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

TTNUS/TAL-99-023

SITE ASSESSMENT PLAN
ZONE F - UST

Charleston Naval Complex
Charleston, South Carolina

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order CTO-0097

March 1999

TTNUS/TAL-99-023

SITE ASSESSMENT PLAN
ZONE F - UST

CHARLESTON NAVAL COMPLEX
CHARLESTON, SOUTH CAROLINA

Submitted to:
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Naval Facilities Engineering Command
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0097

MARCH 1999

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1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) has prepared this Site Assessment Plan (SAP) for Zone F 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) 0097, 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 April 1, 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.

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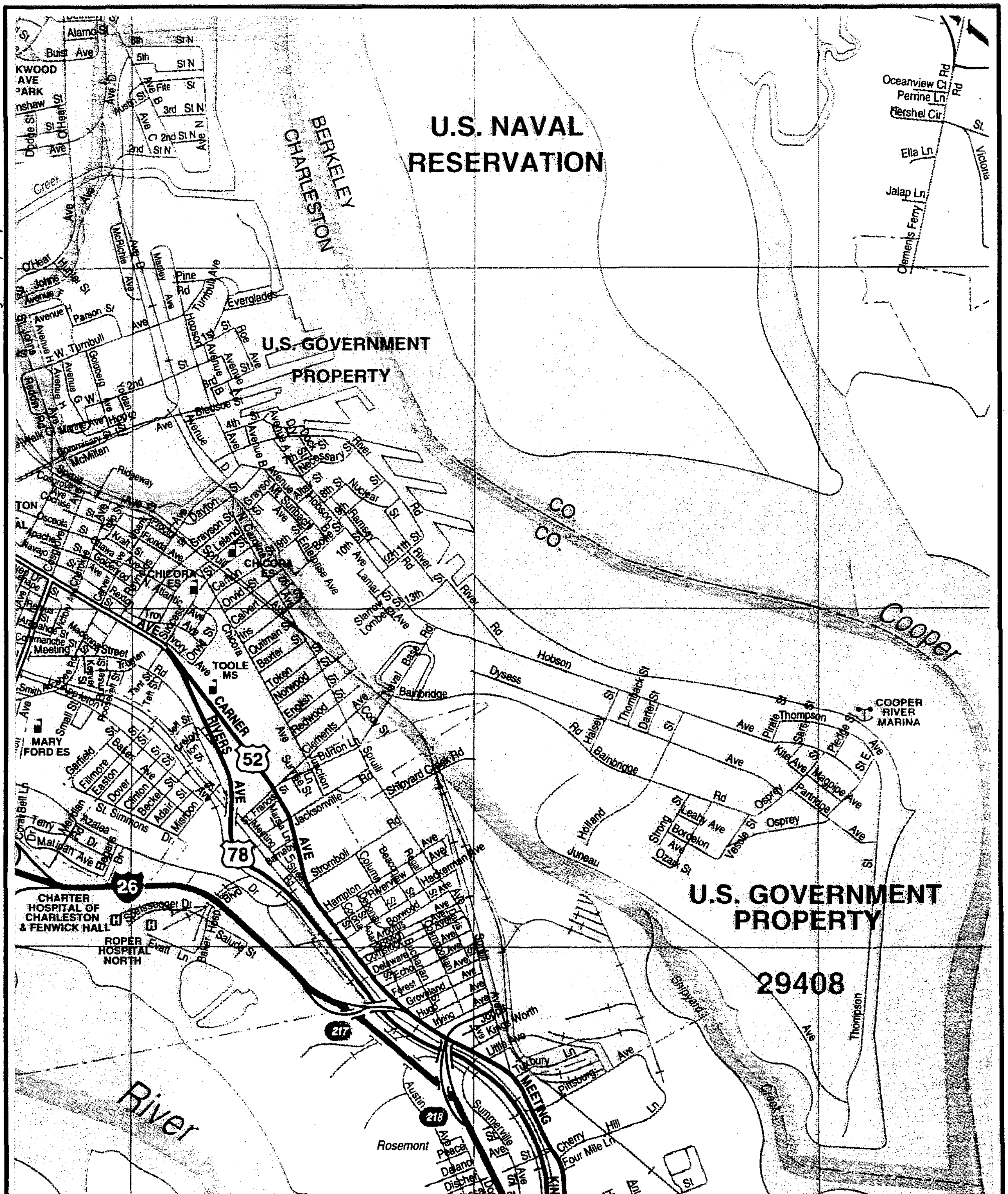


DRAWN BY RO	DATE 2/4/99	FACILITY LOCATION MAP CHARLESTON NAVAL COMPLEX - ZONE F CHARLESTON, SOUTH CAROLINA	CONTRACT NO.	
CHECKED BY	DATE		APPROVED BY	DATE
COST/SCHED-AREA			APPROVED BY	DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 1-1	REV. 0

FORM CADD NO. SDIV_AV.DWG - REV 0 - 1/20/98

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 F is predominantly an industrial area located in the central portion of CNC. Approximately nineteen underground and aboveground storage tanks were permanently closed at CNC Zone F. These tanks were used to store gasoline, diesel, heating fuel, and waste oil products. Tank Closure Assessment Reports for all 19 tanks have been submitted to the South Carolina Department of Health and Environmental Control (SCDHEC). All 19 tanks were either removed, cleaned, and disposed, or cleaned and abandoned in place. Associated piping was removed and disposed or cleaned and capped where removal was not feasible. As a result of these tank closure activities, petroleum contamination was discovered at approximately seven tank locations within CNC Zone F. These seven underground storage tank (UST) locations will require additional investigation. Three of the USTs (10551-1, 10551-2 and 10551-3) are located in close proximity and will be investigated as a single site.

In addition to the five sites identified above, a Tier II investigation is required for Facility 1346. Facility 1346 is the location of eleven USTs. Only three of these are still in service - the other USTs have been abandoned in place. All of these tanks have reportedly been used to store gasoline. In addition to the eleven USTs, ten fuel dispensers and a significant amount of associated piping are present at this site.

Six risk-based Rapid Assessments (five Tier I Assessments and one Tier II Assessment) will be performed within CNC Zone F to determine the extent of petroleum contamination and evaluate each site for corrective action. The sites are as follows:

Site 20	UST 240
Site 21	UST 241
Site 22	UST 242
Site 23	UST 1175-1, 1175-2, 1175-3
Site 24	UST NS1346
Site 25	UST Suite 1: 1346-D, 1346-E, 1346-F, 1346-G, 1346-H
	UST Suite 2: 1346-A, 1346-B, 1346-C
	UST Suite 3: 1346-I, 1346-J, 1346-K

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

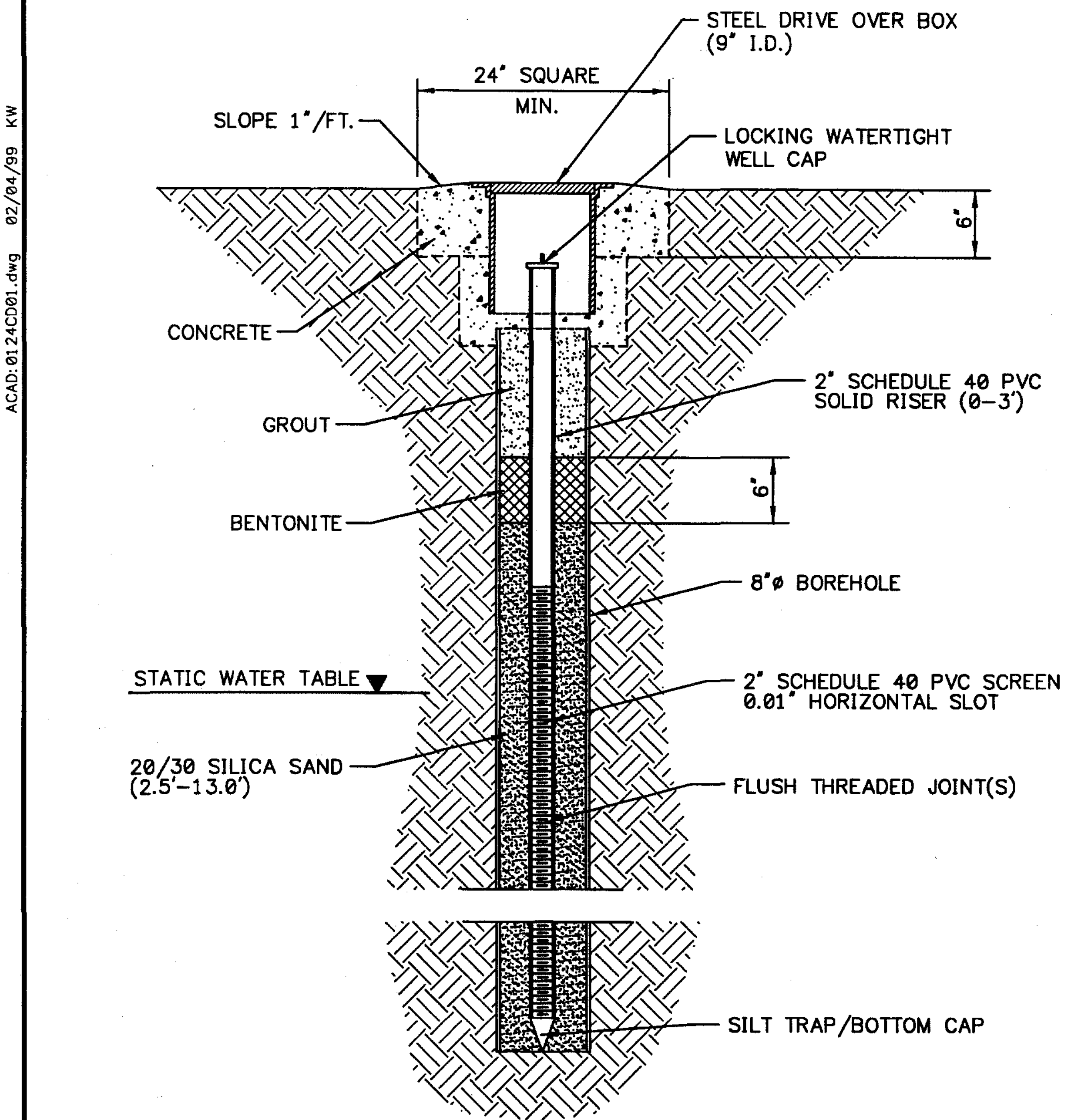
All permanent monitoring wells will be installed in accordance with the South Carolina Well Standards and Regulations, as well as the *Monitoring Well Design, Installation, Construction and Development Guidelines*

(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



DRAWN BY KW	DATE 2/4/99		TYPICAL MONITORING WELL DETAIL CHARLESTON NAVAL COMPLEX - ZONE F CHARLESTON, SOUTH CAROLINA	CONTRACT NO.	
CHECKED BY	DATE			APPROVED BY	DATE
COST/SCHED–AREA				APPROVED BY	DATE
SCALE NOT TO SCALE				DRAWING NO. FIGURE 4–1	REV. 0

FORM CADD NO. SDIV_AV.DWG – REV 0 – 1/20/98 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 F
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 8260B	102	6	6	6	6	12	**138**
PAH	SW-846 8270C	102	6	6	6	6	0	**126**
Lead	EPA 200.7	40	2	2	2	2	0	**48**
TAL Metals (except mercury)	SW-846 6010B Trace ICP	28	2	2	2	2	0	**36**
Mercury	SW-846 7471	28	2	2	2	2	0	**36**
Sulfate	EPA 375.3	18	0	0	0	0	0	**18**
Nitrate	EPA 352.1	18	0	0	0	0	0	**18**
Dissolved Methane	RSK SOPs 147 and 175	18	0	0	0	0	0	**18**
SOIL								
BTEX, EDB, MTBE & Naphthalene	SW-846 8260B	42	6	6	6	0	0	**60**
PAH	SW-846 8270C	42	6	6	6	0	0	**60**
Lead	EPA 200.7	7	2	2	2	0	0	**13**
TAL Metals (except mercury)	SW-846 6010B Trace ICP	14	2	2	2	0	0	**20**
Mercury	SW-846 7471	14	2	2	2	0	0	**20**
TPH	SW-846 9071A	22	2	3	2	0	0	**29**
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
EDB - ethlyene dibromide
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 F. 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 F
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_sSO_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 F
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 F
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 F
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 0097 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 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), lead (for tanks used for storage of leaded gasoline), total petroleum hydrocarbons (TPH) and metals (for tanks used for storage of waste or used oil). 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 TPH.

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 (for tanks used for storage of leaded gasoline). Additionally, three monitoring wells from each site will be sampled for the biological indicator parameters ferrous iron, nitrate, and sulfate.

6.0 PROPOSED SCHEDULE

Phase 1 of the fieldwork is proposed to begin in late May and take approximately 35 days to complete. Phase 2 work is anticipated to begin in late June. 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 field screening 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 240
Site ID #14689

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 14689 **County** CHARLESTON **Facility Name** CNC, BLDG. 240

Facility Address CHARLESTON NAVAL COMPLEX, ZONE F

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

No. USTs 1 **removed?** 15 AUG 1996 (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 INTALL MONITORING POINTS. SOIL AND GROUNDWATER SAMPLES WILL BE COLLECTED FROM EACH POINT AND ANALYZED 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 4 **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	5	BTEX	7
NAPHTHALENE	5	PAH	7
MTBE	5	TPH	7
PAH	5	TOC/FOC	1
METALS	5	GRAIN SIZE	2
		METALS	7

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 # 14689 **Facility Name** CNC, BLDG. 240

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

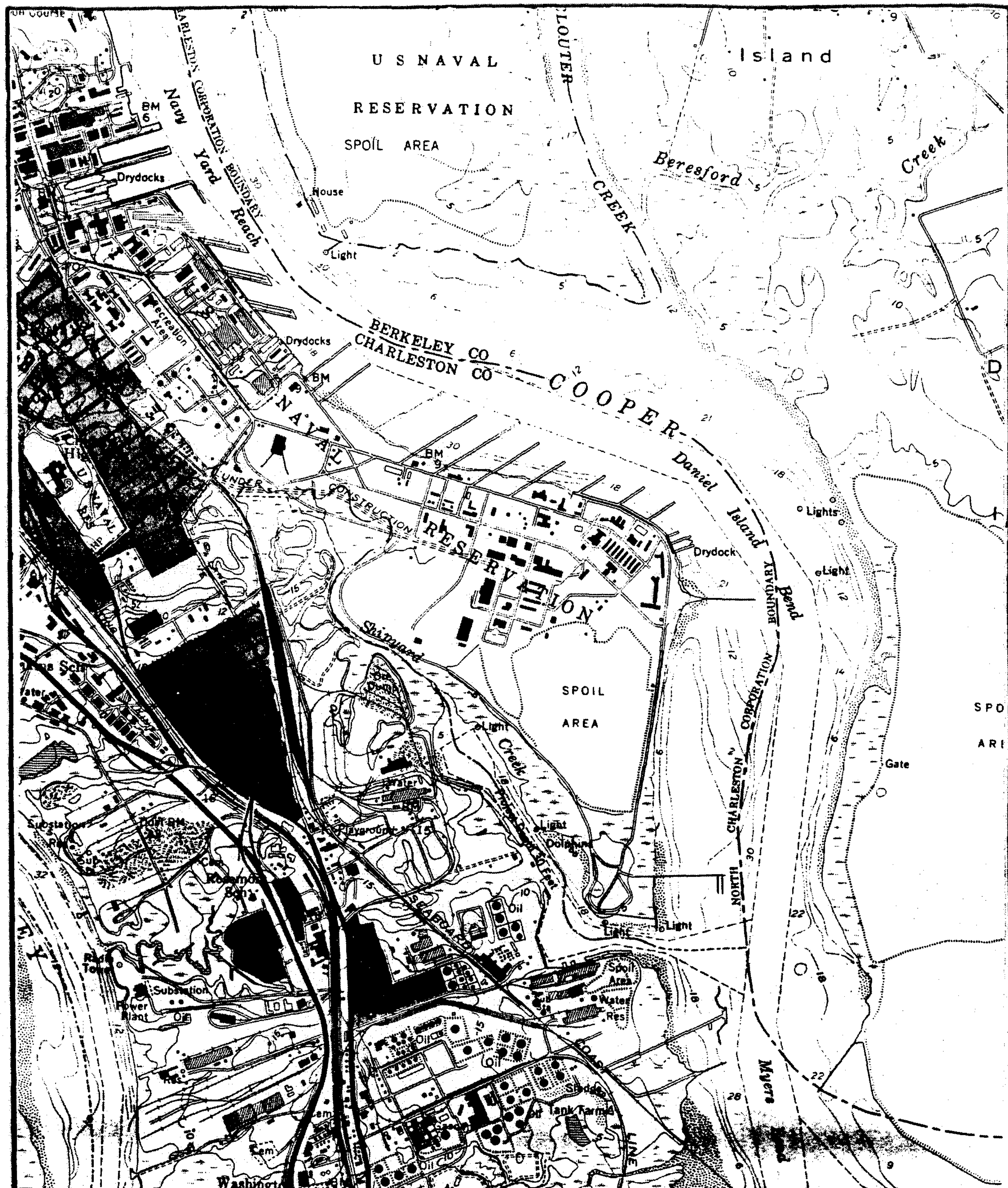
Soil INVESTIGATIVE DERIVED WATE WILL BE CONTAINERIZED IN 55-GALLON DRUMS AND REMAIN AT A STAGING AREA UNTIL CHEMICAL ANALYSIS IS COMPLETE. AFTER ANALYSIS, THE DRUMS WILL BE TRANSFERRED TO THE ENVIRONMENTAL DETACHMENT CHARLESTON FOR DISPOSAL

Purge Water ____

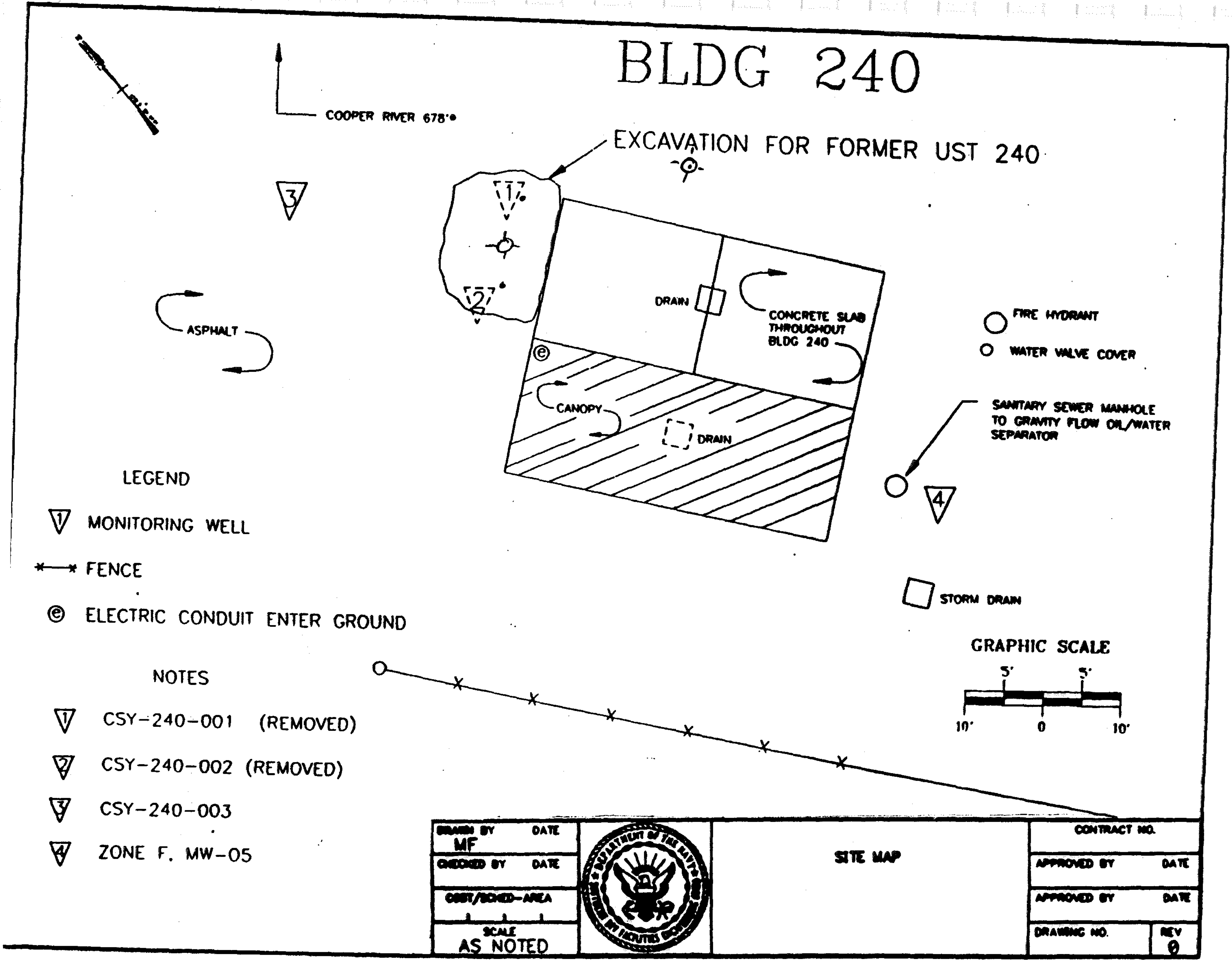
Additional Comments

____

RAP.2(8/25/95)



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



BLDG 240
COOPER RIVER 678'
EXCAVATION FOR FORMER UST 240
1
2
3
4
ASPHALT
DRAIN
CONCRETE SLAB THROUGHOUT BLDG 240
CANOPY
DRAIN
FIRE HYDRANT
WATER VALVE COVER
SANITARY SEWER MANHOLE TO GRAVITY FLOW OIL/WATER SEPARATOR
STORM DRAIN
GRAPHIC SCALE
5'
5'
10'
0
10'
LEGEND
MONITORING WELL
FENCE
ELECTRIC CONDUIT ENTER GROUND
NOTES
1 CSY-240-001 (REMOVED)
2 CSY-240-002 (REMOVED)
3 CSY-240-003
4 ZONE F. MW-05
DRAWN BY
DATE
MF
CHECKED BY
DATE
SCALE
AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
DATE
APPROVED BY
DATE
DRAWING NO.
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Rapid Assessment Plan
UST 02-241-001
Site ID #17706

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 17706 **County** CHARLESTON **Facility Name** CNC, BLDG 241 UST 02-241-001

Facility Address CHARLESTON NAVAL COMPLEX, ZONE F

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

No. USTs 1 **removed?** 22 JULY 1996 (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 INTALL MONITORING POINTS. SOIL AND GROUNDWATER SAMPLES WILL BE COLLECTED FROM EACH POINT AND ANALYZED 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 20 **total depth** 20'

# of deep wells 2 **total depth** 40' (If necessary)

Comments, if warranted ______

Analyses

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

GROUNDWATER		SOIL	
BTEX	22	BTEX	7
NAPHTHALENE	22	PAH	7
MTBE	22	TPH	2
PAH	22	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 # 17706 Facility Name CNC BLDG. 241 UST 02-241-001

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 ____

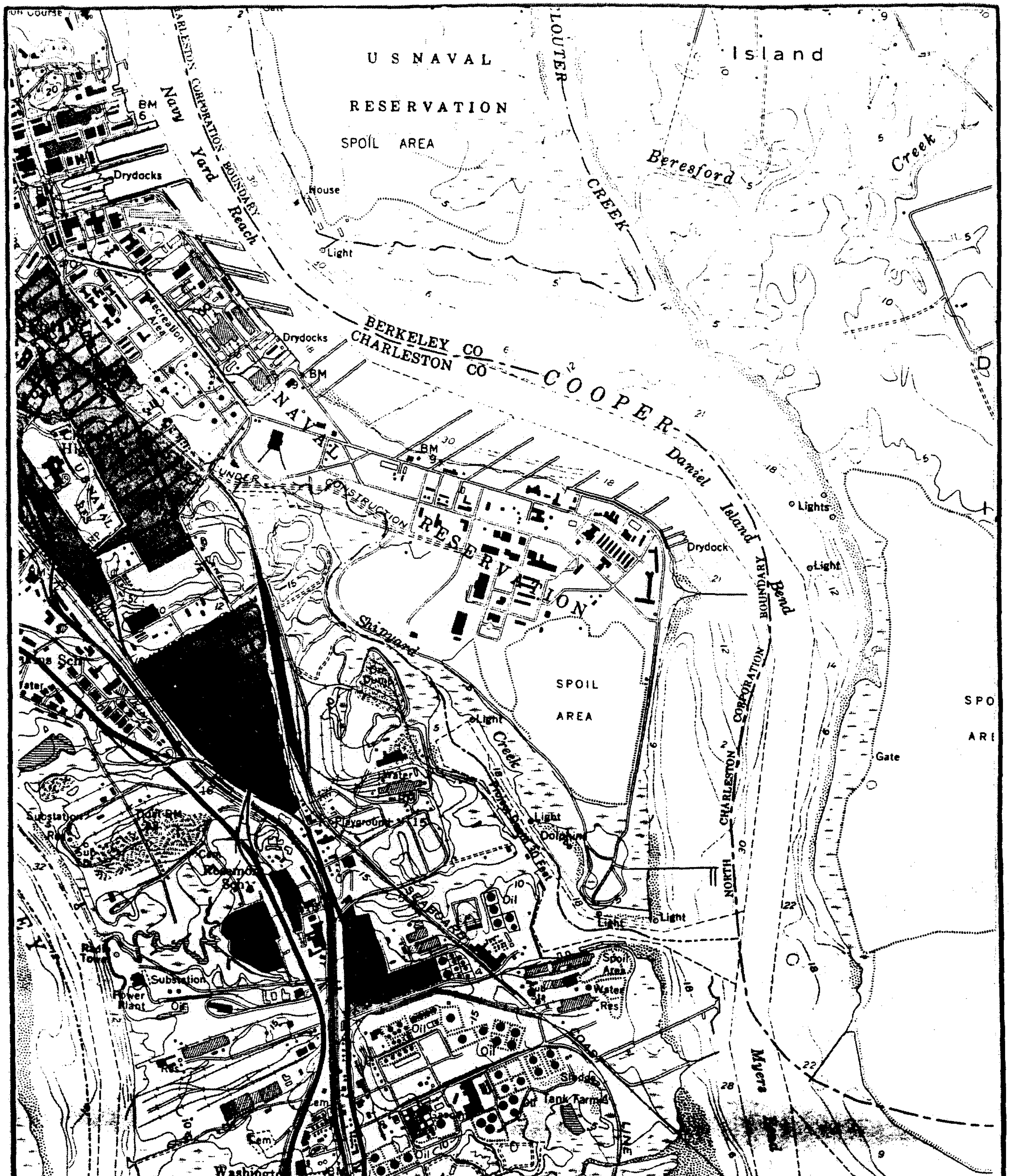
WILL PROVIDE GROUNDWATER FLOW DATA FOR ENTIRE ASSESSMENT AREA

Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WATE 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

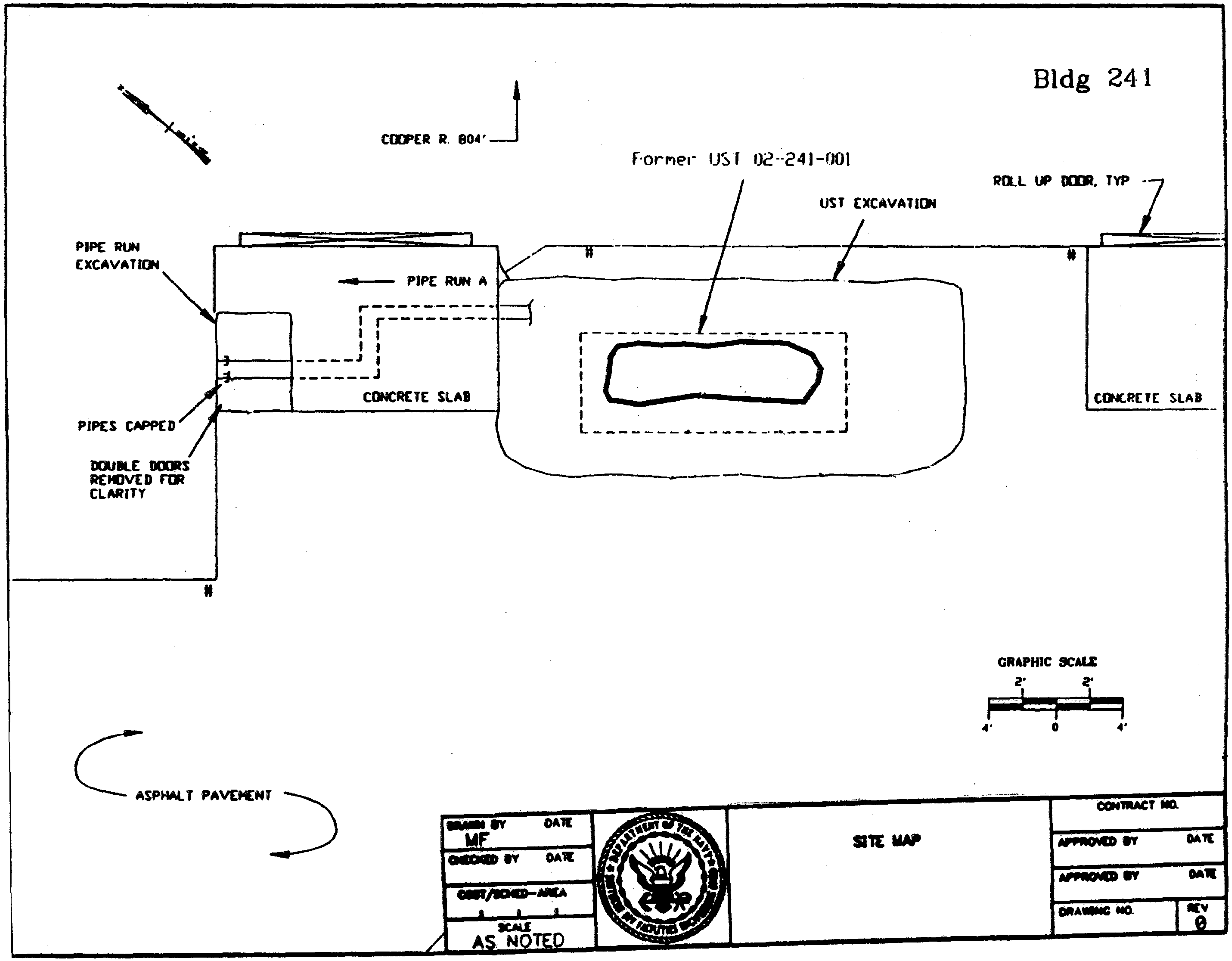
Purge Water ____

Additional Comments ____



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

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND



Bldg 241
COOPER R. 804'
Former UST 02-241-001
ROLL UP DOOR, TYP
UST EXCAVATION
PIPE RUN EXCAVATION
PIPE RUN A
CONCRETE SLAB
CONCRETE SLAB
PIPES CAPPED
DOUBLE DOORS REMOVED FOR CLARITY
GRAPHIC SCALE
2'
2'
4'
0
4'
ASPHALT PAVEMENT
DRAWN BY
DATE
MF
CHECKED BY
DATE
SCALE
AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
DATE
APPROVED BY
DATE
DRAWING NO.
REV
0

Rapid Assessment Plan
UST 242
Site ID #10645

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 10645 **County** CHARLESTON **Facility Name** CNC, BUILDING 242

Facility Address CHARLESTON NAVAL COMPLEX, ZONE F

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

No. USTs 1 **removed?** 8 APR 1997 (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 INTALL MONITORING POINTS. SOIL AND GROUNDWATER SAMPLES WILL BE COLLECTED FROM EACH POINT AND ANALYZED 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 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	7
PAH	9	TOC/FOC	1
METALS	9	GRAIN SIZE	2
		METALS	7

Implementation Schedule

Start up date ______ **Completion date** ______

Report submittal date ______

RAP.1 (3/20/96)

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 10645 **Facility Name** CNC, BUILDING 242

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

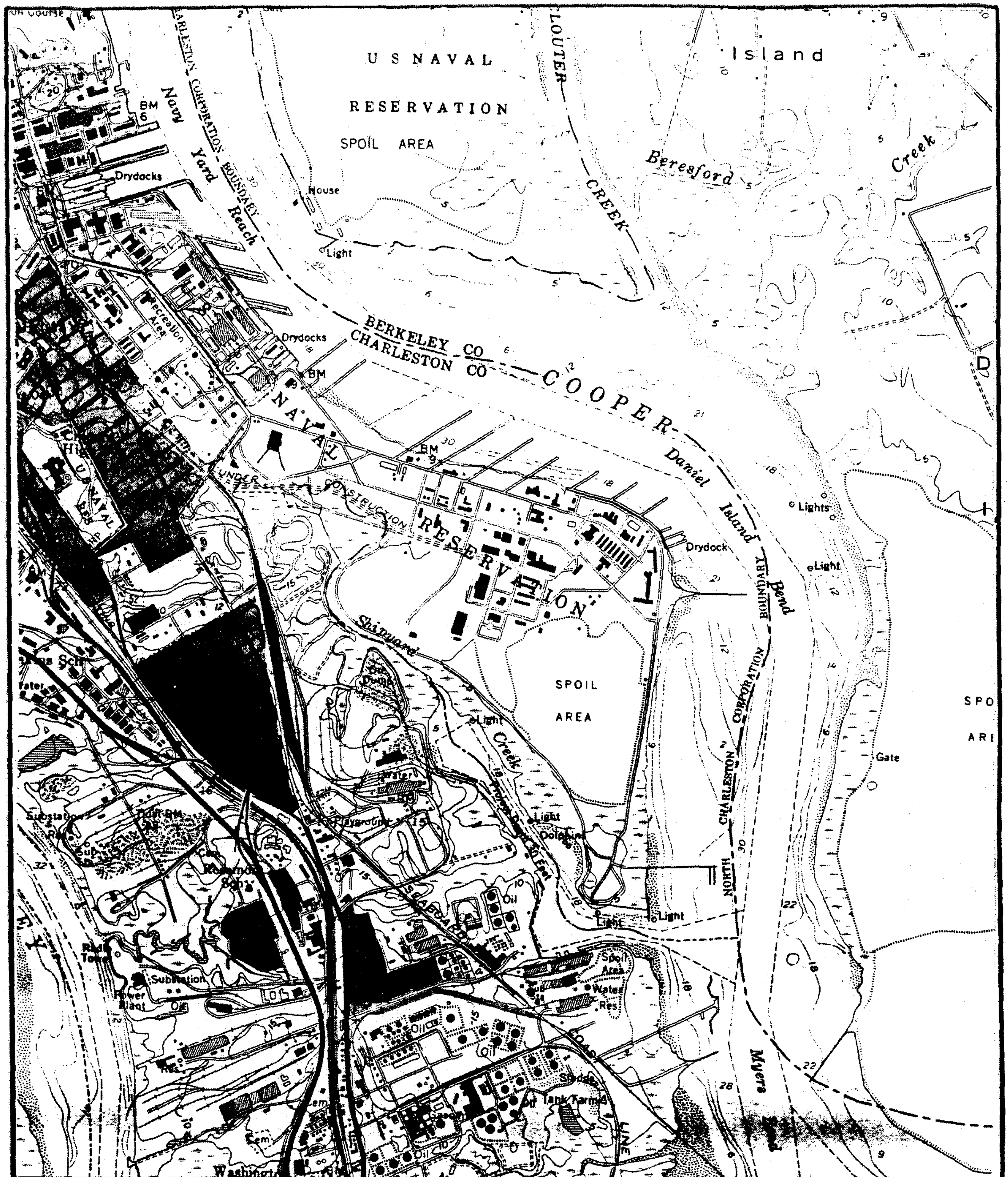
Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WATE 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

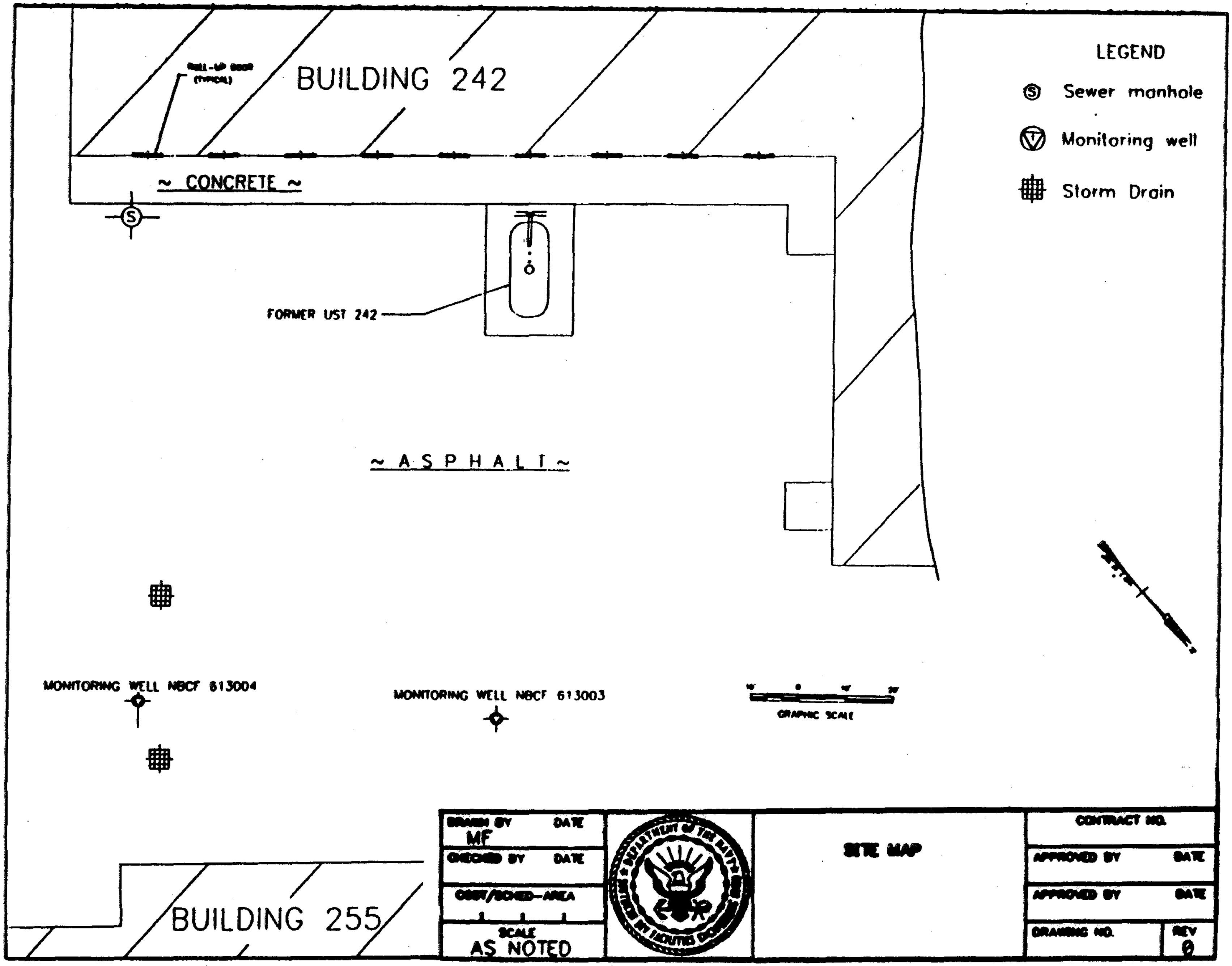
Purge Water ____

Additional Comments ____

RAP.2(8/25/95)



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



BUILDING 242
ROLL-UP DOOR (TYPICAL)
~ CONCRETE ~
LEGEND
Sewer manhole
Monitoring well
Storm Drain
FORMER UST 242
~ ASPHALT ~
MONITORING WELL NBCF 613004
MONITORING WELL NBCF 613003
GRAPHIC SCALE
BUILDING 255
DRAWN BY
DATE
MF
CHECKED BY
DATE
COST/SCHED-AREA
SCALE
AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
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DRAWING NO.
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0

Rapid Assessment Plan
USTs 1175-1, 1175-2, 1175-3
Site ID #10551

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 10551 **County** CHARLESTON **Facility Name** CNC, BLDG.1175

Facility Address CHARLESTON NAVAL COMPLEX, ZONE F

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

No. USTs 3 **removed?** IN PLACE (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 INTALL MONITORING POINTS. SOIL AND GROUNDWATER SAMPLES WILL BE COLLECTED FROM EACH POINT AND ANALYZED 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 8 **total depth** 20'

# of deep wells 2 **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
LEAD	10	GRAIN SIZE	2
EDB	10	LEAD	7
		EDB	7

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 # 10551 Facility Name CNC, BLDG. 1175

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

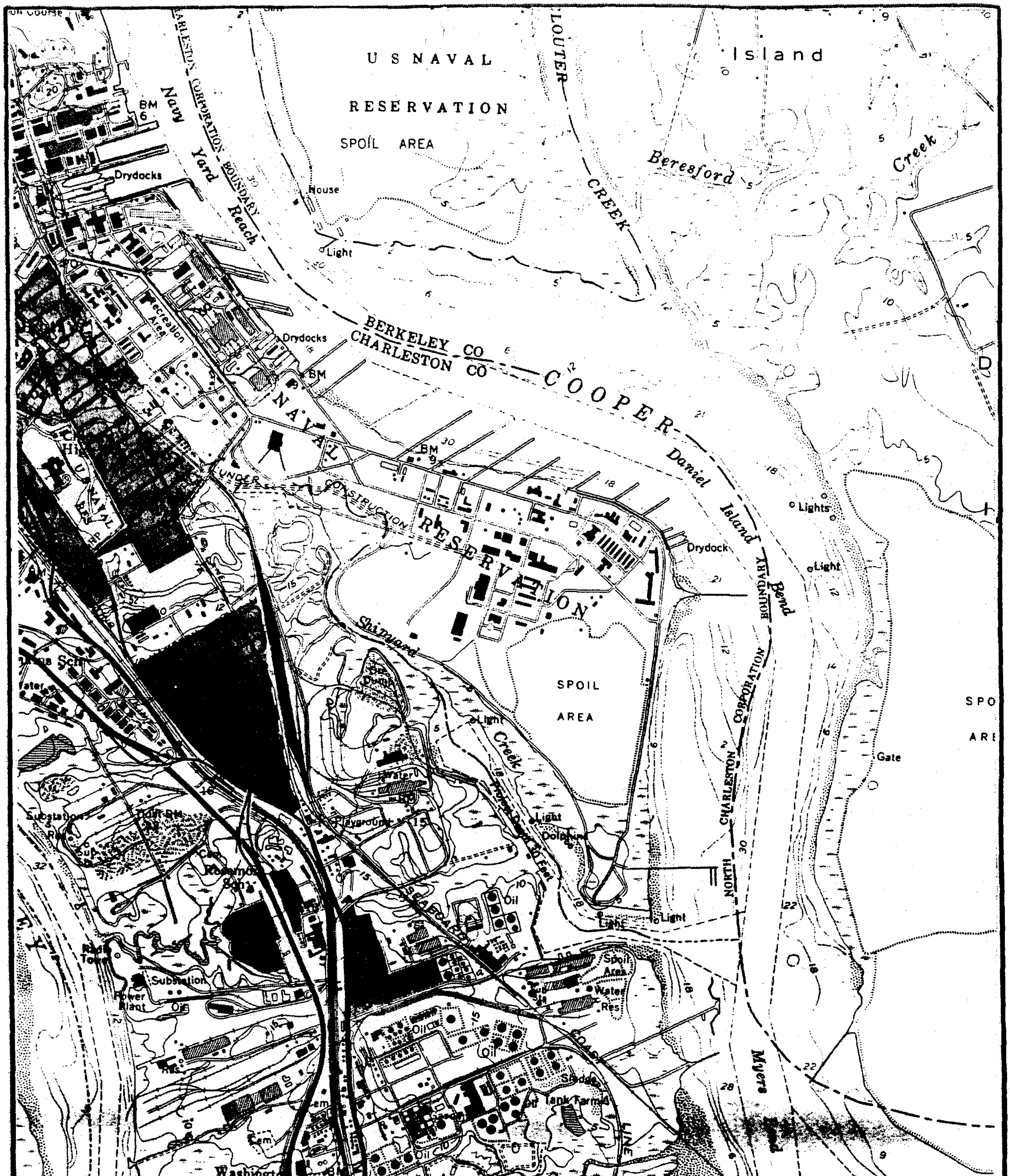
Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WATE 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

RAP.2(8/25/95)



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CHECKED BY DATE

COST/SCHED-AREA

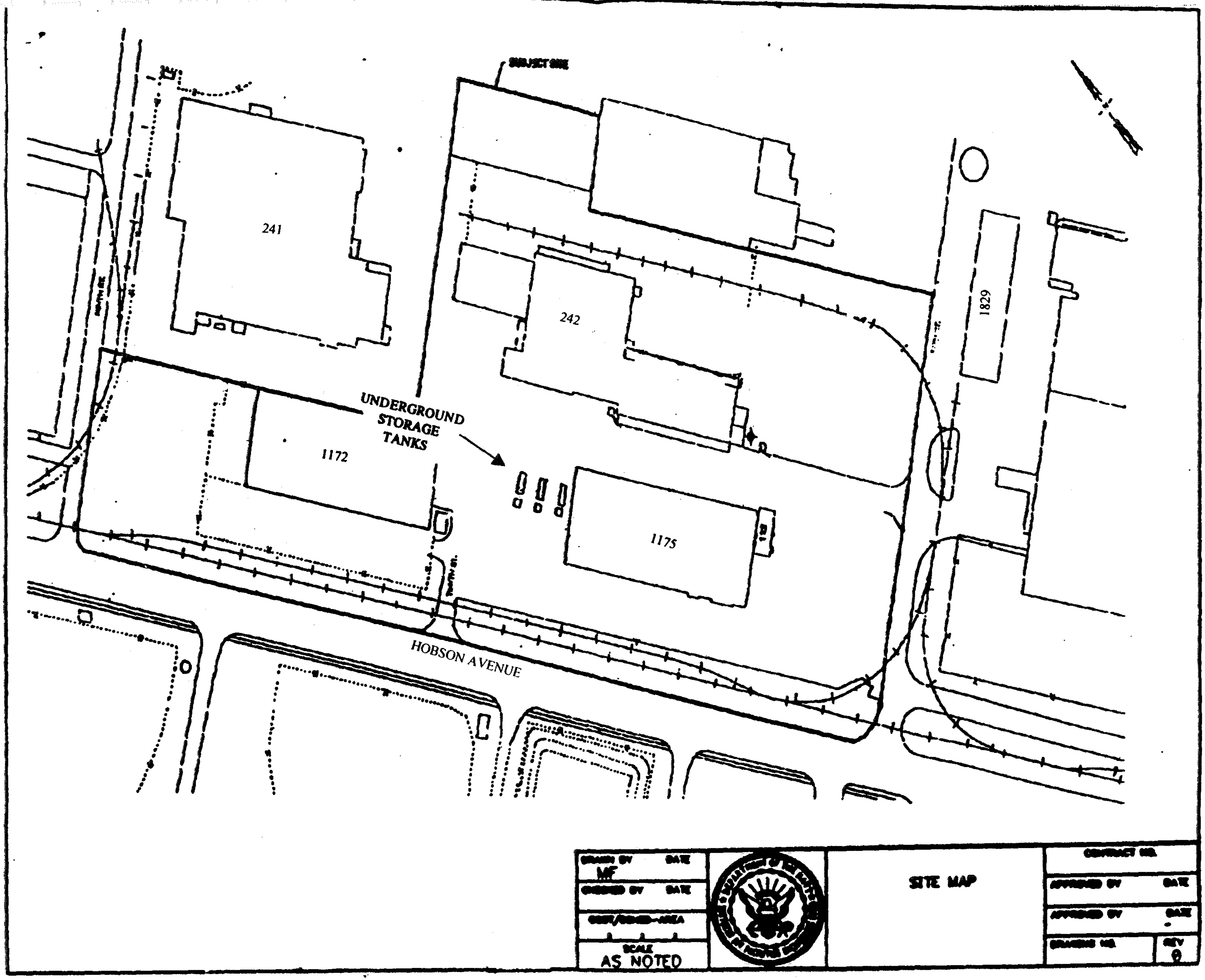
SCALE AS NOTED

TOPOGRAPHIC MAP

CONTRACT NO.

APPROVED BY DATE

APPROVED BY DATE



241
242
1172
1175
1829
UNDERGROUND
STORAGE
TANKS
HOBSON AVENUE
SITE MAP
SCALE
AS NOTED

Rapid Assessment Plan
UST NS1346
Site ID #01782

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 01782 **County** CHARLESTON **Facility Name** CNC, NS1346

Facility Address CHARLESTON NAVAL COMPLEX, ZONE F

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

No. USTs 1 **removed?** 21 MAY 1996 (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 INTALL MONITORING POINTS. SOIL AND GROUNDWATER SAMPLES WILL BE COLLECTED FROM EACH POINT AND ANALYZED 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 4 **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	5	BTEX	7
NAPHTHALENE	5	PAH	7
MTBE	5	TPH	7
PAH	5	TOC/FOC	1
METALS	5	GRAIN SIZE	2
		METALS	7

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 # 01782 **Facility Name** CNC,NS 1346

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

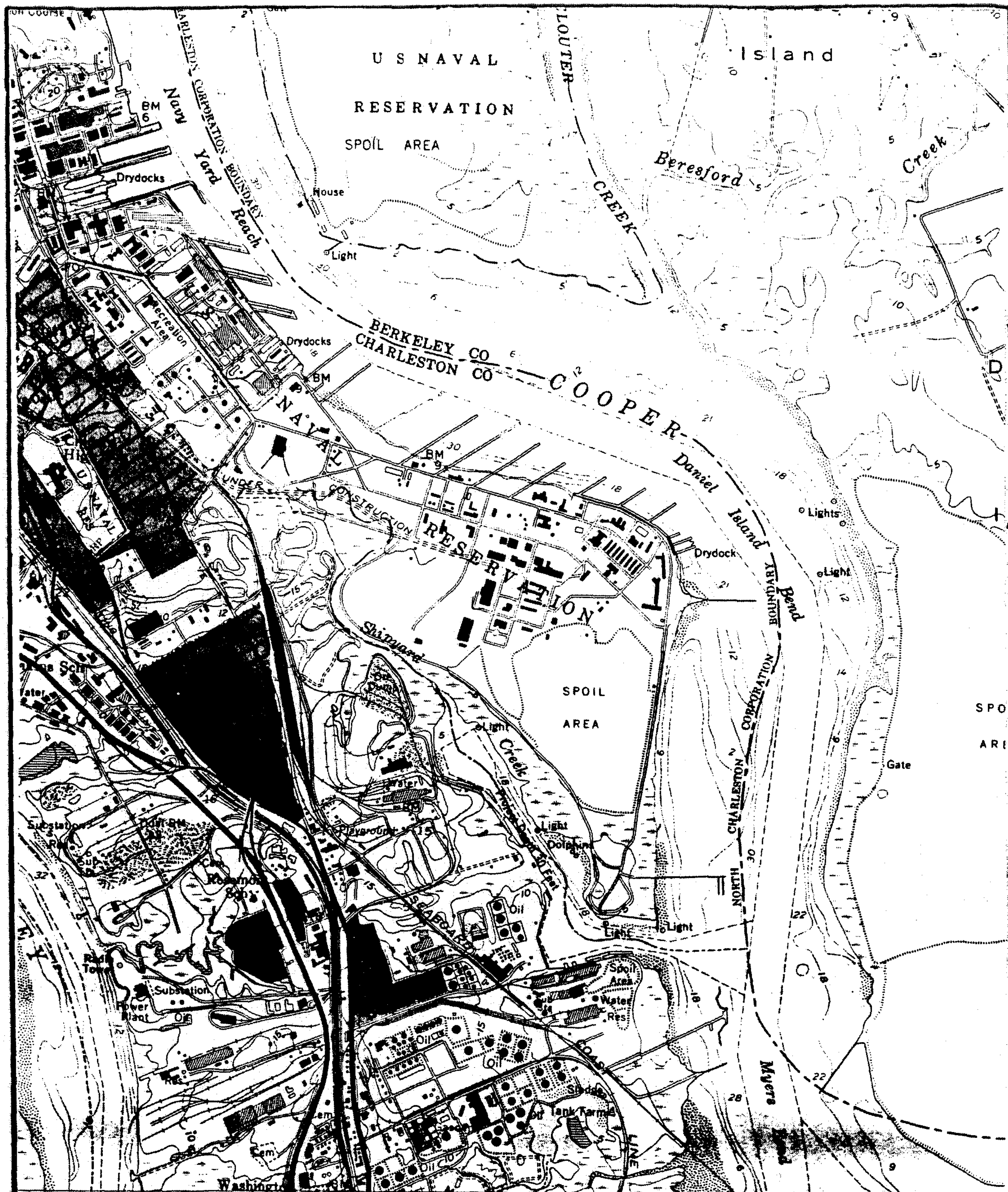
Small Volume Disposal Type and Method

Soil INVESTIGATIVE DERIVED WATE 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

RAP.2(8/25/95)



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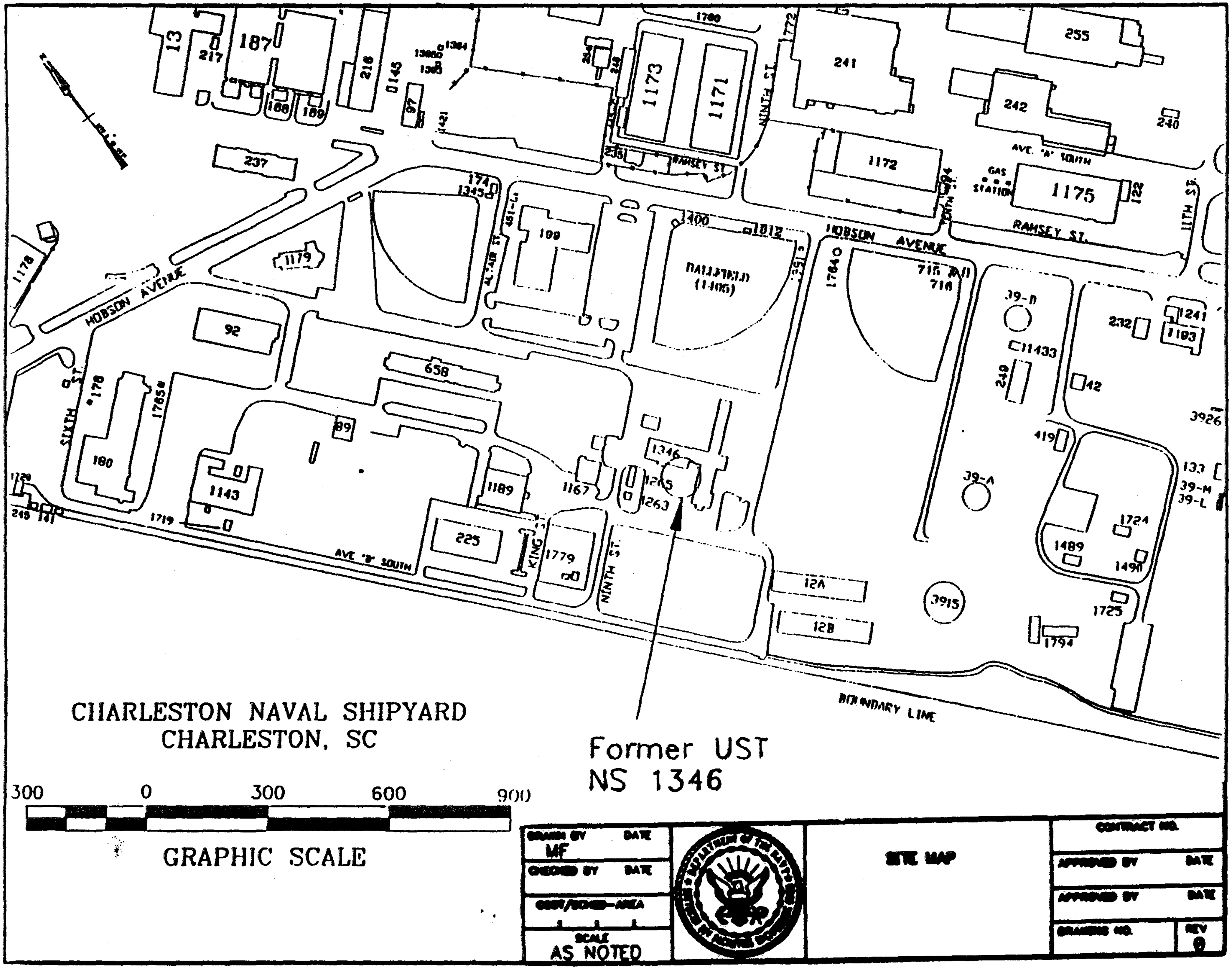
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE AS NOTED	

TOPOGRAPHIC MAP

CONTRACT NO.	
APPROVED BY	DATE
APPROVED BY	DATE



CHARLESTON NAVAL SHIPYARD
CHARLESTON, SC
Former UST
NS 1346
300 0 300 600 900
GRAPHIC SCALE
DRAWN BY
DATE
MF
CHECKED BY
DATE
SCALE
AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
DATE
APPROVED BY
DATE
DRAWING NO.
REV
0
HOBSON AVENUE
RAMSEY ST.
AVE. "A" SOUTH
AVE "B" SOUTH
NINTH ST.
SIXTH ST.
KING
11TH ST.
GAS STATION
BOUNDARY LINE
BALLFIELD (1405)
1346
1173
1171
1172
1175
241
242
255
187
237
92
658
1143
1189
225
1779
12A
12B
3915

Rapid Assessment Plan
USTs 1346-A, 1346-B, 1346-C, 1346-D, 1346-E, 1346-F, 1346-G, 1346-H, 1346-I, 1346-J, 1346-K
Site ID #01782

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 01782 **County** CHARLESTON **Facility Name** CNC, BLDG 1346

Facility Address CHARLESTON NAVAL COMPLEX, ZONE F

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

No. USTs 11 **removed?** SEE ATTACHED LIST **(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 INTALL MONITORING POINTS. SOIL AND GROUNDWATER SAMPLES WILL BE COLLECTED FROM EACH POINT AND ANALYZED 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
LEAD	10	GRAIN SIZE	2
EDB	10	LEAD	7
		EDB	7

Implementation Schedule

Start up date ______ **Completion date** ______

Report submittal date ______

RAP.1 (3/20/96)

RAPID ASSESSMENT PLAN

SOUTH CAROLINA

Department of Health and Environmental Control

Bureau of Underground Storage Tank Management

Site ID # 01782 **Facility Name** CNC, BDLG. 1346

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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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 WATE 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

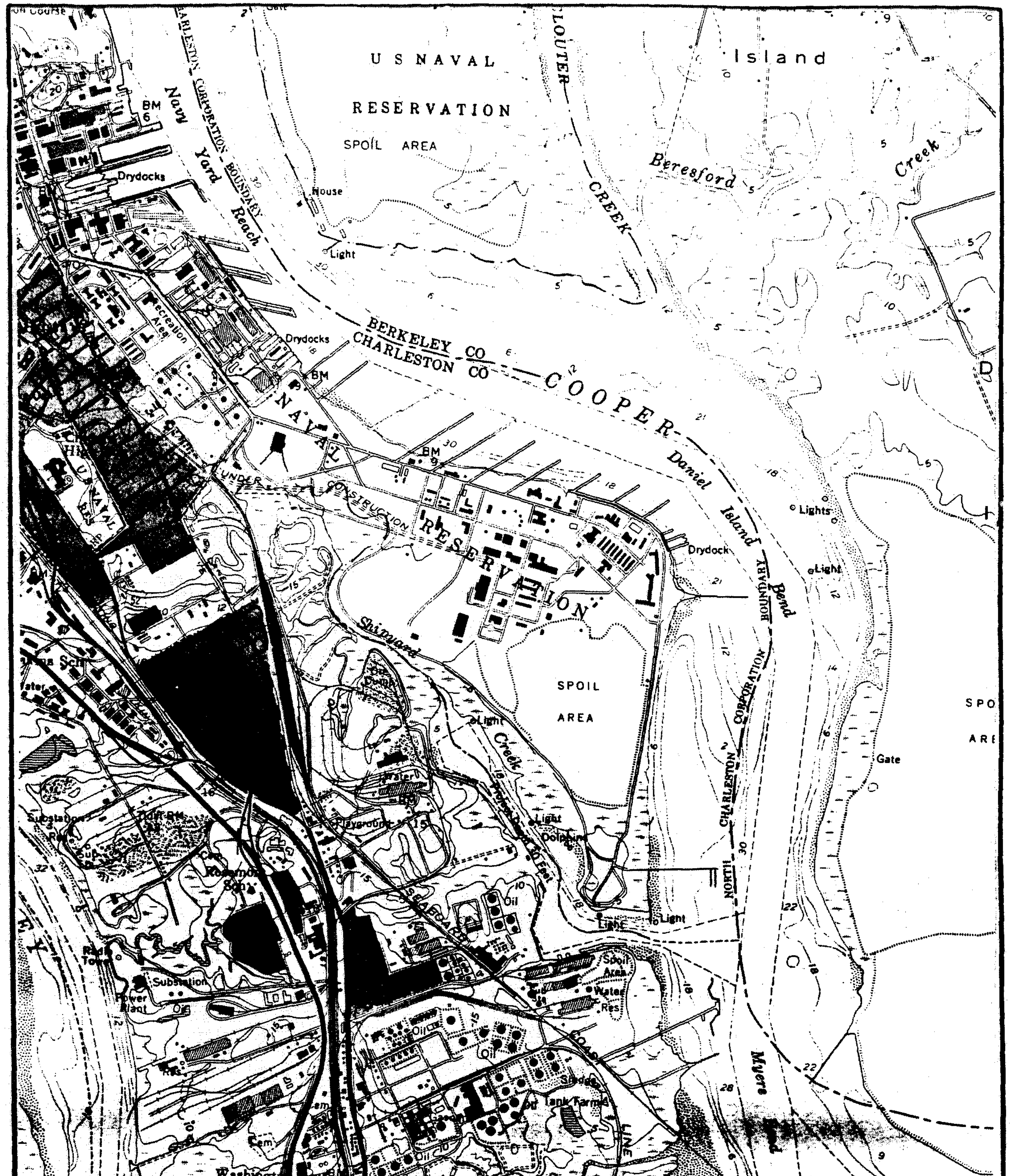
RAP.2(8/25/95)

List of USTs at Site ID# : 01782

UST Suite 1: 1346-D, 1346-E, 1346-F, 1346-G, 1346-H (tanks abandoned in place)

UST Suite 2: 1346-A, 1346-B, 1346-C (tanks abandoned in place)

UST Suite 3: 1346-I, 1346-J, 1346-K (tanks in service)



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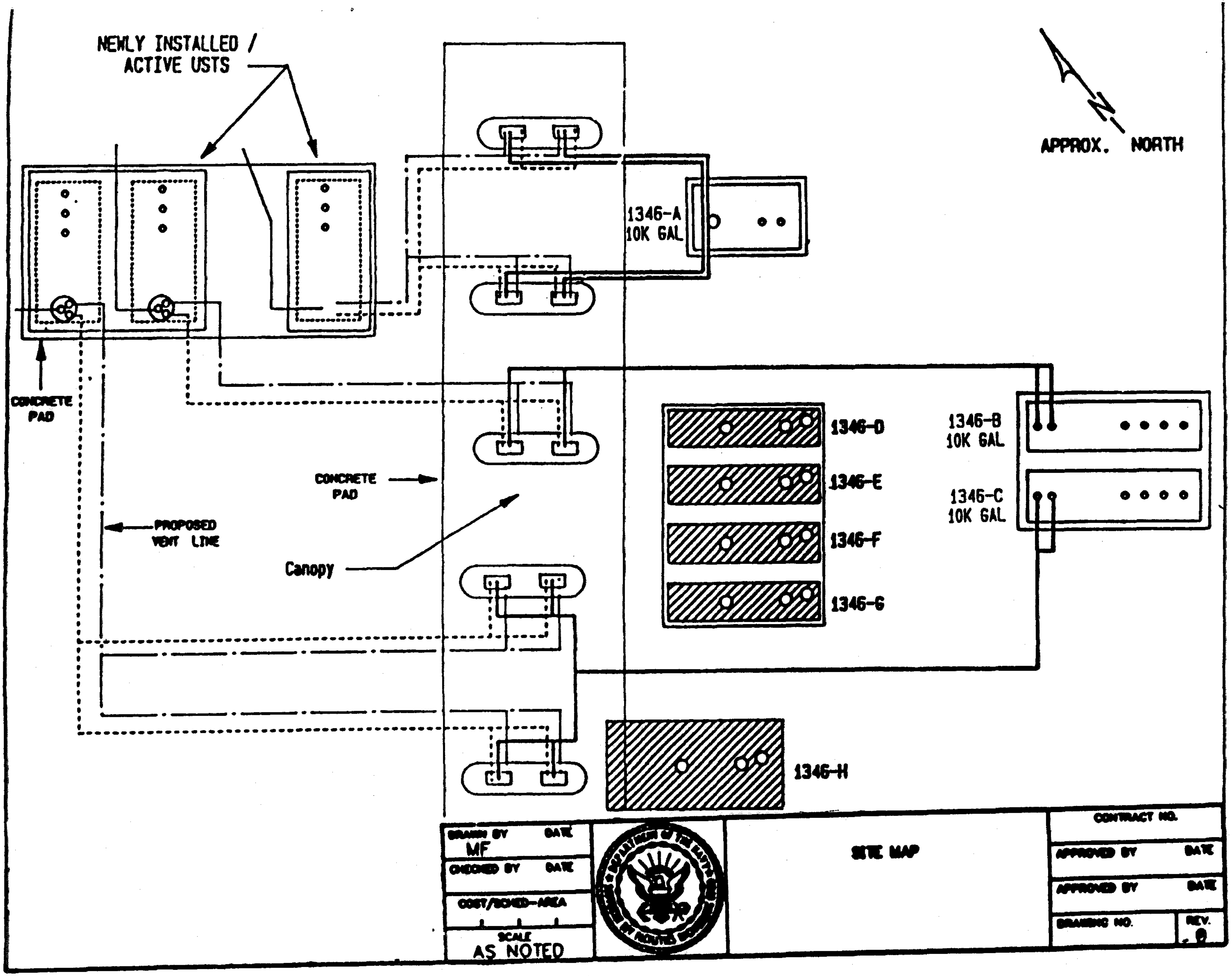
MF	8/17/98
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE	AS NOTED

TOPOGRAPHIC MAP

CONTRACT NO.	
APPROVED BY	DATE
APPROVED BY	DATE


NEWLY INSTALLED / ACTIVE USTS
APPROX. NORTH
N
1346-A 10K GAL
CONCRETE PAD
1346-D
1346-B 10K GAL
1346-E
1346-C 10K GAL
1346-F
1346-G
CONCRETE PAD
PROPOSED VENT LINE
Canopy
1346-H
DRAWN BY
DATE
MF
CHECKED BY
DATE
COST/SCHED-AREA
SCALE
AS NOTED
SITE MAP
CONTRACT NO.
APPROVED BY
DATE
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DATE
DRAWING NO.
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0

APPENDIX B

TETRA TECH NUS
STANDARD OPERATING PROCEDURES
AND STANDARD FIELD FORMS

TABLE OF CONTENTS

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).

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%(+)>1/4"Ø	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 W/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%(+)<1/4"Ø	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 W/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) — 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	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 Effects	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.)	0-2"
Broken	(Br.)	2"-1'
Blocky	(Bl.)	1'-3'
Massive	(M.)	3'-10'

LEGEND:

SOIL SAMPLES - TYPES

S-2" Split-Barrel Sample

ST-3" O.D. Undisturbed Sample

O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X-NX (Conventional) Core (≈2-1/8" O.D.)

Q-NQ (Wireline) Core (≈1-7/8" O.D.)

Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18 ▽ 12.6' Initial Level w/Date & Depth

12/18 ▼ 12.6' Stabilized Level w/Date & Depth

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

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

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

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

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

5.2.4 Weight Percentages

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

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

Examples:

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

5.2.5 Moisture

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

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

5.2.6 Stratification

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

5.2.7 Texture/Fabric/Bedding

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

5.2.8 Summary of Soil Classification

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

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

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

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

- 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 -- <u>some</u> 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 -- <u>few</u> 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 "<u>interbedded</u> 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.

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/MW 1
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 Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ
S-1	0.0	7/6	1.5/2.0		M DENSE	BRN	SILTY SAND - SOME	SM	MOIST SL. ORG.	5	0	0	0
@ 0800	2.0	9/10			↓	TO BLK	ROCK FR; TR BRICKS		ODOR				
							(FILL)		FILL TO 4'±				
	4.0			4.0									
S-2 @		5/7	2.0/2.0		M DENSE	BRN	SILTY SAND - TR FINE	SM	MOIST - W ODOR	10	0	-	-
0810	6.0	9/8					GRAVEL		NAT. MATL. TOOK SAMPLE				
	•			7' ▽ ±					SB01-0406 FOR ANALYSIS				
	8.0			8.0	↓	↓	↓						
S-3 @		6/8	1.9/2.0		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			12.0	↓	↓	↓						
S-4 @		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'				
				16	M HARD	BRN	SILTSTONE	WBR	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				
4.9/5.0	②		5.0/5.0						SET 2"Ø PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
	25.0			25	↓	↓	↓	↓	PELLETS 12-14				

* When rock coring, enter rock brokenness.

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

• 1-20% 1-80%

Drilling Area Background (ppm): 0

Remarks: CME-55 RIG, 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

- 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.

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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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 include:

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

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

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the 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

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 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

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

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

.2.4 Protective Casing

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

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

3 <u>Monitoring Well Installation</u>

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 gers 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 anufacturers of these types of samplers claim that four samplers can be installed in a 3-inch-diameter orehole. 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 hen the water table is within 25 feet of the surface (the typical range of suction pumps). Two anufacturers 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 aterials.

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 struments 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.

e 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 nples to the surface. Where the depth to ground water is less than 25 feet, the piston pumps are not uired. The assembly is made of easily obtained materials; however, the cost of labor to assemble hese monitoring systems may not be cost-effective.

5 Well Development Methods

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

.1 Overpumping and Backwashing

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

.4.2 Surging with a Surge Plunger

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

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.

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.

- 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 <u>General</u>

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.

- 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.

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

;.5.3 Measurement of Temperature

5.5.3.1 General

ı 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. emperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water ımples 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 mperature 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.

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

5 .4 Measurement of Dissolved Oxygen Concentration

;.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 h rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for lissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible,)O measurements shall be taken in-situ, since concentration may show a large change in a short time e sample is not adequately preserved.

- 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.

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.

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

- 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

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

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)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT 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
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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		Prepared Earth Sciences Department	
Subject SOIL SAMPLING		Approved D. Senovich	

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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.

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 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.

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.

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

- 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

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

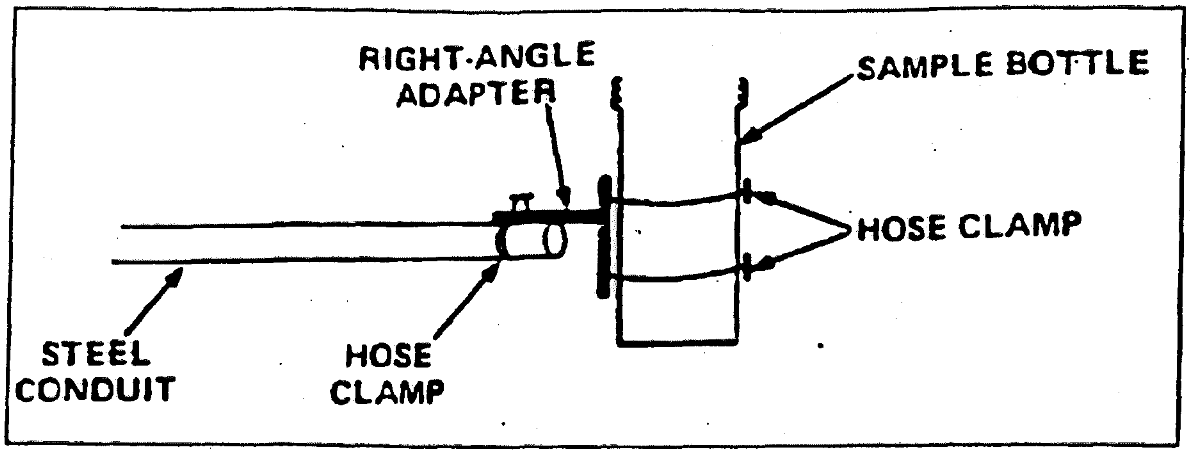
All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non working hours unless adequately covered or otherwise protected.

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 B
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING



BROWN & ROOT ENVIRONMENTAL	STANDARD OPERATING PROCEDURES	Number SA-6.3	Page 1 of 32
		Effective Date 03/01/96	Revision 0
		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
Subject FIELD DOCUMENTATION		Approved D. Senovich	

TABLE OF CONTENTS

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.

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.

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.

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-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 Sampled By: ____________________

☐ Stream ☐ Lake

☐ Other ____________________

☐ QA Sample Type: ____________________ C.O.C. No.: ____________________

Sample Data		
Date and Time	Method	Depth

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

Analysis	Preservative	Container Requirements	Collected (✓)

Observations/Notes:

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

TBD: To Be Determined

ATTACHMENT B-4
CONTAINER SAMPLE LOG SHEET FORM

Brown & Root Environmental

Page ___ of _

☐ Container Data

Case #: ______

By: ______

roject 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		Layer 1	Layer 2	Layer 3
☐ Container opened but not sampled. Reason: ______	Phase	☐Sol. ☐Liq.	☐Sol. ☐Liq.	☐Sol. ☐Liq.
	Color	______	______	______
	Viscosity	☐L ☐M ☐H	☐L ☐M ☐H	☐L ☐M ☐H
☐ Container not opened. Reason: ______	% of Total Volume	______	______	______
	Other	______	______	______

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

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 C-1
EXAMPLE GROUNDWATER LEVEL MEASUREMENT SHEET

GROUNDWATER LEVEL MEASUREMENT SHEET

Page ____ of ____

PROJECT NAME: ______________________
PROJECT NUMBER: ______________________
PERSONNEL: ______________________
DATE: ______________________
WEATHER CONDITIONS: ______________________

LOCATION: ______________________
MEASURING DEVICE: ______________________
ADJUSTMENT FACTOR: ______________________
REMARKS: ______________________

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

*Measurements to nearest 0.01 foot.

Signature(s): ______________________

ATTACHMENT C-3

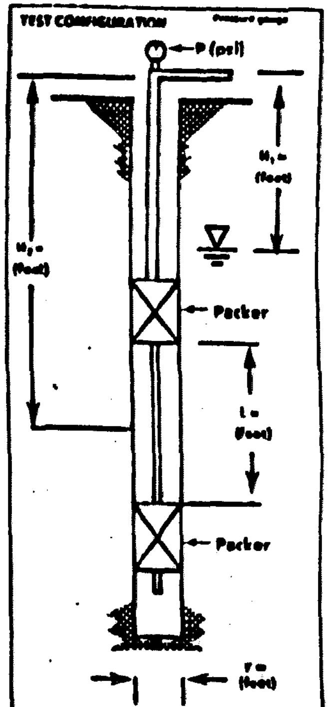
PACKER TEST REPORT FORM

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 (ft³)	Δ Flow, ΔQ (gal)	Flow Rate Q (gal/min)	H₁* (ft)	Hp(ft) = 2.31·p(psi)	H₂* (ft)	H = Hp + (H1 or H2)	Cp	K(ft/yr) = Cp·Q/H	K (cm/sec) = 9.67 x 10⁻⁷ · K (ft/yr)



Length of test section (in feet), l	Cp			
	Casing Bit Size			
	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[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

* 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.

Remarks: ____

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%(+)>1/4"Ø	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 W/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%(+)<1/4"Ø	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 W/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)

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

LEGEND:

SOIL SAMPLES - TYPES

S-2" Split-Barrel Sample

ST-3" O.D. Undisturbed Sample

O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X-NX (Conventional) Core (-2-1/8" O.D.)

Q-NQ (Wireline) Core (-1-7/8" O.D.)

Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

12/18 ▽ 12.6' Initial Level w/Date & Depth

12/18 ▽ 12.6' Stabilized Level w/Date & Depth

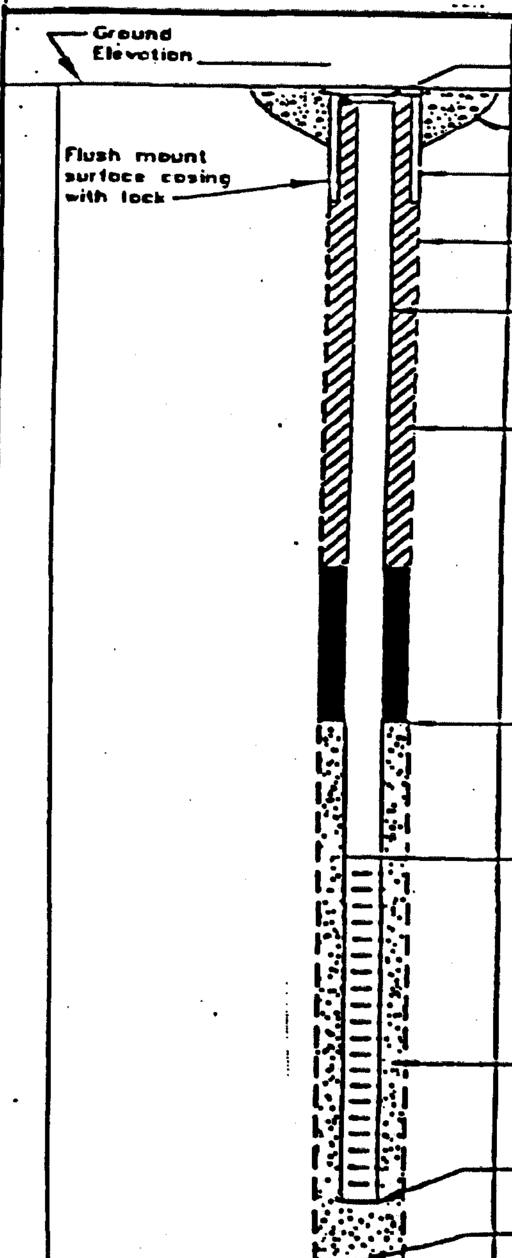
ATTACHMENT C-5A
EXAMPLE OVERBURDEN MONITORING WELL SHEET (FLUSHMOUNT)

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: ____________

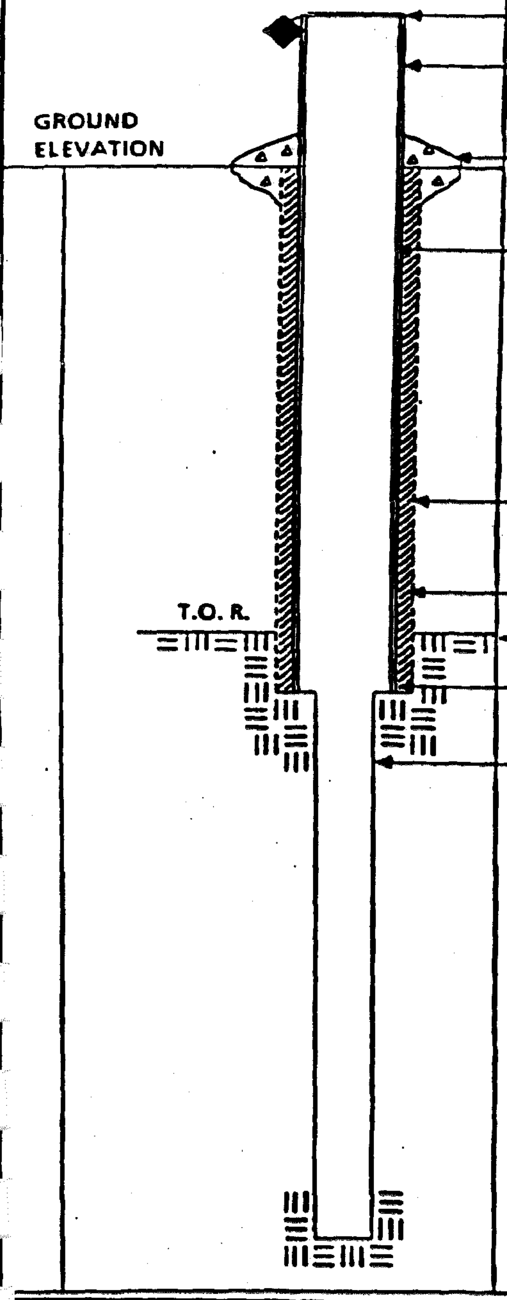
DEPTH/ELEVATION BOTTOM OF SCREEN: ______/______
DEPTH/ELEVATION BOTTOM OF SAND: ______/______
DEPTH/ELEVATION BOTTOM OF HOLE: ______/______
BACKFILL MATERIAL BELOW SAND: ____________

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

BORING NO.: __________

BEDROCK
MONITORING WELL SHEET
OPEN HOLE WELL

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



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

BORING NO.: ____________

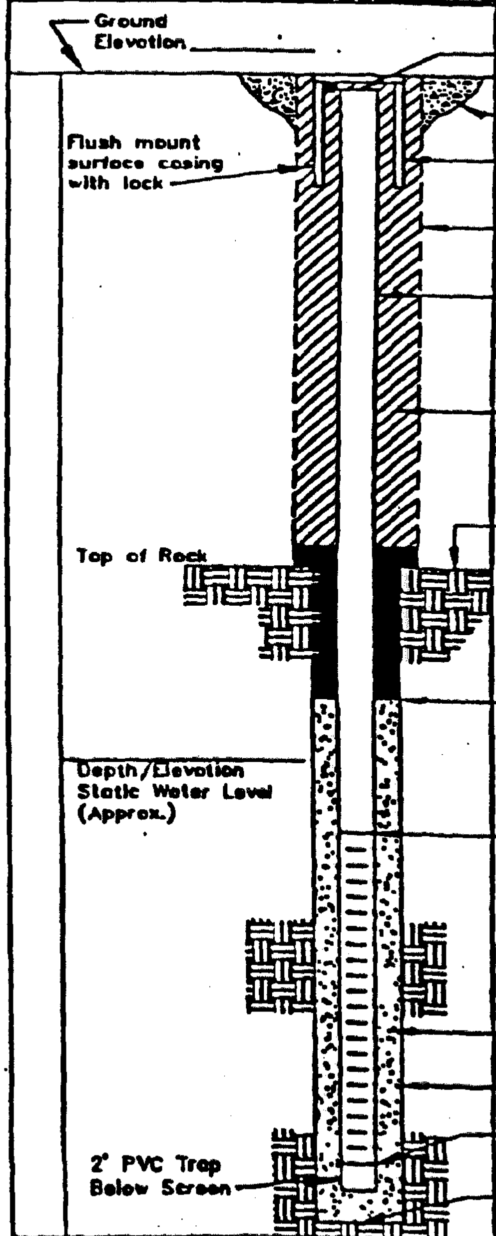
BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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 D
EXAMPLE EQUIPMENT CALIBRATION LOG

Brown & Root Environmental

EQUIPMENT CALIBRATION LOG

INSTRUMENT NAME / MODEL: ______________

MANUFACTURER: ______________

JOB NAME: ______________

JOB NUMBER: ______________

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

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: ____

____

____

____

WN & ROOT ENVIRONMENTAL	STANDARD OPERATING PROCEDURES	Number SA-7.1	Page 1 of 9
		Effective Date 03/16/98	Revision 2
		Applicability B&R Environmental, NE	
		Prepared Earth Sciences Department	
DECONTAMINATION OF FIELD EQUIPMENT AND WASTE HANDLING		Approved D. Senovich	

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5.1 Drilling Equipment

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

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

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

Guidance to be used when decontaminating drilling equipment shall include:

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

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

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

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.

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

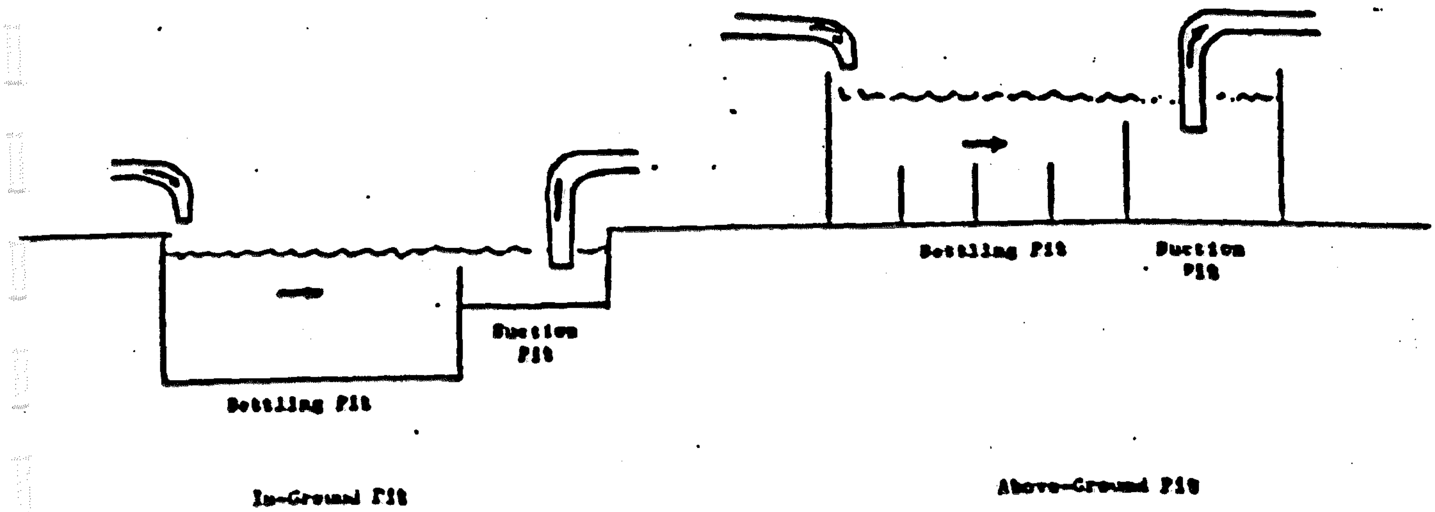
A spill is always possible when containers of liquids are opened or moved. Contaminated sorbents and soils resulting from spills must be contained. Small quantities of spill-contaminated materials are usually best contained in drums, while larger quantities can be placed in lined pits or in other impermeable 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

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: ______________________ Sample ID No.: ______________
Project No.: ______________________ Sample Location: ______________
Sampled By: ______________
C.O.C. No.: ______________

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

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

EQUIPMENT 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	

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.)

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: ____________________