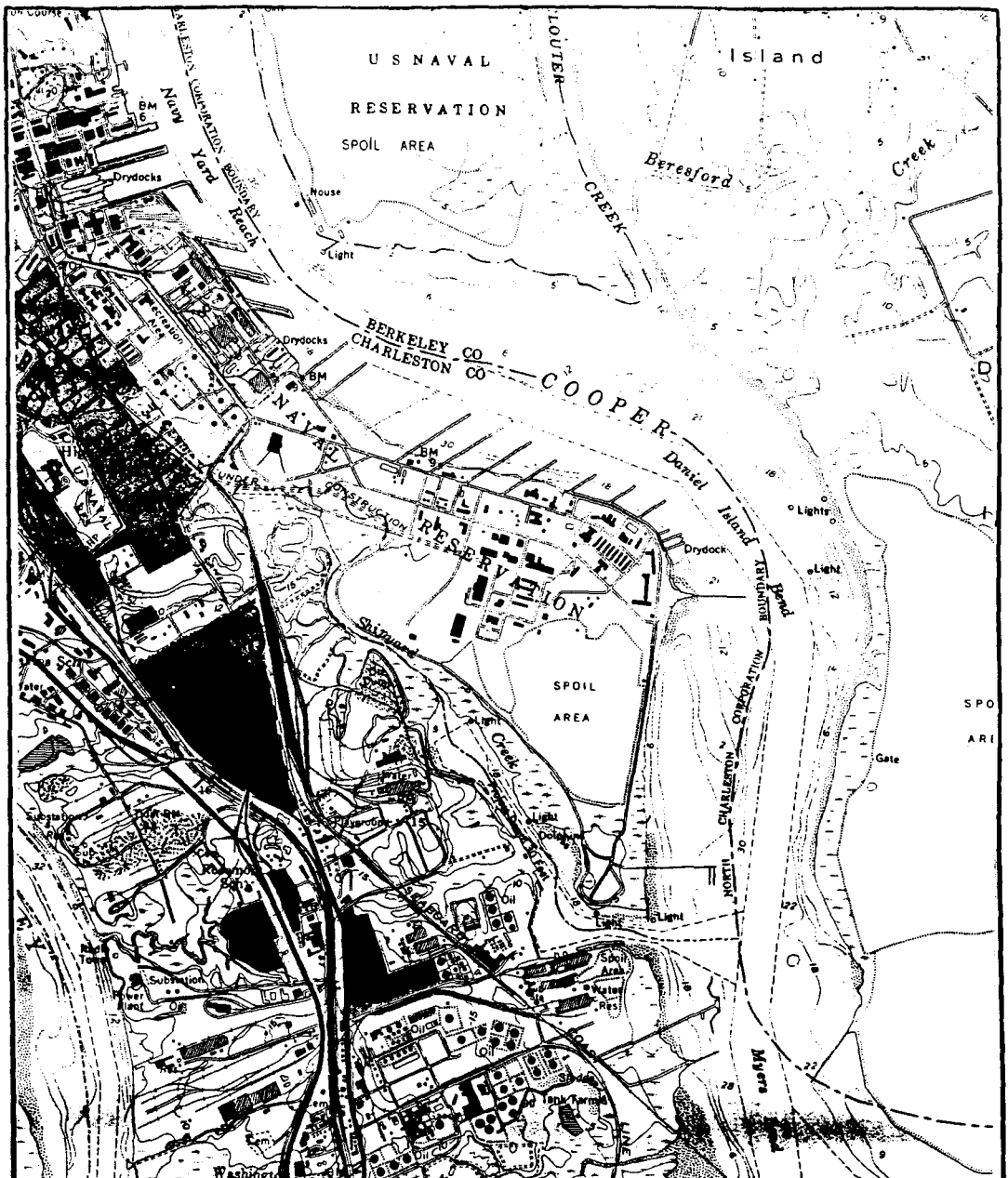
WILL PROVIDE GROUNDWATER FLOW DATA FOR ENTIRE ASSESSMENT AREA

Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WASTE WILL BE CONTAINERIZED IN 55-GALLON DRUMS AND REMAIN AT A STAGING AREA UNTIL CHEMICAL ANALYSIS IS COMPLETE. AFTER ANALYSIS, THE DRUMS WILL BE TRANSFERRED TO THE ENVIRONMENTAL DETACHMENT CHARLESTON FOR DISPOSAL

Purge Water

Additional Comments



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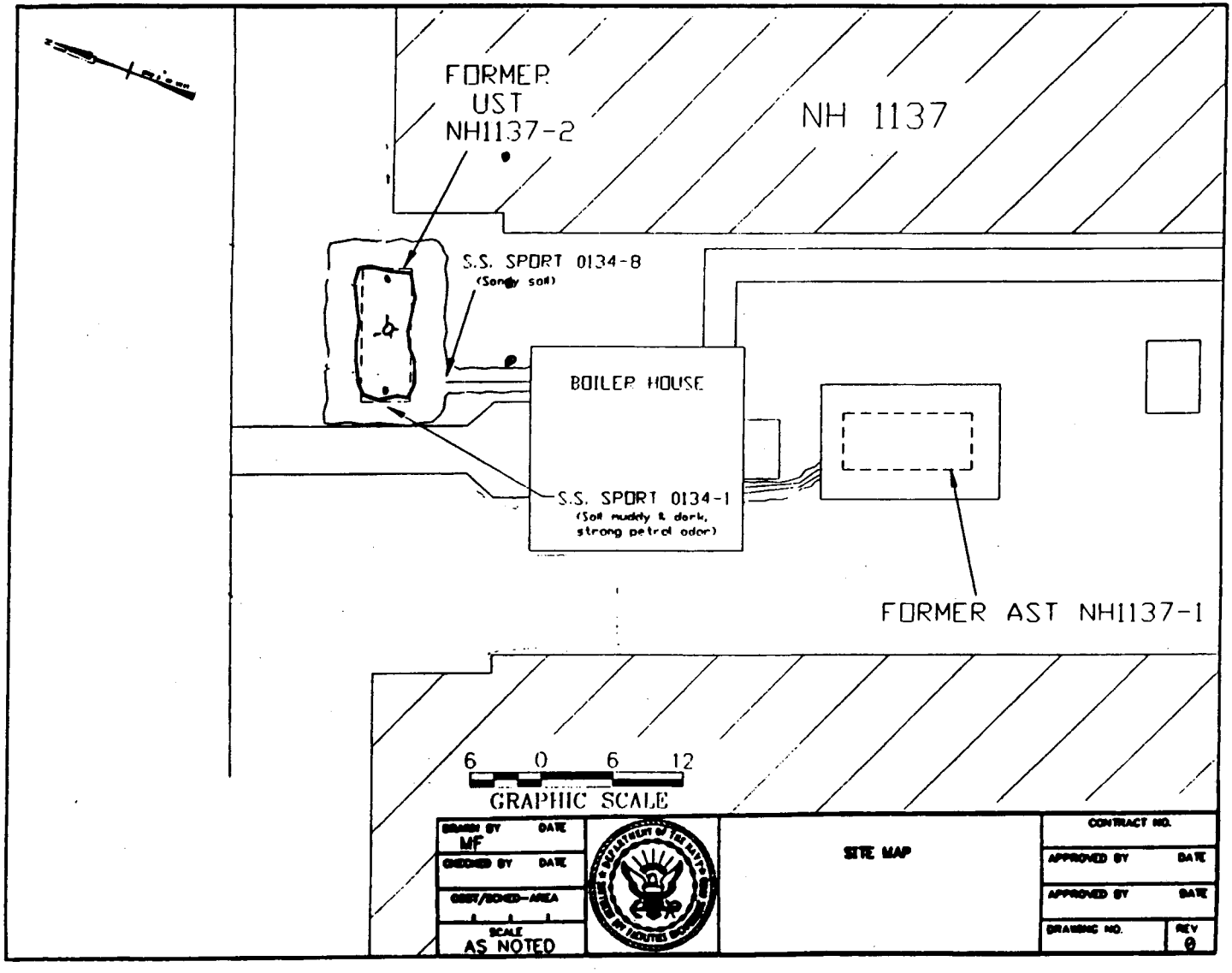
SCALE AS NOTED		

TOPOGRAPHIC MAP


FORMER
UST
NH1137-2
NH 1137
S.S. SPORT 0134-8
(Sandy soil)
BOILER HOUSE
S.S. SPORT 0134-1
(Soil muddy & dark,
strong petrol odor)
FORMER AST NH1137-1
6 0 6 12
GRAPHIC SCALE
DRAWN BY
MF
DATE
CHECKED BY
DATE
GRID/ZONED-AREA
SCALE
AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
DATE
APPROVED BY
DATE
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0

APPENDIX B

TETRA TECH NUS
STANDARD OPERATING PROCEDURES
AND STANDARD FIELD FORMS

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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.

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).

FIGURE 1

BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler B.Z.**	Backhoe**	Driller B.Z.**

* When rock coring, enter rock brakeness.

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

Remarks: _____

Drilling Area Background (ppm): _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS — More Than Half of Material is LARGER Than No. 200 Sieve Size

Field Identification Procedures (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			Group Symbol	Typical Names
GRAVELS (50%(+)>#4/#4-#200)	CLEAN GRAVELS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS WITH FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+)<#4/#4-#200	CLEAN SANDS (Low % Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS WITH FINES (High % Fines)	Non-plastic fines (for identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS — More Than Half of Material is SMALLER Than No. 200 Sieve Size

Field Identification Procedures (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)					Group Symbol	Typical Names
Identification Procedures on Fraction Smaller Than No. 40 Sieve Size						
	Dry Strength (Crushing Characteristics)	Dilatancy (Reaction to Shaking)	Toughness (Consistency near Plastic Limit)			
SILTS AND CLAYS Liquid Limit <50	None to Slight	Quick to Slow	None		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
	Medium to High	None to Very Slow	Medium		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	Slight to Medium	Slow	Slight		OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit >50	Slight to Medium	Slow to None	Slight to Medium		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	High to Very High	None	High		CH	Inorganic clays of high plasticity, fat clays.
	Medium to High	None to Very Slow	Slight to Medium		OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				Pt	Peat and other organic soils

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS

DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC COMPRESSIVE STRENGTH (Tons/Sq. Ft.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)

Descriptive Term	Screwdriver or Knife Efforts	Hammer Effects
Soft	Easily Gouged	Crushes when pressed with hammer
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges
Medium Hard	Can be scratched	Breaks (one blow); sharp edges
Hard	Cannot be scratched	Breaks conchoidally (several blows); sharp edges

ROCK BROKENNESS

Descriptive Term	Abbreviation	Spacing
Very Broken	(V. Br.)	0-3"
Broken	(Br.)	3"-1'
Blocky	(Bl.)	1'-3'
Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

0.5" Split-Barrel Sample
3.25" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

2.125" (Conventional) Core (.5-1/8" O.D.)
0.125" (Wireline) Core (.1-1/8" O.D.)
I - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/30 ▽ 12.0' Initial Level w/Date & Depth
12/30 ▽ 11.0' Stabilized Level w/Date & Depth

BOREHOLE AND SAMPLE LOGGING

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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 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

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

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

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

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

5.2.3 Relative Density and Consistency

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

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

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

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

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

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

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

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

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

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).

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)

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

5.3 Classification of Rocks

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

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.

- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.

- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.

- Shale - A fissile very fine-grained rock. Fractures along bedding planes.

- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.

- Coal - Rock consisting mainly of organic remains.

- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

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

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

5.3.1 Rock Type

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

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

5.3.2 Color

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

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

5.3.3 Bedding Thickness

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

5.3.4 Hardness

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

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

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

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

5.3.5 Fracturing

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

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

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

Method of Calculating RQD
(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.

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.

5.4 Abbreviations

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

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

5.5 Boring Logs and Documentation

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

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

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)

BORING LOG

Page 1 of 1

PROJECT NAME: NSB- SITE
PROJECT NUMBER: 9594
DRILLING COMPANY: SOILTEST CO.
DRILLING RIG: CME-55

BORING NUMBER: SB/MW1
DATE: 3/8/96
GEOLOGIST: SJ CONTI
DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft) or Sampling Interval	Soil Density/Consistency or Rock Hardness	Color	Material Classification	USCS	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole*	Outer BZ**
S-1	0.0	7/6	1.5/2.0		M DENSE	BRN TO BLK	SILTY SAND - SOME	SM	MOIST SL. ORG. ODOR	5	0	0	0
C 0800	2.0	9/10					ROCK FR: TR BRICKS (FILL)		FILL TO 4'±				
	4.0			4.0									
S-2 C		5/7	3.9/2.0		M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE	10	0	-	-
0810	6.0	9/8		7'▽					S801-0406 FOR ANALYSIS				
	8.0			8.0									
S-3 C		6/8	1.8/2.0		DENSE	TAN BRN	FINE TO COARSE SAND	SW	WET	0	0	0	0
0820	10.0	17/16					TR. F. GRAVEL		HIT WATER = 7'±				
	12.0			13.0									
S-4 C		7/6	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-
0830	14.0	5/8											
	15.0			15.0					AUGER REF @ 15'				
				LIKELIHOOD 16	M HARD	BRN	SILTSTONE	VBR	WEATHERED				
									LO ∠ JNTS @ 15.5				
9/5	①		4.0/5.0						WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
				19'					LOSING SOME				
	20.0				HARD	GRAY	SANDSTONE - SOME	BR	DRILL H2O @ 17'±				
							SILTSTONE		SET TEMP 6" CAS TO 15.5				
4.8/50	②		5.0/5.0						SET 2" PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
	25.0			25					PELLETS 12-14				

* When rock coring, enter Rock Smoothness.

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

● 1-20Z
1-90Z

Drilling Area Background (ppm): 0

Remarks: CME-55 R16, 4¼" ID HSA - 9" OD±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN (1) = 25 min. RUN (2) = 15 min

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

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.

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominate material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace: 0 - 10 percent
  - Some: 11 - 30 percent
  - And/Or: 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

- Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

- Particle shape - flat, elongated, or flat and elongated.

- Maximum particle size or dimension.

- Water level observations.

- Reaction with HCl - none, weak, or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.

  - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

  - Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - 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.

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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. A	RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT) / RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)	12
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0 PURPOSE

ıis procedure provides general guidance and information pertaining to proper monitoring well design, stallation, and development.

0 SCOPE

ıis procedure is applicable to the construction of permanent monitoring wells. The methods described rein may be modified by project-specific requirements for monitoring well construction. In addition, any regulatory agencies have specific regulations pertaining to monitoring well construction and rmitting. These requirements must be determined during the project planning phases of the vestigation, and any required permits must be obtained before field work begins. Innovative monitoring ell installation techniques, which typically are not used, will be discussed only generally in this ocedure.

0 GLOSSARY

onitoring Well - A well which is properly screened (if screening is necessary, e.g., open borehole), sed, and sealed which is capable of providing a groundwater level and groundwater sample presentative of the zone being monitored.

ezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the ttom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may ıge in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

tentiometric Surface - The surface representative of the level to which water will rise in a well cased the screened aquifer.

ell Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a id, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground h a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater ıction and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples water quality data.

RESPONSIBILITIES

ler - The driller provides adequate and operable equipment, sufficient quantities of materials, and an erienced and efficient labor force capable of performing all phases of proper monitoring well allation and construction. The driller may also be responsible for obtaining, in advance, any required mits for monitoring well installation and construction.

Geologist - The rig geologist supervises and documents well installation and construction performed he driller, and insures that well construction is adequate to provide representative groundwater data ı the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well:

- Health and safety equipment as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installations tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives for each monitoring well and its intended use must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials to be used. The objectives for installing the monitoring wells may nclude:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow and potential well locations can be determined through the eview of geologic data and the site terrain. In addition, data from production wells or other monitoring vells in the area may be used to determine the groundwater flow direction. If these methods cannot be ised, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary nvestigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the levels at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The

ll diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling quirements, drilling method and cost.

e decision concerning the monitored interval and well depth is based on the following (and possibly ner) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

nost situations where groundwater flow lines are horizontal, depending on the purpose of the well and site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (1 to 2 feet) are ually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate asurement of the potentiometric head at a specific point).

ny factors influence the diameter of a monitoring well. The diameter of the monitoring well depends the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

ndard monitoring well diameters are 2, 4, 6, or 8 inches. However, drive points are typically 1-1/4 or ches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch l-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in itoring programs in which open-hole monitoring wells are required. In the smaller diameter wells, volume of stagnant water in the well is minimized, and well construction costs are reduced, however, type of sampling devices that can be used are limited. In specifying well diameter, sampling iirements must be considered (up to a total of 4 gallons of water may be required for a single sample ccount for full organic and inorganic analyses, and split samples). The volume of water in the itoring well available for sampling is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Depth to Obtain 1 Gallon Water (Feet)	Total Depth of Standing Water for 4 Gallons (Feet)
2	6.13	25
4	1.53	6
6	0.68	3

However, if a specific well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells; however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength" and Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed. Properties of these two materials are compared in Attachment B. Stainless steel is preferred where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, and ease of manipulation; however, there are also some questions about organic chemical sorption and leaching that are currently being researched (see Barcelona et al., 1983). Concern about the use of PVC can be minimized if PVC wells are used strictly for geohydrologic measurements and not for chemical sampling. The crushing strength of PVC may limit the depth of installation, but Schedule 80 materials normally used for wells greater than 50 feet deep may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe, may corrode and release metal ions or chemically react with organic constituents, but this is considered by some to be less of a problem than the problem associated with PVC material. Galvanized steel is not

commended where samples may be collected for metal analyses, as zinc and cadmium levels in oundwater samples may become elevated from leaching of the zinc coating.

readed, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and el can all be obtained with threaded joints at slightly more costs. Welded-joint steel casing is also ceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be ed if the well is to be sampled for organic constituents.

hen the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well reen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, ch as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally ed when a screen is necessary and the screened interval is artificially packed with a fine sand. The t size controls the quantity of water entering the well and prevents entry of natural materials or sand ck. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. e rig geologist shall specify the combination of screen slot size and sand pack which will be mpatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and vement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to . 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot een.

.3 Annular Materials

terials placed in the annular space between the borehole and riser pipe and screen include a sand k when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine-nedium-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. quantity of sand placed in the annular space is dependent upon the length of the screened interval, should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite ets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then ed to extent from the top of the bentonite pellets to the ground surface.

occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be ked naturally (i.e., no artificial sand pack installed), and the natural formation material is allowed to apse around the well screen after the well is installed. This method has been used where the ation material itself is a relatively uniform grain size, or when artificial sand packing is not possible to borehole collapse.

tonite expands by absorbing water and provides a seal between the screened interval and the tying portion of the annular space and formation. Cement-bentonite grout is placed on top of the onite pellets extending to the surface. The grout effectively seals the well and eliminates the sibility for surface infiltration reaching the screened interval. Grouting also replaces material removed g drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used troduce grout from the bottom of the hole upward, to prevent bridging, and to provide a better seal. ever, in shallow boreholes that don't collapse, it may be more practical to pour the grout from the ace without a tremie pipe.

it is a general term which has several different connotations. For all practical purposes within the itoring well installation industry, grout refers to the solidified material which is installed and occupies annular space above the bentonite pellet seal. Grout, most of the time, is made up of two mblages of material, (e.g., cement-bentonite). A cement-bentonite grout normally is a mixture of ent, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus

to 5 pounds of granular or flake-type bentonite, and 6 gallons of water. A neat cement consists of one nety-pound bag of Portland Type I cement and 6 gallons of water.

ı certain cases, the borehole may be drilled to a depth greater than the anticipated well installation epth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets or quivalent. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately elow the screen, as a silt reservoir, when significant post-development silting is anticipated. This will nsure that the entire screen surface remains unobstructed.

2.4 Protective Casing

'hen the well is completed and grouted to the surface, a protective steel casing is often placed over the p of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. A vent ole shall be provided in the cap to allow venting of gases and maintain atmospheric pressure as water vels rise or fall in the well. The protective casing has a larger diameter than the well and is set into the et cement grout over the well upon completion. In addition, one hole is drilled just above the cement ollar through the protective casing which acts as a weep hole for the flow of water which may enter the nnulus during well development, purging, or sampling.

protective casing which is level with the ground surface is used in roadway or parking lot applications here the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to inches below the pavement, and a locking protective casing is cemented in place to 3 inches below e pavement. A large diameter protective sleeve is set into the wet cement around the well with the top t level with the pavement. A manhole-type lid placed over the protective sleeve. The cement should slightly mounded to direct pooled water away from the well head.

3 Monitoring Well Installation

rtinent data regarding monitoring well installation shall be recorded on log sheets as depicted and cussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction various types of monitoring wells.

.1 Monitoring Wells in Unconsolidated Sediments

er the borehole is drilled to the desired depth, well installation can begin. The procedure for well tallation will partially be dictated by the stability of the formation in which the well is being placed. If borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must installed and well installation will proceed through the center of the temporary casing, and continue the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the bers will act to stabilize the borehole during well installation.

ore the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be asured with an engineer's rule to ensure proper placement. When measuring sections, the threads one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections screwed flush together.

er the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. eighted tape measure must be used during the installation procedure to carefully monitor installation gress. The sand is poured into the annulus between the riser pipe and temporary casing, as the ing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order nsure an adequate sand pack. However, if too much sand is within the temporary casing (greater

1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may ır.

the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then ɔentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 3 feet of bentonite pellets should be installed above the sand pack.

cement-bentonite grout is then mixed and either poured or tremied into the annulus as the temporary ng or augers are withdrawn. Finally, the protective casing can be installed as detailed in ion 5.2.4.

able formations where borehole collapse does not occur, the well can be installed as discussed ve, and the use of a temporary casing is not needed. However, centralizers may have to be installed, above and one below the screen, to assure enough annular space for sand pack placement.

? Confining Layer Monitoring Wells

n drilling and installing a well in a confined aquifer, proper well installation techniques must be ied to avoid cross contamination between the unconfined and confined aquifer. Under most litions, this can be accomplished by installing double-cased wells. This is accomplished by drilling ge-diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and ıg and pressure grouting or tremie grouting the outer casing into the confining layer. The grout rial must fill the space between the native material and the outer casing. A smaller diameter boring en continued through the confining layer for installation of the monitoring well as detailed for ɔurden monitoring wells (with the exception of not using a temporary casing during installation). :ient time (determined by the rig geologist), must be allowed for setting of the grout prior to drilling ıgh the confined layer.

Bedrock Monitoring Wells

ı installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and ɔximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted mie grouted in place. After the grout has cured, a smaller diameter boring is continued through edrock to the desired depth. If the boring does not collapse, the well can be left open, and a n is not necessary. If the boring collapses, then a screen is required and can be installed as ed for overburden monitoring wells. However, if a screen is to be used, then the casing which is ed through the overburden and into the bedrock does not require grouting and can be installed ɔrary until final well installation is completed.

Drive Points

points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The n is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply ied into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding ft.

Innovative Monitoring Well Installation Techniques

n innovative sampling devices have proven advantageous. These devices are essentially screened ers installed in a borehole with only one or two small-diameter tubes extending to the surface.

Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch-diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet of the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each manufacturer offers various construction materials.

Two additional types of multilevel sampling systems have been developed. Both employ individual screened openings through a small-diameter casing. One of these systems (marketed by Westbay Instruments Ltd. of Vancouver, British Columbia, Canada) uses a screened port and a sampling probe to obtain samples and head measurements or perform permeability tests. This system allows sampling ports at intervals as close as 5 feet, if desired, in boreholes from 3 to 4.8 inches in diameter.

The second system, developed at the University of Waterloo at Waterloo, Ontario, Canada, requires field assembly of the individual sampling ports and tubes that actuate a simple piston pump and force the samples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not required. The assembly is made of easily obtained materials; however, the cost of labor to assemble these monitoring systems may not be cost-effective.

.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity and temperature taken during development may yield information (stabilized values) that sufficient development is reached. The selection of the well development method shall be made by the rig geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water pulls the materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid

gers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers designed to produce a greater inflow than outflow of water during surging.

3 Compressed Air

ıpressed air can be used to develop a well by either of two methods: backwashing or surging. kwashing is done by forcing water out through the screens, using increasing air pressure inside a ed well, then releasing the pressurized air to allow the water to flow back into the well. Care should aken when using this method so that the water level does not drop below the top of the screen, thus ıcing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes ir suddenly into an open well below the water level to produce a strong surge by virtue of the stance of water head, friction, and inertia. Pumping of the well is subsequently done using the air ıethod.

4 High Velocity Jetting

ıe high velocity jetting method, water is forced at high velocities from a plunger-type device and ugh the well screen to loosen fine particles from the sand pack and surrounding formation. The ıg tool is slowly rotated and raised and lowered along the length of the well screen to develop the e screened area. Jetting using a hose lowered into the well may also be effective. The fines washed the screen during this process can then be bailed or pumped from the well.

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RECORDS

itical part of monitoring well installation is recording of significant details and events in the site ook or field notebook. The geologist must record the exact depths of significant hydrogeological ıres screen placement, gravel pack placement, and bentonite placement.

ɔnitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed thus ensuring the uniform rding of data for each installation and rapid identification of missing information. Well depth, length, rials of construction, length and openings of screen, length and type of riser, and depth and type backfill materials shall be recorded. Additional information shall include location, installation date, lems encountered, water levels before and after well installation, cross-reference to the geologic ıg log, and methods used during the installation and development process. Documentation is very ıtant to prevent problems involving questionable sample validity. Somewhat different information

will need to be recorded.depending on whether the well is completed in overburden, in a confined layer, in bedrock with a cased well, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have a general idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

otentially-Deteriorating ubstance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
uffered Weak Acid	100	56	51	59	97	100	100
eak Acid	98	59	43	47	96	100	100
neral Acid/ gh Solids Content	100	48	57	60	80	82	100
queous/Organic xtures	64	69	73	73	98	100	100
rcent Overall Rating	91	58	56	59	93	96	100

eliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

entially- eriorating ostance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
fered Weak Acid	97	97	100	97	90	92	87	85	100
ak Acid	92	90	94	96	78	78	75	75	100
eral Acid/ h Solids Content	100	100	100	100	95	100	78	82	100
ieous/Organic tures	62	71	40	60	49	78	49	44	100
cent Overall ng	88	90	84	88	78	87	72	72	100

iminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

ademark of DuPont

ce: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

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PURPOSE

e purpose of this procedure is to provide general reference information regarding the sampling of undwater wells.

SCOPE

s procedure provides information on proper sampling equipment, onsite water quality testing, and hniques for groundwater sampling. Review of the information contained herein will facilitate planning he field sampling effort by describing standard sampling techniques. The techniques described shall ollowed whenever applicable, noting that site-specific conditions or project-specific plans may require difications to methodology.

GLOSSARY

nductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-tional area. For groundwater measurements, a volume of water contained in a 1 cm x 1 cm sample tainer (the water acts as the conductor). Conductivity and specific conductance are used onymously.

trolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. cell functions in much the same way as a galvanic cell, only the current flows in the opposite ction due to the external source of applied voltage. Electrolytic cells are used in dissolved oxygen surement.

anic Cell - A electrochemical cell in which chemical energy is spontaneously converted to electrical gy. The electrical energy produced is supplied to an external circuit. Galvanic cells are used in olved oxygen measurement.

- Standard unit of electrical resistance (R). Used in specific conductance measurement. A siemen mho) is the standard unit of electrical conductance, the inverse of the ohm.

ation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species termined by the electromotive force developed by a noble metal electrode, immersed in water, as nced against a standard hydrogen electrode.

The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for actical purposes, pH is a measure of the hydrogen ion concentration.

per - Indicator paper that turns different colors depending on the pH of the solution to which it is ed. Comparison with color standards supplied by the manufacturer will then give an indication of lution's pH.

ance - A measure of the solution's ability to oppose the passage of electrical current. For metals olutions, resistance is defined by Ohm's Law, E = IR, where E is the potential difference, I is the t, and R is the resistance. Used in measurement of specific conductance.

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.

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).

tratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and spersion processes, layers of variable permeability, and the presence of separate-phase product (i.e, oating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can lute or increase the contaminant concentrations in the recovered sample compared to what is presentative of the integrated water column as it naturally occurs at that point, thus the result is the ollection of a non-representative sample.

2 **Sampling, Monitoring, and Evacuation Equipment**

mple containers shall conform with the guidelines expressed in SOP SA-6.1.

e following equipment shall be on hand when sampling ground water wells (reference SOPs SA-6.1 d 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 - Thermometer, pH paper/meter, camera and film (if appropriate), appropriate keys (for locked wells), engineer's rule, water level indicator, specific conductivity meter, and turbidity meter (as applicable).

- Pumps

  - Shallow-well pumps: Centrifugal, pitcher, 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 air-lift apparatus where applicable.

- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary). Bailers or submersible centrifugal pumps shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

- Pails - Plastic, graduated.

- Decontamination solutions - Deionized water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvents (e.g., methanol, acetone, hexane), as required.

ly, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior e, reusable, able to operate at remote sites in the absence of power sources, and capable of ering variable rates for well flushing 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).
- 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 $V = (0.163)(T)(r^2)$

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, electrical 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.
- 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, peristaltic, and pitcher 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. The pitcher pump is a common farm hand-pump.

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.

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) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements
- Turbidity

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.

vo methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper used when only a rough estimate of the pH is required, and the pH meter when a more accurate easurement is needed. The response of a pH meter can be affected to a slight degree by high levels colloidal or suspended solids, but the effect is usually small and generally of little significance. onsequently, specific methods to overcome this interference are not described. The response of pH per is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless tremely high levels capable of coating or masking the paper are encountered. In such cases, use of pH meter is recommended.

5.1.2 Principles of Equipment Operation

e of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity the solution created by the addition of the water sample reacting with the indicator compound on the per. Various types of pH papers are available, including litmus (for general acidity or basicity termination) and specific pH range hydrion paper.

e of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on ablishment of a potential difference across a glass or other type of membrane in response to (in this ance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic cies and, in combination with a standard or reference electrode, a potential difference proportional he ion concentration is generated and measured.

1.3 Equipment

following equipment is needed for taking pH measurements:

- Stand-alone 150 portable pH meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- 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.

.4 Measurement Techniques for Field Determination of pH

leter

ollowing procedure is used for measuring pH with a pH meter (meter standardization is according inufacturer'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.

- Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.

- 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 following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.

- Immerse the electrode(s) in the unknown solution, 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 solution. pH shall be recorded to the nearest 0.1 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.

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.

s important to obtain a specific conductance measurement soon after taking a sample, since perature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the cific conductance.

2.2 Principles of Equipment Operation

aqueous system containing ions will conduct an electric current. In a direct-current field, the positive s migrate toward the negative electrode, while the negatively charged ions migrate toward the positive ctrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or ium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as rose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at

nductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used neasurement of electrical resistance. The ratio of current applied to voltage across the cell may also sed as a measure of conductance. The core element of the apparatus is the conductivity cell aining the solution of interest. Depending on ionic strength of the aqueous solution to be tested, tential difference is developed across the cell which can be converted directly or indirectly ending on instrument type) to a measurement of specific conductance.

.3 Equipment

ollowing equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber.
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

iety of conductivity meters are available which may also be used to monitor salinity and ratures. Probe types and cable lengths vary, so equipment must be obtained to meet the specific ement of the sampling program.

Measurement Techniques for Specific Conductance

eps involved in taking specific conductance measurements are listed below (standardization is ling to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.

- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration. Attachment B provides guidance in this regard.

  Rinse the cell with one or more portions of the sample to be tested or with deionized water.

- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature (if applicable).
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled or dial-type thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

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 Concentration

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.

he monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical ethods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample anipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted aters, because the probe is completely submersible, and is not susceptible to interference caused by olor, turbidity, colloidal material or suspended matter.

.5.4.2 Principles of Equipment Operation

Issolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of lifferent nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable iembrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable otential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the ithode surface. An electrical current is developed that is directly proportional to the rate of arrival of ygen molecules at the cathode.

nce the current produced in the probe is directly proportional to the rate of arrival of oxygen at the ithode, it is important that a fresh supply of sample always be in contact with the membrane. herwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low adings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain sh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional ygen is introduced through the air-water interface at the sample surface. To avoid this possibility, me probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface the solution undisturbed.

ssolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are ictions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not sily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted the field log book and checked if possible. Temperature variations can also cause interference use probes exhibit temperature sensitivity. Automatic temperature compensation is normally vided by the manufacturer.

.4.3 Equipment

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.
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

4.4 Measurement Techniques for Dissolved Oxygen Determination

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

- The equipment shall be calibrated and have its batteries checked in the warehouse 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.

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 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 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. 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.

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

5.5.6.4 Measurements Techniques for Specific Conductance

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.

5.6 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.

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 groundwarer 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. Never collect volatile organics samples using a vacuum pump.

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 the sampling level before filling.

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).

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). Peristaltic pumps may be used only for inorganic sample collection.
- 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 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.
- 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 - eH 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 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 turbid 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 three to five 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 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 three to five 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 three to five minute intervals). If the parameters have stabilized, but turbidity remains above 5 NTU goal, decrease pump flow rate, and continue measurement of parameters every three to five 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 and 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.

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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
PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/ Length (inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volum e	$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)	1.75/36	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A
PURGING EQUIPMENT SELECTION
PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/ Length (inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/ flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/ flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

- PE Polyethylene
- PP Polypropylene
- PVC Polyvinyl chloride
- SS Stainless steel
- PC Polycarbonate
- EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

- NA Not applicable
- AC Alternating current
- DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B

SPECIFIC CONDUCTANCE OF 1 MOLAR KCl AT VARIOUS TEMPERATURES[1]

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.

ATTACHMENT C

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

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	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

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

Temperature (°C)	Dissolved Oxygen (mg/L)					
	Chloride Concentration in Water					Difference/ 100 mg Chloride
	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.

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ATTACHMENTS

A SPLIT-SPOON SAMPLER 18
B REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING 19

1.0 PURPOSE

This procedure discusses the methods used to collect surface, near surface, and subsurface soil samples. Additionally, it describes the method for sampling of test pits and trenches to determine subsurface soil and rock conditions, and recover small-volume or bulk samples.

2.0 SCOPE

This procedure is applicable to the collection of surface, near surface and subsurface soils for laboratory testing, which are exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites.

3.0 GLOSSARY

Composite Sample - A composite sample exists as a combination of more than one sample at various locations and/or depths and times, which is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples are not to be collected for volatile organics analysis.

Grab Sample - One sample collected at one location and at one specific time.

Non-Volatile Sample - A non-volatile sample includes all other chemical parameters (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Hand Auger - A sampling device used to extract soil from the ground in a relatively undisturbed form.

Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2-inch OD to 3-1/2 inch OD. The larger sizes are commonly used when a larger volume of sample material is required.

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine the shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher excavator, or bulldozer).

Confined Space - As stipulated in 29 CFR 1910.146, a confined space means a space that: 1) is large enough and so configured that an employee can bodily enter and perform assigned work; 2) has limited or restricted means for entry or exit (for example tanks, vessels, silos, storage bins, hoppers, vaults, and pits, and excavations are spaces that may have limited means of entry.); and 3) is not designed for continuous employee occupancy. Brown & Root Environmental considers all confined space as permit-required confined spaces.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for determining sampling objectives, as well as, the field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches, and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan. This will include (but not be limited to) performing air quality monitoring during sampling, boring and excavation activities, and to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the FOL on other safety-related matters regarding boring, excavation and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - The FOL is responsible for finalizing the location of surface, near surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits and trenches, and for adherence to OSHA regulations during these operations.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of soil samples and the completion of all required paperwork (i.e., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms).

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

5.0 PROCEDURES

5.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they have migrated into the water table, and can establish the amount of contamination sorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can effect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during the sampling operations, particularly noting the location, depth, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. As a result, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers and be analyzed as soon as possible.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. Often this information on soil properties can be obtained from published soil surveys available through the U.S. Geological Surveys and other government or farm agencies. It is the intent of this procedure to present the most commonly employed soil sampling methods used at hazardous waste sites.

5.2 Soil Sample Collection

5.2.1 Procedure for Collecting Soil Samples for Volatile Organic Compounds

The above described traditional sampling techniques, used for the collection of soil samples for volatile organic analysis have recently been evaluated by the scientific community and determined to be ineffective in producing accurate results (biased low) due to the loss of volatile organics in the sampling stages and microbial degradation of aromatic volatiles. One of the newly adopted sampling procedures for collecting soil samples include the field preservation of samples with methanol or sodium bisulfate to minimize volatilization and biodegradation. These preservation methods may be performed either in the field or laboratory, depending on the sampling methodology employed.

Soil samples to be preserved by the laboratory are currently being performed using method SW-846, 5035. Laboratories are currently performing low level analyses (sodium bisulfate preservation) and high level analyses (methanol preservation) depending on the end users needs.

It should be noted that a major disadvantage of the methanol preservation method is that the laboratory reporting limits will be higher than conventional testing. The reporting levels using the new method for most analytes is 0.5 µg/g for GC/MS and 0.05 µg/g for GC methods.

The alternative preservation method for collecting soil samples is with sodium bisulfate. This method is more complex to perform in the field and therefore is not preferred for field crews. It should also be noted that currently, not all laboratories have the capabilities to perform this analysis. The advantage to this method is that the reporting limits (0.001 µg/g for GC/PID or GC/ELCD, or 0.010 for GC/MS) are lower than those described above.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

5.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organics that are to be preserved at the laboratory will be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample will be obtained using a reusable sampling handle provided with the EnCore™ sampler. The sample is collected by pushing the EnCore™ sampler directly into the soil, ensuring that the sampler is packed tight with soil, leaving zero headspace. Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives.

Once the sample is collected, it should be placed on ice immediately and shipped to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

If the lower detection limits are necessary, an option would be to collect 3 EnCore™ samplers at a given sample location. Send all samplers to the laboratory and the laboratory can perform the required preservation and analyses.

5.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) method and medium-level (methanol preservation) method.

Methanol Preservation (Medium Level):

Soil samples to be preserved in the field with methanol will utilize 40-60 mL glass vials with septum lids. Each sample bottle will be filled with 25 mL of demonstrated analyte-free purge and trap grade methanol. Bottles may be prespiked with methanol in the laboratory or prepared in the field.

Soil will be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol preserved sample bottle. Calibration of the scale should be performed prior to use and intermittently throughout the day according to the manufacturers requirements.

The sample should be collected by pulling the plunger back and inserting the syringe into the soil to be sampled. The top several inches of soil should be removed before collecting the sample. Approximately 10 grams ±2g (8-12 grams) of soil should be collected. The sample should be weighed and adjusted until obtaining the required amount of sample. The sample weight should be recorded to the nearest 0.01 gram in the field logbook and/or sample log sheet. The soil should then be extruded into the methanol preserved sample bottle taking care not to contact the sample container with the syringe. The threads of the bottle and cap must be free of soil particles.

After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

Samples to be preserved using the sodium bisulfate method are to be prepared as follows:

Add 1 gram of sodium bisulfate to 5 mL of laboratory grade deionized water in a 40-60 mL glass vial with septum lid. Bottles may be prespiked in the laboratory or prepared in the field. The soil sample should be collected in a manner as described above and added to the sample container. The sample should be weighed to nearest 0.01 gram as described above and recorded in field logbook or sample log sheet.

Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soils containing carbonates (limestone) may cause the sample to effervescent or the vial to possibly explode.

When preparing samples using the sodium bisulfate preservation method, duplicate samples must be collected using the methanol preservation method on a one for one sample basis. The reason

for this is because it is necessary for the laboratory to perform both the low level and medium level analyses. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

If the lower detection limits are necessary, an option to field preserving with sodium bisulfate would be to collect 3 EnCore™ samplers at a given sample location. Send all samplers to the laboratory and the laboratory can perform the required preservation and analyses.

5.2.2 Procedure for Collecting Non-Volatile Soil Samples

Non-volatile soil samples may be collected as either grab or composite samples. The non-volatile soil sample is thoroughly mixed in a stainless steel or disposable, inert plastic tray, using a stainless steel trowel or other approved tool, then transferred into the appropriate sample container(s). Head space is permitted in a non-volatile soil sample container to allow for sample expansion.

5.2.3 Procedure for Collecting Undisturbed Soil Samples (ASTM D1587-83)

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) will be employed. The following method will be used:

1. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Use of any side-discharge bits is permitted.

3. A stationary piston-type sampler may be required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

4. To minimize chemical reaction between the sample and the sampling tube, brass tubes may be required, especially if the tube is stored for an extended time prior to testing. While steel tubes coated with shellac are less expensive than brass, they're more reactive, and shall only be used when the sample will be tested within a few days after sampling or if chemical reaction is not anticipated. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

5. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch

thickness of wax applied in a way that will prevent the wax from entering the sample. Clean filler must be placed in voids at either end of the tube prior to sealing with wax. Place plastic caps on the ends of the sample tube, tape the caps in place, and dip the ends in wax.

6. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label. Mark the "up" direction on the side of the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms (see SOP SA-6.3). Do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs, and therefore their use shall be weighed against the need for acquiring an undisturbed sample.

5.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples (most commonly collected to a depth of 6 inches) for subsequent analysis is by use of a stainless steel trowel.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel trowel.
- Real-time air monitoring instrument (e.g., PID, FID, etc.).
- Latex gloves.
- Required Personal Protective Equipment (PPE).
- Required paperwork.
- Required decontamination equipment.
- Required sample container(s).
- Wooden stakes or pin flags.
- Sealable polyethylene bags (i.e., Ziploc baggies).
- Heavy duty cooler.
- Ice (if required) double-bagged in sealable polyethylene bags.
- Chain-of-custody records and custody seals.

When acquiring surface soil samples, the following procedure shall be used:

1. Carefully remove vegetation, roots, twigs, litter, etc., to expose an adequate soil surface area to accommodate sample volume requirements.

2. Using a decontaminated stainless steel trowel, follow the procedure cited in Section 5.2.1 for collecting a volatile soil sample.

3. Thoroughly mix (in-situ) a sufficient amount of soil to fill the remaining sample containers and transfer the sample into those containers utilizing the same stainless steel trowel employed above. Cap and securely tighten all sample containers.

4. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.

5. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

5.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6-18 inches) can be accomplished with tools such as shovels and stainless steel trowels.

The following equipment is necessary to collect near surface soil samples:

- Clean shovel.
- Plus the equipment listed under Section 5.3 of this procedure.

To obtain near-surface soil samples, the following protocol shall be observed:

1. With a clean shovel, make a series of vertical cuts to the depth required in the soil to form a square approximately 1 foot by 1 foot.

2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel trowel to remove any loose soil.

3. Follow steps 2 through 5 listed under Section 5.3 of this procedure.

5.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of all stainless steel bucket bits (i.e., cylinders 6-1/2" long, and 2-3/4", 3-1/4", and 4" in diameter), a series of extension rods (available in 2', 3', 4' and 5' lengths), and a cross handle. A larger diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then withdrawn. In turn, the larger diameter bit is replaced with a smaller diameter bit, lowered down the hole, and slowly turned into the soil at the completion depth (approximately 6"). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil both from the surface, or to depths in excess of 12 feet. However, the presence of rock layers and the collapse of the borehole normally contribute to its limiting factors.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes).
- Stainless steel mixing bowls.
- Plus the equipment listed under Section 5.3 of this procedure.

To obtain soil samples using a hand auger, the following procedure shall be followed:

1. Attach a properly decontaminated bucket bit to a clean extension rod and further attach the cross handle to the extension rod.

2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).

3. Begin augering (periodically removing accumulated soils from the bucket bit) and add additional rod extensions as necessary. Also, note (in a field notebook or on standardized data sheets) any changes in the color, texture or odor of the soil.

4. After reaching the desired depth, slowly and carefully withdraw the apparatus from the borehole.

5. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is commonly smaller in diameter than the bucket bit employed to initiate the borehole.

6. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.

7. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.

8. Discard the top of the core (approximately 1"), which represents any loose material collected by the bucket bit before penetrating the sample material.

9. Fill volatile sample container(s), using a properly decontaminated stainless steel trowel, with sample material directly from the bucket bit. Refer to Section 5.2.1 of this procedure.

10. Utilizing the above trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl and thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.

11. Follow steps 4 and 5 listed under Section 5.3 of this procedure.

5.6 Subsurface Soil Sampling With a Split-Barrel Sampler (ASTM D1586-84)

Split-barrel (split-spoon) samplers consist of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment A). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-lb. or larger casing driver.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (O.D. 2 inches, I.D. 1-3/8 inches, either 20 inches or 26 inches long); Larger O.D. samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-lb. weight, driving head and guide permitting free fall of 30 inches.

- Stainless steel mixing bowls.
- Plus equipment listed under Section 5.3 of this procedure.

The following steps shall be followed to obtain split-barrel samples:

1. Remove the drive head and nosepiece, and open the sampler to reveal the soil sample. Immediately scan the sample core with a real-time air monitoring instrument (e.g., OVA, HNu, etc.). Carefully separate the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.

2. Collect the volatile sample from the center of the core where elevated readings occurred. If no elevated readings where encountered the sample material should still be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact). Refer to Section 5.2.1 of this procedure.

3. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl. Thoroughly homogenize the sample material prior to filling the remaining sample containers. Refer to Section 5.2.2 of this procedure.

4. Follow steps 4 and 5 listed under Section 5.3 of this procedure.

5.7 Excavation and Sampling of Test Pits and Trenches

5.7.1 Applicability

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise which control the method of excavation. No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is still required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden or steel support structures. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments. Any entry may constitute a Confined Space and must be done in conformance with all applicable regulations. In these cases, substantial air monitoring is required before entry, and appropriate respiratory gear and protective clothing is mandatory. There must be at least two persons present at the immediate site before entry by one of the investigators. The reader shall refer to OSHA regulations 29 CFR 1926, 29 CFR 1910.120, 29 CFR 1910.134, AND 29 CFR 1910.146.

Excavations are generally not practical where a depth of more than about 15 feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be

adequately stored or disposed. If data on soils at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

5.7.2 Test Pit and Trench Excavation

These procedures describe the methods for excavating and logging test pits and trenches excavated to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented as described in SOP SA-6.3.

Test pits and trenches may be excavated by hand or by power equipment to permit detailed description of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration.
- The space required for efficient excavation.
- The chemicals of concern.
- The economics and efficiency of available equipment.

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table, which is based on equipment efficiencies, gives a rough guide for design consideration:

Equipment	Typical Widths, in Feet
Trenching machine	2
Backhoe	2-6
Track dozer	10
Track loader	10
Excavator	10
Scraper	20

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous waste materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit, temporary staging area and spoils pile will be predicated based on site conditions and wind

direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

As mentioned previously, no personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is still required, Occupational Safety and Health Administration (OSHA) requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be in the hole at all times, and a temporary guardrail must be placed along the surface of the hole before entry). It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example, samples of leachate, groundwater, or sidewall soils can be taken with telescoping poles, etc.

Dewatering may be required to assure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation dry. This is an important consideration for excavations in cohesionless material below the groundwater table. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

5.7.3 Sampling in Test Pits and Trenches

5.7.3.1 General

Test pits and trenches are usually logged as they are excavated. Records of each test pit/trench will be made as described in SOP SA-6.3. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable Health and Safety and OSHA requirements have been met.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information would include soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples, which can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

5.7.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks and hand augers, stainless steel trowels.

- Sample container - bucket with locking lid for large samples; appropriate bottleware for chemical or geotechnical analysis samples.

- Polyethylene bags for enclosing sample containers; buckets.

- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps and right angle adapter for conduit (see Attachment B).

5.7.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 5.7.3.4.

- Excavate trench or pit in several depth increments. After each increment, the operator will wait while the sampler inspects the test pit from grade level to decide if conditions are appropriate for sampling. (Monitoring of volatiles by the SSO will also be used to evaluate the need for sampling.) Practical depth increments range from 2 to 4 feet.

- The backhoe operator, who will have the best view of the test pit, will immediately cease digging if:

- Any fluid phase or groundwater seepage is encountered in the test pit.

- Any drums, other potential waste containers, obstructions or utility lines are encountered.

- Distinct changes of material are encountered.

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending upon the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Remove loose material to the greatest extent possible with backhoe.

- Secure walls of pit if necessary. (There is seldom any need to enter a pit or trench which would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)

- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material once it has been deposited on the ground. The sampler or Field Operations Leader directs the backhoe operator to remove material from the selected depth or location within the test pit/trench. The bucket is brought to the surface and moved away from the pit. The sampler and/or SSO then approaches the bucket and monitors its contents with a photoionization or flame ionization detector. The sample is collected from the center of the bucket or pile and placed in sample containers using a decontaminated stainless steel trowel or spatula.

- If a composite sample is desired, several depths or locations within the pit/trench are selected and a bucket is filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory

conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

- Using the remote sampler shown in Attachment B, samples can be taken at the desired depth from the side wall or bottom of the pit. The face of the pit/trench shall first be scraped (using a long-handled shovel or hoe) to remove the smeared zone that has contacted the backhoe bucket. The sample shall then be collected directly into the sample jar, by scraping with the jar edge, eliminating the need to utilize samplers and minimizing the likelihood of cross-contamination. The sample jar is then capped, removed from the assembly, and packaged for shipment.

- Complete documentation as described in SOP SA-6.3.

5.7.3.4 <u>In-Pit Sampling</u>

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soils or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There is no practical alternative means of obtaining such data.

- The Site Safety Officer and Competent Person determines that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of volatile organics, explosive gases and available oxygen).

- A Company-designated Competent Person determines that the pit/trench is stable or is made stable (by grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements must be strictly observed.

If these conditions are satisfied, one person will enter the pit/trench. On potentially hazardous waste sites, this individual will be dressed in safety gear as required by the conditions in the pit, usually Level B. He/she will be affixed to a safety rope and continuously monitored while in the pit.

A second individual will be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations. The individual entering the pit will remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon. As an added precaution, it is advisable to keep the backhoe bucket in the test pit when personnel are working below grade. Such personnel can either stand in or near the bucket while performing sample operations. In the event of a cave-in they can either be lifted clear in the bucket, or at least climb up on the backhoe arm to reach safety.

5.7.3.5 Geotechnical Sampling

In addition to the equipment described in Section 5.7.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., open tube samplers), which can be pushed or driven into the floor of the test pit.
- Suitable driving (i.e., a sledge hammer) or pushing (i.e., the backhoe bucket) equipment which is used to advance the sampler into the soil.
- Knives, spatulas, and other suitable devices for trimming hand-carved samples.
- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.
- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soils in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification, while larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soils using open tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the sampler when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 5.7.3.4 of this procedure must be followed. The open tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate, because the sample will not have the correct orientation.

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry of the test pit, the requirements in Section 5.7.3.4 of this procedure must be followed. Prepare, label, pack and transport the sample in the required manner, as described in SOP SA-6.3.

5.7.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew shall photograph all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL.

If a low permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

5.8 Records

The appropriate sample log sheet (see SOP SA-6.3; Field Documentation) must be completed by the site geologist/sampler. All soil sampling locations must be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) and shall be noted the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see SOP SA-6.3; Field Documentation) shall contain a sketch of pit conditions. In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job.
- Date of boring and excavation.
- Approximate surface elevation.
- Total depth of boring and excavation.
- Dimensions of pit.
- Method of sample acquisition.
- Type and size of samples.
- Soil and rock descriptions.
- Photographs.
- Groundwater levels.
- Organic gas or methane levels.
- Other pertinent information, such as waste material encountered.

6.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

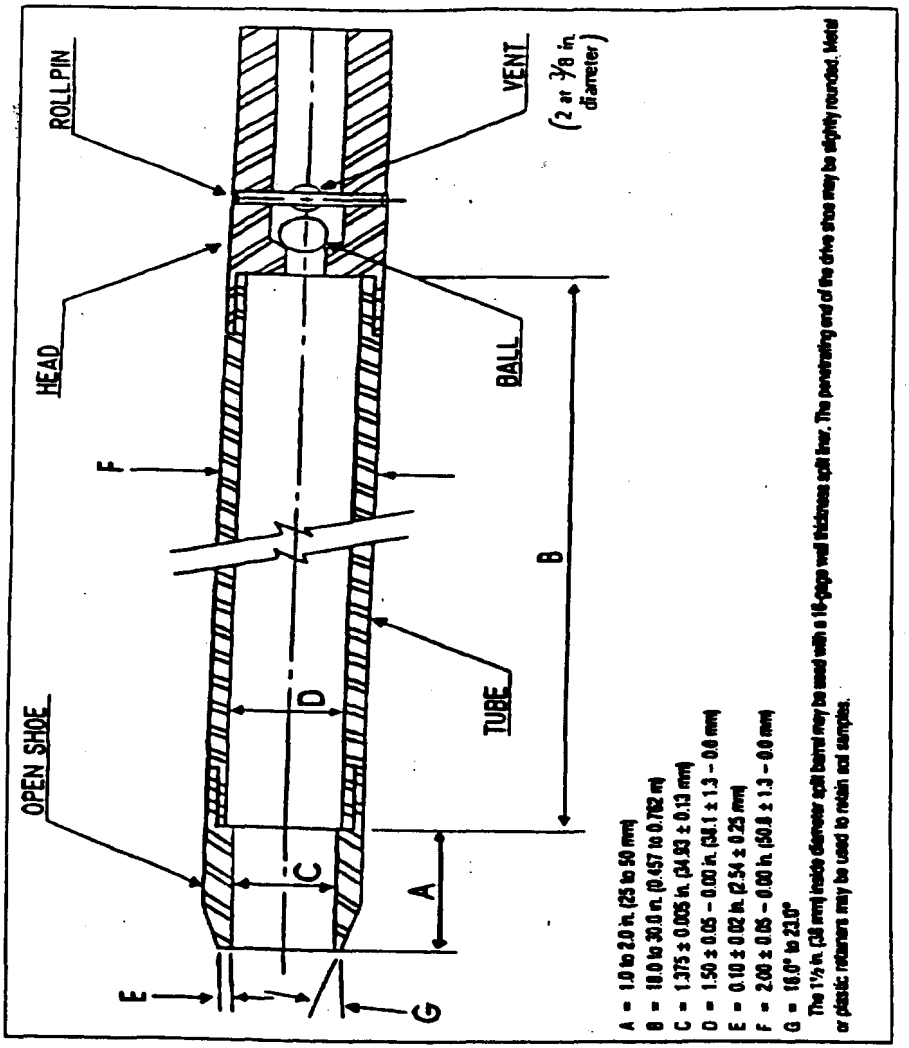
NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

OSHA, Confined Space Entry 29 CFR 1910.146.

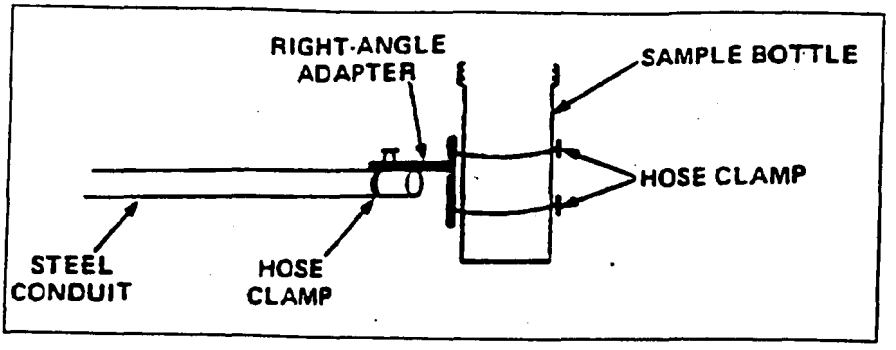
ATTACHMENT A
SPLIT-SPOON SAMPLER



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

ATTACHMENT B
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING



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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Brown & Root Environmental field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Brown & Root Environmental field activities, as applicable. Other or additional documents may be required by specific client contracts.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all forms used in site activities (i.e., records, field reports, and upon the completion of field work, the site logbook) in the project's central file.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Brown & Root Environmental or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Brown & Root Environmental project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the site notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook. If possible, such techniques shall be avoided, since they can adversely affect the admissibility of photographs as evidence. Chain-of-custody procedures depend upon the subject matter, type of film, and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Adequate logbook notation and receipts must be compiled to account for routine film processing. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook descriptions. The site photographs and associated negatives must be docketed into the project's central file.

5.2 Site Notebooks

Key field team personnel may maintain a separate dedicated notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate site notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a site notebook.

5.3 Sample Forms

A summary of the forms illustrated in this procedure is shown as the listing of Attachments in the Table of Contents for this SOP. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment and Request for Analysis

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. Attachments B-1 to B-4 are examples of Sample Log Sheets. The data recorded on these sheets are useful in describing the waste source and sample as well as pointing out any problems encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B-5. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One part of the completed COC form is retained by the field crew while the other two or three portions are sent to the laboratory. The original (top, signed copy) and extra carbonless copies of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the first cooler. The COC form should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment B-6. A supply of these forms are purchased and stocked by the field department of the various Brown & Root Environmental offices. Alternately, COC forms supplied by the laboratory may be used. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Brown & Root Environmental Project Manager). The COC form is signed and one of the remaining two parts are retained by the laboratory while the last part becomes part of the samples' corresponding analytical data package. Internal laboratory chain-of-custody procedures are documented in the Laboratory Quality Assurance Plan (LQAP).

5.3.1.4 Chain-of-Custody Seal

Attachment B-7 is an example of a custody seal. The Custody seal is also an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transit to the laboratory. The COC seals are signed and dated by the samplers and affixed across the opening edges of each cooler containing environmental samples. COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.2 Geohydrological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A groundwater level measurement sheet, shown in Attachment C-1 must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The pumping test data sheet (Attachment C-2) facilitates this task by standardizing the data collection format, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A packer test report form shown in Attachment C-3 must be completed for each well upon which a packer test is conducted following well installation.

5.3.2.4 Summary Log of Boring

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring (Attachment C-4) is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples or cuttings from the borehole (using HNU or OVA detectors), these results must be entered on the boring log (under the "Remarks" column) at the appropriate depth. The "Remarks" column can also be used to subsequently enter the laboratory sample number and the concentration of a few key analytical results. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well piezometer or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock), different forms are used (see Attachments C-5 through C-9). Similar forms are used for flush-mount well completions. The Monitoring Well Construction Details Form is not a controlled document.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log (Attachment C-10) must be filled out by the responsible field geologist or sampling technician.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of

equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log (Attachment D) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Weekly Status Reports

To facilitate timely review by project management, Xeroxed copies of logbook/notebook entries may be made for internal use. To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

It should be noted that in addition to the summaries described herein, other summary reports may also be contractually required.

5.4.2 Daily Activities Report

5.4.2.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors (Attachment E is an example of a Daily Activities Report).

5.4.2.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.2.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

6.0 ATTACHMENTS

Attachment A	TYPICAL SITE LOGBOOK ENTRY
Attachment B-1	EXAMPLE GROUNDWATER SAMPLE LOG SHEET
Attachment B-2	EXAMPLE SURFACE WATER SAMPLE LOG SHEET
Attachment B-3	EXAMPLE SOIL/SEDIMENT SAMPLE LOG SHEET
Attachment B-4	CONTAINER SAMPLE LOG SHEET FORM
Attachment B-5	SAMPLE LABEL
Attachment B-6	CHAIN-OF-CUSTODY RECORD FORM
Attachment B-7	CHAIN-OF-CUSTODY SEAL
Attachment C-1	EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET
Attachment C-2	EXAMPLE PUMPING TEST DATA SHEET
Attachment C-3	PACKER TEST REPORT FORM
Attachment C-4	EXAMPLE BORING LOG
Attachment C-5	EXAMPLE OVERBURDEN MONITORING WELL SHEET
Attachment C-5A	EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)
Attachment C-6	EXAMPLE CONFINING LAYER MONITORING WELL SHEET
Attachment C-7	EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL
Attachment C-8	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK
Attachment C-8A	EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK (FLUSHMOUNT)
Attachment C-9	EXAMPLE TEST PIT LOG
Attachment D	EXAMPLE EQUIPMENT CALIBRATION LOG
Attachment E	EXAMPLE DAILY ACTIVITIES RECORD
Attachment F	FIELD TRIP SUMMARY REPORT

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____

PERSONNEL:

BROWN & ROOT ENV.	DRILLER	EPA
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B-1
EXAMPLE GROUNDWATER SAMPLE LOG SHEET

GROUNDWATER

SAMPLE LOG SHEET

Page ____ of ____

Project Site Name: _____

Project No.: _____

- ☐ Domestic Well Data
- ☐ Monitoring Well Data
- ☐ Other Well Type: _____
- ☐ QA Sample Type: _____

Sample ID No.: _____

Sample Location: _____

Sampled By: _____

C.O.C. No.: _____

Sampling Data	pH	S.C.	Temp. (°C)	Turbidity	Color	TBD	TBD	TBD
Date: _____								
Time: _____								
Method: _____								

Purge Data	Volume	pH	S.C.	Temp. (°C)	Turbidity	Color	TBD	TBD
Date: _____								
Method: _____	Initial							
Monitor Reading (ppm):	1							
Well Casing Dia. & Material Type:	2							
	3							
Total Well Depth (TD):	4							
Static Water Level (WL):	5							
TD-WL (ft.) =								
One Casing Volume: (gal/L)								
Start Purge (hrs.):								
End Purge (hrs.):								
Total Purge Time (min):								
Total Amount Purged (gal/L):								

Analyses	Preservative	Container/Regulation	Collected

Observations/Notes:

If Applicable		Signature(s):
MS/MSD	Duplicate ID No:	

TBD: To Be Determined

ATTACHMENT B-2
EXAMPLE SURFACE WATER SAMPLING LOG SHEET

SURFACE WATER
SAMPLING LOG SHEET

Page ___ of ___

Project Site Name: _____ Sample ID No.: _____

Project No.: _____ Sample Location: _____

☐ Spring ☐ Pond
☐ Stream ☐ Lake
☐ Other _____
☐ QA Sample Type: _____

Sampled By: _____

C.O.C. No.: _____

Sample Date		
Dislend Time	Method	Depth

pH	S.C.	Temp (°C)	Turbidity	Colors	TBD	TBD	TBD

Analyses	Preservatives	Container Requirements	Collected (✓)

Observations/Notes:

Circle if Applicable		Signature(s):
MS/MSD	Duplicate ID No.:	

TBD: To Be Determined

ATTACHMENT B-3
EXAMPLE SOIL/SEDIMENT SINGLE SAMPLE LOG SHEET

SOIL/SEDIMENT
SINGLE SAMPLE LOG SHEET

Page ___ of ___

Project Site Name: _____

Project No.: _____

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Other _____
- ☐ QA Sample Type: _____

Sample ID No.: _____

Sample Location: _____

Sampled By: _____

C.O.C. No.: _____

Sample Method:	[illegible]		
	Sample	Time	Color/Description
Depth Sampled:			
Sample Date and Time:			
Type of Sample			
☐ Grab			
☐ Composite			
☐ Grab-Composite	[illegible]		
☐ High Concentration	Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)	
☐ Low Concentration			

Preservative	Container Type/Material	Quantity	Map:

Observations/Notes:

Circle if Applicable		Signature(s):
MS/MSD	Duplicate ID No:	

ATTACHMENT B-4
CONTAINER SAMPLE LOG SHEET FORM

Brown & Root Environmental

Page ___ of _

☐ Container Data

Case #: _____

By: _____

Project Site Name: _____ Project Site No. _____

Brown & Root Env. Source No. _____ Source Location: _____

Container Source	Container Description
☐ Drum ☐ Bung Top ☐ Lever Lock ☐ Bolted Ring ☐ Other _____ ☐ Bag/Sack ☐ Tank ☐ Other _____	Color: _____ Condition: _____ Markings: _____ Vol. of Contents: _____ Other: _____

Disposition of Sample	Sample Description			
☐ Container Sampled ☐ Container opened but not sampled. Reason: _____ ☐ Container not opened. Reason: _____		Layer 1	Layer 2	Layer 3
	Phase	☐Sol. ☐Liq.	☐Sol. ☐Liq.	☐Sol. ☐Liq.
	Color	_____	_____	_____
	Viscosity	☐L ☐M ☐H	☐L ☐M ☐H	☐L ☐M ☐H
	% of Total Volume	_____	_____	_____
	Other	_____	_____	_____

Monitor Reading:	Type of Sample	
Sample Method:	☐ Low Concentration ☐ High Concentration	☐ Grab ☐ Composite ☐ Grab-composite
Sample Date & Time:	Sample Identification	Organic / Inorganic
Sampled by:		
Signature(s):		
	Date Shipped	
Analysis:	Time Shipped	
	Lab	
	Volume	

ATTACHMENT B-5

SAMPLE LABEL

Brown & Root Environmental PROJECT: _____

STATION LOCATION: _____

DATE: ___/___/___ TIME: _____ hrs.

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MEDIUM ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNAs ☐	Cool to 4°C ☐
PCBs ☐ PESTICIDES ☐	HNO_3 to pH < 2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NaOH to pH > 12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

Remarks:

ATTACHMENT B-6

CHAIN-OF-CUSTODY RECORD FORM
(Original is 8.5 x 11")

PROJECT NO.	PROJECT NAME					NO. OF CONTAINERS								REMARKS
SAMPLERS: (Signature)														
STA NO.	DATE	TIME			STATION LOCATION									

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks:	

ATTACHMENT B-7

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date	**Date**
Signature	**Signature**

ATTACHMENT C-1
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

GROUNDWATER LEVEL MEASUREMENT SHEET

Page ___ of ___

PROJECT NAME: _____ LOCATION: _____
PROJECT NUMBER: _____ MEASURING DEVICE: _____
PERSONNEL: _____ ADJUSTMENT FACTOR: _____
DATE: _____ REMARKS: _____
WEATHER CONDITIONS: _____

Well or Piezometer Number	Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Groundwater Elevation (Feet)	Comments

*Measurements to nearest 0.01 feet.

Signature(s): _____

ATTACHMENT C-2
EXAMPLE PUMPING TEST DATA SHEET

PUMPING TEST DATA SHEET

Page ___ of ___

PROJECT NAME: _____
PROJECT NUMBER: _____
PUMPING TEST: [ ]
TEST NUMBER: _____
METHOD OF MEASUREMENT: _____
DATE(s): _____
STATIC H_2O LEVEL (ft) (SO) _____
PUMPING TEST PERFORMED BY: _____
REMARKS: _____

PUMPING WELL NUMBER: _____
MEASURED WELL NUMBER: _____
STEP DRAW DOWN TEST [ ]
MONITORING POINT: _____
DEPTH CORRECTION (ft) _____
PUMP SETTING (Ft. below monitoring point): _____
DISTANCE FROM PUMPING WELL (ft) (r): _____

MILITARY TIME	ELAPSED TIME SINCE PUMP START OR STOP (Min.)	WATER LEVEL (Ft.)	CORRECTION (Ft.)	DRAW DOWN OR RECOVERY (Ft.)	FLOW METER READING (Gals.)	PUMPING RATE (GPM)	REMARKS

SIGNATURE(s): _____

ATTACHMENT C-3

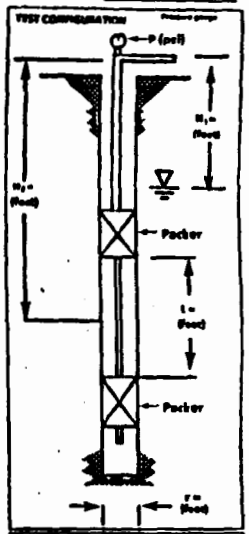
PACKER TEST REPORT FORM

PROJECT: _____ PROJECT NO.: _____ TEST NO: _____ PAGE ____ OF ____

BORING NO.: _____ CASING DEPTH: _____ CONTRACTOR: _____ STATIC WATER LEVEL _____

TEST INTERVAL: _____ BY: _____ CHECKED: _____ PACKER PRESSURE _____

Flow Test					Calculated Results							
Pressure-P (psi)	Elapsed Time (min)	Flow Reading	Δ Flow, ΔQ (gal)	Δ Time, ΔQ (gal)	Flow Rate Q (gal/min)	H_1* (ft)	Head, H = / H1-Qm)	H_2* (ft)	H = Hp + (H1 or H2)	Cp	Σ (Poly) = Cp·Qm	Σ (Average) = 0.8Σ + 1Σ (Poly)



Length of test section in feet, L	Cp (Working Out Table)			
	r = (1.5")	r = (2.0")	r = (2.3")	r = (3")
1	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]

$CP = (1/(2 \pi L)) \ln(L/r)(70.315 S)$

7.48 Gallons = 1 ft^3

1 psi = 2.31 ft head

Remarks: _____

* H_1 is used when the test length is below the water table.
H_2 is used when the test length is above the water table.

ATTACHMENT C-4
EXAMPLE BORING LOG

BORING LOG

Page___ of___

PROJECT NAME: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
WATER LEVEL DATA: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows/6" or RQD (%)	Sample Recovery/ Sample Length	Lithology Change (Depth/Ft.) or Sample Interval	MATERIAL DESCRIPTION			USCS	Remarks	PID or FID Reading (ppm)

*When rock coring enter rock brokenness.

CONVERTED TO WELL: ___ Yes ___ No: WELL I.D.#: _____
REMARKS: _____

Signature(s): _____

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS — More Than Half of Material is LARGER Than No. 200 Sieve Size				
FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3 inches and basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
GRAVELS (50% or more of coarse fraction retained on No. 4 sieve)	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (For identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.
		Plastic fines (For identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS (50% or more of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sands, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (For identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (For identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE-GRAINED SOILS — More Than Half of Material is SMALLER Than No. 200 Sieve Size						
FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3 inches and basing fractions on estimated weights) — Identification Procedures on Fraction Smaller than No. 40 Sieve Size		DRY STRENGTH (Crushing characteristics)	DILATANCY (Reaction to shaking)	TOUGHNESS (Consistency near plastic limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS AND CLAYS Liquid Limit 50 or less		None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
		Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
SILTS AND CLAYS Liquid Limit 50 or more		Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays.
		Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity.
HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils

Dualsymbols: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS

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

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENESS		
Descriptive Terms	Screwdriver or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily dented	Crushes when pressed with hammer	Very Broken	(V. Br.)	0-2"
Medium Soft	Can be dented	Crumbs (one blow); crumbly edges	Broken	(Br.)	2"-1'
Medium Hard	Can be scratched	Crumbs (one blow); sharp edges	Blocky	(Bl.)	1'-3'
Hard	Cannot be scratched	Crumbs cumulatively (several blows); sharp edges	Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

2-5" Split-barrel Sample

ST-3" O.D. Undisturbed Sample

O - other samples, Specify in Remarks

ROCK SAMPLES - TYPES

2-NX (Conventional) Core (.0-2/0" O.D.)

O-NX (Wireline) Core (.1-7/0" O.D.)

Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/10 ▽ 12.0' Initial Level w/Date & Depth

12/10 ▽ 12.0' Stabilized Level w/Date & Depth

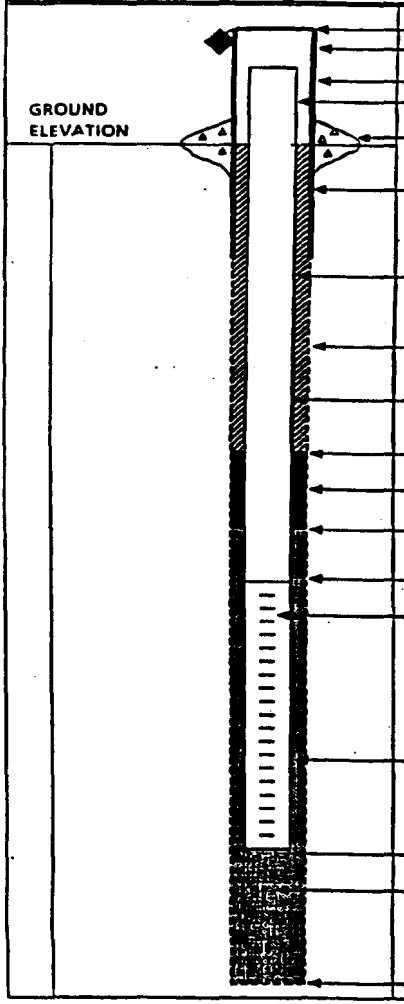
Project	Number	Page
FIELD DOCUMENTATION	SA-6.3	21 of 32
Revision 0	Effective Date 03/01/96	

ATTACHMENT C-5
EXAMPLE OVERBURDEN MONITORING WELL SHEET

BORING NO.: _____

OVERBURDEN MONITORING WELL SHEET

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
ELEVATION _____	DATE _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

STICK - UP TOP OF SURFACE CASING: _____
STICK - UP RISER PIPE : _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____

RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____ / _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____ / _____

TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____ / _____

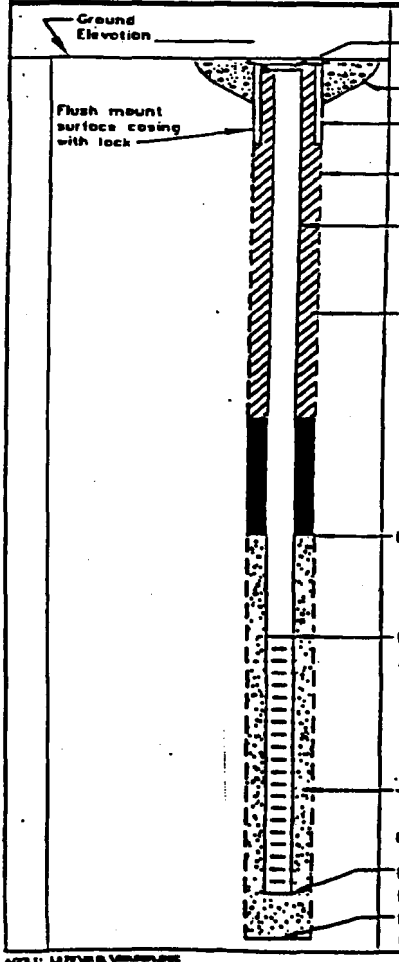
ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)

BORING NO.: _____

MONITORING WELL SHEET

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

DEPTH/ELEVATION TOP OF SAND: _____ / _____

DEPTH/ELEVATION TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____

DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____

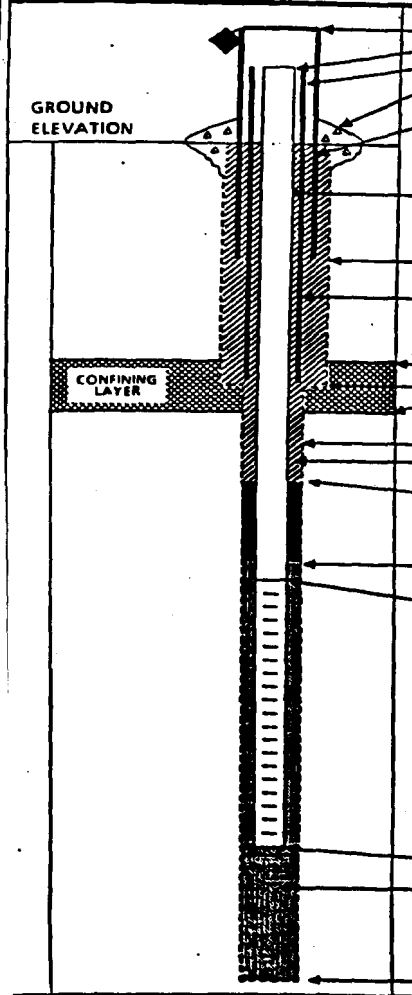
BACKFILL MATERIAL BELOW SAND: _____

ATTACHMENT C-6
EXAMPLE CONFINING LAYER MONITORING WELL SHEET

BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____
ELEVATION TOP OF PERM. CASING: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
TYPE OF SURFACE CASING: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
BOREHOLE DIAMETER: _____
PERM. CASING I.D. _____
TYPE OF CASING & BACKFILL: _____
ELEVATION / DEPTH TOP CONFINING LAYER: _____
ELEVATION / DEPTH BOTTOM OF CASING: _____
ELEVATION / DEPTH BOT. CONFINING LAYER: _____
BOREHOLE DIA. BELOW CASING: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____
DEPTH TOP OF SAND PACK: _____
ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
TYPE OF SAND PACK: _____
ELEVATION / DEPTH BOTTOM OF SCREEN: _____
ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____
ELEVATION / DEPTH OF HOLE: _____

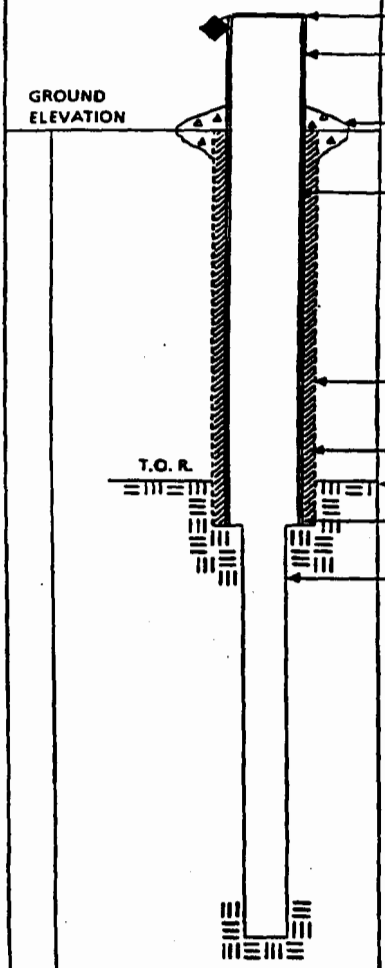
ATTACHMENT C-7
EXAMPLE BEDROCK MONITORING WELL SHEET - OPEN HOLE WELL

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

PROJECT _____ LOCATION _____
PROJECT NO. _____ BORING _____
ELEVATION _____ DATE _____
FIELD GEOLOGIST _____

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____
TYPE OF CASING: _____

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____

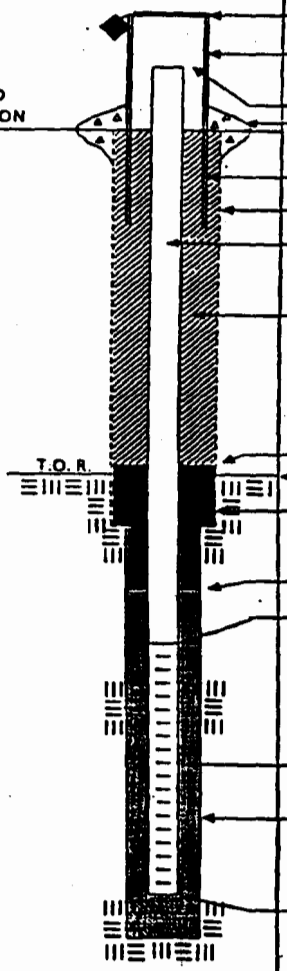
ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C-8
EXAMPLE BEDROCK MONITORING WELL SHEET - WELL INSTALLED IN BEDROCK

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT _____ LOCATION _____ DRILLER _____
PROJECT NO. _____ BORING _____ DRILLING METHOD _____
ELEVATION _____ DATE _____ DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____



ELEVATION OF TOP OF SURFACE CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

I.D. OF SURFACE CASING: _____

DIAMETER OF HOLE: _____

RISER PIPE I.D.: _____

TYPE OF RISER PIPE: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____ / _____

ELEVATION / DEPTH TOP OF BEDROCK: _____ / _____

TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND: _____ / _____

ELEVATION / DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. SCREEN: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK:

CORE / REAM: _____

ELEVATION / DEPTH BOTTOM SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF HOLE: _____ / _____

ATTACHMENT C-8A
EXAMPLE BEDROCK MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK (FLUSHMOUNT)

BORING NO.: _____

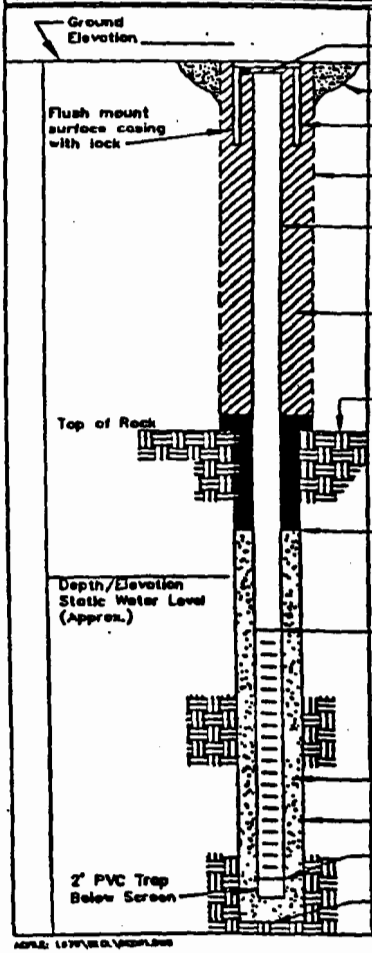
BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

PROJECT: _____ LOCATION: _____ DRILLER: _____

PROJECT NO.: _____ BORING: _____ DRILLING METHOD: _____

ELEVATION: _____ DATE: _____ DEVELOPMENT METHOD: _____

FIELD GEOLOGIST: _____



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

_____

DEPTH/ELEVATION TOP OF BEDROCK: _____ / _____

DEPTH/ELEVATION TOP OF SAND: _____ / _____

DEPTH/ELEVATION TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____

DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____

ATTACHMENT C-9
EXAMPLE TEST PIT LOG

TEST PIT LOG

Brown & Root Environmental

PROJECT: _____ TEST PIT NO.:

PROJECT NO _____ DATE: _____

LOCATION: _____

FIELD GEOLOGIST: _____

DEPTH (ft.)	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION (Soil Density / Consistency, Color)	USCS	REMARKS

Test Pit Cross Section and / or Plan View

REMARKS _____

PHOTO LOG _____ TEST PIT _____

PAGE ____ OF ____

ATTACHMENT D
EXAMPLE EQUIPMENT CALIBRATION LOG

Brown & Root Environmental

EQUIPMENT CALIBRATION LOG

INSTRUMENT NAME / MODEL : _____

JOB NAME : _____

MANUFACTURER : _____

JOB NUMBER : _____

CALIBRATION DATE	INITIAL SETTINGS	STANDARDS USED	PROCEDURE	ADJUSTMENTS MADE	FINAL SETTINGS	SIGNATURE	COMMENTS

ATTACHMENT E
EXAMPLE DAILY ACTIVITIES RECORD

Brown & Root Environmental

DAILY ACTIVITIES RECORD

PROJECT _____ LOCATION _____
CLIENT _____ ARRIVAL TIME _____ JOB NO. _____
DATE _____ DEPARTURE TIME _____
CONTRACTOR _____ DRILLER _____
BORING NO. _____ HNUS REPRESENTATIVE _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

APPROVED BY:

_____ HNUS FIELD REPRESENTATIVE

_____ DRILLER OR REPRESENTATIVE

ATTACHMENT F
FIELD TRIP SUMMARY REPORT
PAGE 1 OF 2

SUNDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

MONDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

TUESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

WEDNESDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

ATTACHMENT F
PAGE 2 OF 2
FIELD TRIP SUMMARY REPORT

THURSDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

FRIDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

SATURDAY

Date: _____ Personnel: _____

Weather: _____ Onsite: _____

Site Activities: _____

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A TWO TYPES OF MUD PITS USED IN WELL DRILLING 9

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.

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.

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.

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 factions 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.

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* 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.

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). 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 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.

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.

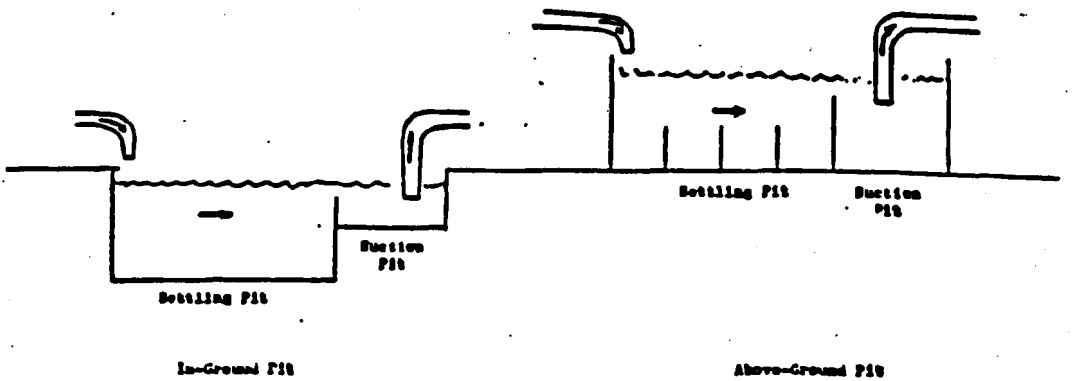
Another consideration in selecting disposal methods for contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable onsite disposal structure is expected, contaminated materials generated during the investigation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

ATTACHMENT A

TWO TYPES OF MUD PITS USED IN WELL DRILLING



STANDARD FIELD FORMS

AS A MINIMUM, THE FOLLOWING ITEMS MUST BE INCLUDED IN THE FIELD LOGBOOK

- o All entries must be made in blue or black indelible ink.
- o Errors must be lined out ONCE and INITIALED.
- o Each page must be sequentially numbered, dated, signed and the project number must be written at the top of each page. No blank pages.
- o List the time of arrival at work site, and the names of all BRE personnel.
- o State the level of personal protection required (level D, level D mod. , level C, etc.)
- o Designation of the Field Team Leader and a Site Safety Officer.
- o State that a Site Safety Meeting/Briefing was conducted and who was present.
- o List weather conditions and update as necessary.
- o List specific reason(s) for site visit (sampling, drilling, etc...).
- o List Subcontractor(s) present at the site and time of arrivals to the site, list all heavy equipment (such as drilling rig, back hoe, jackhammer, etc....).
- o List name(s) and time(s) of arrival/departure of anyone visiting the site (such as BRE or subcontractor personnel, Client, regulators, inspectors.....)
- o Describe the method of decontamination for drilling tools, bailers, and other equipment. Site the reference(s) that you use for decontamination (i.e., In accordance with Section 5 of BRE's FDEP -approved CompQAP, etc...)
- o Indicate that the field instruments have been calibrated and indicate where the calibration information can be found if it is not listed in this logbook. Identify field instruments used by model number and I.D. number or serial number.
- o A physical description of all samples must be recorded. Give location of samples, boreholes, etc... A diagram or map would be most appropriate.
- o Describe the condition of the site prior to departure (such as wells locked, pump operational, diffused aerator down, barricades properly located, boreholes properly abandoned, etc.....)
- o Handling of drill cuttings, development/purge water, and other site derived wastes (e.g., drumming, spreading on plastic, etc.)
- o Reference all field forms that are used.

UNDER NO CIRCUMSTANCES SHOULD THE FIELD LOGBOOK BE IN ANYONE'S POSSESSION OTHER THAN BRE PERSONNEL.

Arnold C. Lamb
District Manager of Quality Assurance
February 2, 1995

DAILY ACTIVITIES RECORD

PROJECT NAME: _____ PROJECT NUMBER: _____

CLIENT: _____ LOCATION: _____

DATE: _____ ARRIVAL TIME: _____

B&RE PERSONNEL: _____ DEPARTURE TIME: _____

CONTRACTOR: _____ DRILLER: _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

APPROVED BY:

_____ _____

B&RE REPRESENTATIVE DRILLER

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: _____
Project No.: _____

[ ] Domestic Well Data
[ ] Monitoring Well Data
[ ] Other Well Type: _____
[ ] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[ ] Low Concentration
[ ] High Concentration

SAMPLING DATA

Date: / Time:	Color	pH	S.C. mS/cm	Temp. °C	Turbidity NTU	DO	Salinity	Eh mV
Method:								

PURGE DATA

Date:	Volume	pH	S.C.	Temp (°C)	Turbidity	DO	Salinity	
Method:	Initial							
Monitor Reading (ppm):	1							
Well Casing Diameter:	2							
Well Casing Material:	3							
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

PROJECT: _____ DATE: _____
PROJECT NUMBER: _____ WEATHER: _____
SITE: _____ PERSONNEL: _____

Well Screen Depth: _____ / _____ ft.
Initial Water Level: _____ @ _____ hrs.

Pump Type/Material: _____
Pump Intake Depth: _____

Tide Cycle: [ ] High @ _____
[ ] Low @ _____
[ ] Not Affected

Total Purge Volume= _____ (gal / L) Drawdown + Tubing Volume= _____ (gal / L)

Time	Water Level feet below TOC	Volume mL	Flow Rate mL/min	Temp °C	pH	p Con mS/cm	DO mg/L	Turbidity NTU	Salinity %	Eh mV	Comments

Remarks: _____

INSTRUMENT CALIBRATION LOG SHEET

JOB NAME/NUMBER: _____

SITE NAME: _____

LOCATION: _____

INSTRUMENT NAME/MODEL: _____

MANUFACTURER: _____

SERIAL NUMBER: _____

Date of Calibration	Time	Performed by	Calibration Standard		Instrument Setting		Instrument Reading		Remarks/ Comments
			Span/Conc.	Lot Number/ Exp. Date	Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration	

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

?roject Site Name: _____
?roject No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

AB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
e:			
e:			
thod:			
nitor Reading (ppm):			

MPOSITE SAMPLE DATA:

e:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
thod:				
nitor Readings				
nge in ppm):				

MPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

SERVATIONS / NOTES:

MAP:

cle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

5 FAIRWAY DRIVE, SUITE 200
ERFIELD BEACH, FLORIDA 33441
05) 570-5885 (305) 570-5974 (FAX)

BRE PROJECT NO.: ________ CODE: ________

P.O. NO.: ________

________ (LABORATORY NAME, CITY)

OF CUSTODY RECORD

LABORATORY ANALYSIS

D BY (PRINT): ________

R SIGNATURE: ________

☐ STANDARD TAT ☐ RUSH

☐ 24 HR. ☐ 48 HR. ☐ 72 HR. ☐ 7 DAY

RESULTS DUE DATE: ________

	DATE	TIME	SAMPLE IDENTIFICATION	SAMPLE TYPE COMP.	SAMPLE TYPE GRAB	MATRIX	PRES. TYPE / PARAMETERS									NUMBER OF CONTAINERS	COMMENTS:
			TOTAL NUMBER OF CONTAINERS														

	SEAL INTACT?	DATE / TIME		SEAL INTACT?	DATE / TIME
LES RELINQUISHED BY (SIGNATURE)	YES NO N/A	DATE: TIME:	EMPTY BOTTLES RECEIVED BY (SIGNATURE) ②	YES NO N/A	DATE: TIME:
D BY (SIGNATURE)	YES NO N/A	DATE: TIME:	RECEIVED BY (SIGNATURE) ④	YES NO N/A	DATE: TIME:
D BY (SIGNATURE)	YES NO N/A	DATE: TIME:	RECEIVED BY (SIGNATURE) ⑥	YES NO N/A	DATE: TIME:

L INSTRUCTIONS:

LABORATORY REMARKS:

TAINERS PRECLEANED BY: ☐ LABORATORY ☐ MANUFACTURER

METHOD OF SHIPMENT: ________

BILL OF LADING NO.: ________

EXECUTED COPY
IVING LABORATORY COPY
ERS' COPY/QA COPY

SAMPLING TEAM:

RECEIVED FOR LABORATORY BY (SIGNATURE):

DATE: TIME:

No. 0257

MONITORING WELL DEVELOPMENT RECORD

Well:_____
Site :_____
Date Installed: _____
Date Developed:_____
Dev. Method:_____
Pump Type:_____

Depth to Bottom (ft): _____
Static Water Level Before(ft):_____
Static Water Level After (ft):_____
Screen Length (ft):_____
Specific Capacity:_____
Casing ID (in): _____

Responsible Professional: _____
Drilling Co.: _____
Project:_____
Project Number:_____
Sheet No._____ of _____

ne	Estimated Sediment Thickness (ft)	Cumulative Water Volume (gallons)	Water Level Reading (ft. below TOC)	Temperature (units_____)	pH	Specific Conductance (microsiemens/cm)	Turbidity (NTU)	Remarks (odor, color, etc.)

SOUTHNAVFAC
WELL ABANDONMENT FORM

Facility Name: _____

Site Name: _____

Site Number: _____ Date(s) Abandoned: _____

Well Number: _____ Well Depth: _____

Well Diameter: _____ Screen Length: _____

Well Location: _____

Reason for Abandonment: _____

_____

Abandonment Contractor: _____

Method of Abandonment[1]:

Grout in Place: _____ Pull and Grout: _____

Overdrill and Grout: _____ Other (Explain): _____

_____

Type and Amount of Grout and Date(s): _____

_____

Final Surface Conditions: _____

_____

Additional Notes/Comments: _____

_____

Inspected by (Contractor): _____ Date: _____

Approved by (Navy Representative: _____ Date: _____

[1] Note that abandonment may be subject to state and local requirements in addition to federal requirements. These requirements should be incorporated into the abandonment process, and additional information provided in the Additional Notes/Comments section of this form.

CERTIFICATE OF CONFORMANCE

Well Designation: _____

Site Name: _____

Date Installed: _____

Project Name: _____

Responsible Professional: _____

Drilling Company: _____

Driller: _____

Project Number: _____

Material	Brand/Description	Source/Supplier	Sample Collected ?
Well Casing			
Well Screen			
End Cap			
Drilling Fluid			
Drilling Fluid Additives			
Backfill Material			
Annular Filter Pack			
Bentonite Seal			
Annular Grout			
Surface Cement			
Protective Casing			
Paint			
Rod Lubricant			
Compressor Oil			

To the best of my knowledge, I certify that the above described materials were used during installation of this monitoring well.

Signature of Responsible Professional: _____