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FINAL WORK PLAN FOR STRAUSS AVENUE AND CAFFEE ROAD THERMAL TREATMENT POINTS NSWC INDIAN HEAD MD

9/1/1992

HALLIBURTON NUS

D-49-8-92-2

FINAL
WORK PLAN FOR
STRAUSS AVENUE AND CAFFEE ROAD
THERMAL TREATMENT POINTS
NAVSURFWARCEN IHDIV

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) PROGRAM

Submitted to:
Northern Division
Naval Facilities Engineering Command
10 Industrial Highway, MS #82
Lester, Pennsylvania 19113

Prepared by:
HALLIBURTON NUS Environmental Corporation
661 Andersen Drive
Pittsburgh, Pennsylvania 15220

CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0056

SEPTEMBER 1992

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SUBMITTED BY:

RALPH BASINSKI
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APPROVED FOR SUBMISSION BY:

JOHN J. TREPANOWSKI, P.E.
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1.0 INTRODUCTION

The Northern Division of the Naval Facilities Engineering Command has issued Contract Task Order (CTO) 56 to HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS), under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298. The activities under the CLEAN Contract are performed by a team of contractors comprised of HALLIBURTON NUS, the prime contractor, and SEC Donohue, Inc. and ENSR Consulting and Engineering, both team subcontractors. HALLIBURTON NUS is the lead technical firm for this project.

The purpose of CTO 56 is to prepare a RCRA Subpart X Permit application for two Open Burning (OB) units at NAVSURFWARCEN IHDIV, and to develop a work plan for the installation of monitoring wells and the collection and analysis of environmental samples. The Work Plan portion of the project includes field activities to assess the local impacts on soils, groundwater and surface water from operations at the OB sites. The environmental sampling and monitoring well installation program completed as part of this Work Plan will be incorporated in to a RCRA Subpart X Permit application, in preparation by HALLIBURTON NUS.

2.0 PROJECT BACKGROUND

2.1 SITE LOCATION

The NAVSURFWARCEN IHDIV is located at Indian Head, Maryland in the west-central portion of Charles County, approximately 30 miles south of Washington, D.C. The site is located on a peninsula formed by the confluence of the Potomac River and Mattawoman Creek, and is situated on approximately 2,000 acres of land. The location of Indian Head is illustrated in Figure 2-1.

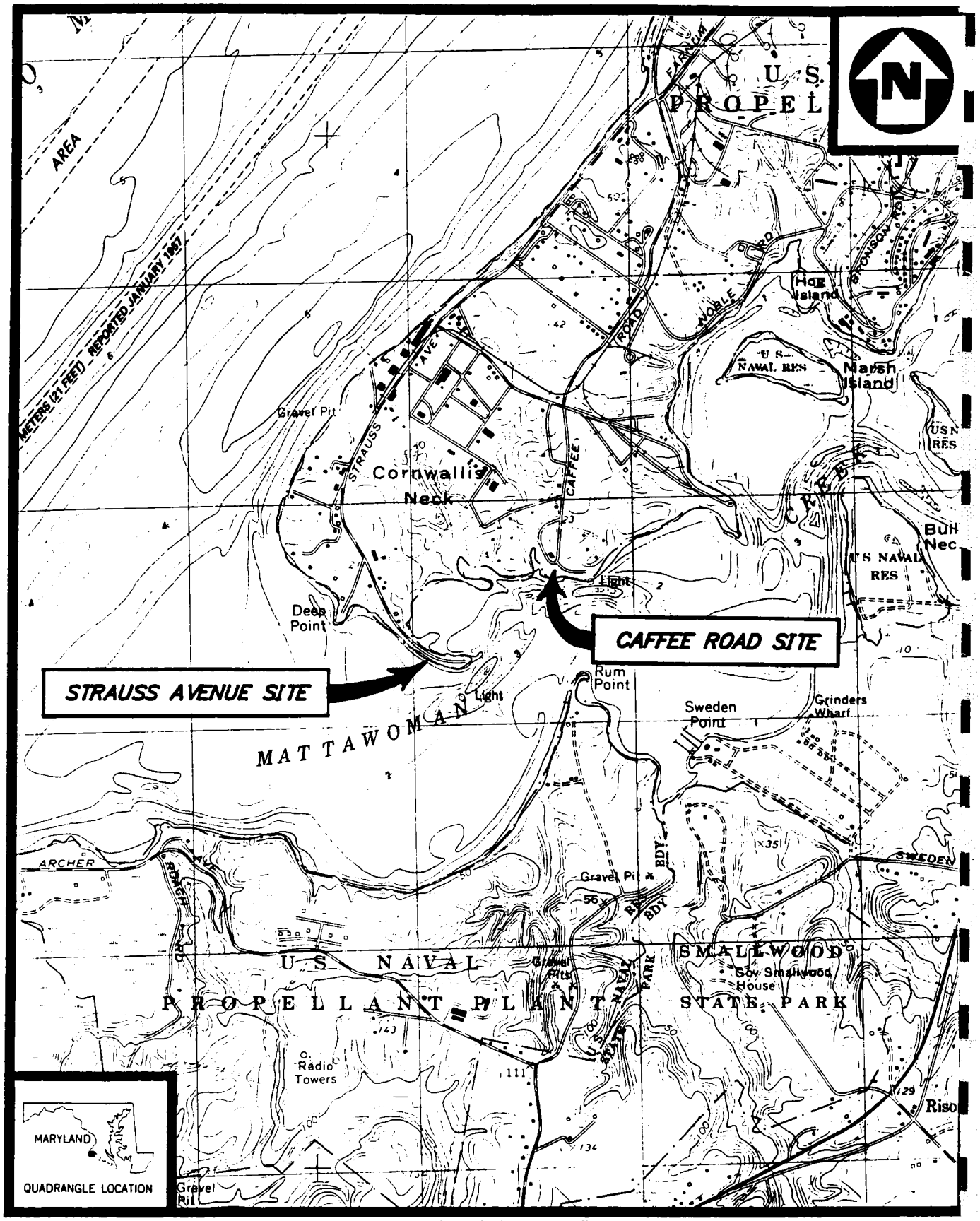
The Thermal Treatment Points (TTPs) being addressed in this Work Plan are located at the southwest portion of the base. The Strauss Avenue activity is on a narrow, 1,100-foot-long peninsula which extends off Indian Head into Mattawoman Creek, a tidal tributary of the Potomac River. The nearby Caffee Road activity occupies approximately 1.25 acres, and is located along the bank of Mattawoman Creek approximately 2,500 feet to the northeast of the Strauss Avenue site. Both of the Thermal Treatment Points are located on the floodplain of the Potomac River. The locations of the two activities are shown on Figure 2-1.

2.2 SITE DESCRIPTION AND HISTORY

The principal mission of the activity at Indian Head is the research, development and production of propellants and explosives for the United States Navy. The site has been used in this capacity for over 100 years. Site operations range from full-scale production of wastes to laboratory research on new explosives and propellants. These operations produce explosives, propellants and explosive/propellant contaminated scrap and dunnage. The wastes, which are regulated under 40 CFR Part 264, Subpart X, must be thermally treated to render them safe. Thermal treatment of these wastes is currently being performed at the Strauss Avenue and Caffee Road Thermal Treatment Points.

2.3 SITE ACTIVITIES

Thermal treatment of RCRA reactive wastes occur by Open Burning (OB) at two locations. These wastes range from pure explosive or propellant to reject ordnance items to propellant/explosive contaminated equipment, chemicals, and other items.



BASE MAP IS A PORTION OF THE U.S.G.S. INDIAN HEAD, MARYLAND—VIRGINIA 7.5 MINUTE QUADRANGLE, PHOTOREVISED 1978.

LOCATION MAP OF INDIAN HEAD PENINSULA

FIGURE 2-1

INDIAN HEAD, MARYLAND

0 2000 4000

SCALE IN FEET

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2.3.1 Strauss Avenue Thermal Treatment Point (SATTP)

Wastes which are thermally treated at the SATTP include rocket grains (motors), explosive scrap, and other wastes contaminated with explosives and propellants. Treatment activity occurs at two locations at the SATTP. The Main Point, located at the end of the Strauss Avenue peninsula, is used for the majority of wastes which require thermal treatment. There are seven (7) burn pans along the perimeter of the Main Point. The Auxiliary Point is a smaller peninsula which branches off from the Strauss Avenue peninsula. This area contains five (5) burn pans, one (1) solvent treatment vessel, one (1) igniter treatment vessel and one (1) JATO block, and one (1) clay pad (for large grain treatment). A map of the SATTP is shown in Figure 2-2.

Thermal treatment occurs daily at the Main Point, while the Auxiliary Point is used less frequently. The majority of thermal treatment of wastes occurs in clay-lined burn pans on the Main and Auxiliary Points. These burn pans are lined with a minimum of 6 inches of clay, which serves as a support medium for the wastes treated, and also serves to protect the pans from the heat generated during treatment. In many cases it is necessary to add supplementary fuel, such as excelsior or fuel oil, to assist in initiating and sustaining effective thermal treatment of the waste. Burn pans are covered when not in use to prevent accumulation of precipitation inside the pans and to prevent wind dispersal of ash.

At the Auxiliary Point, in addition to the use of burn pans, jet-assisted takeoff (JATO) rocket grains and potentially propulsive items are treated by attaching them to a large concrete block to prevent unrestrained motion of the items during treatment. Liquid wastes and solvents contaminated with explosives are treated at the Auxiliary Point in a solvent treatment vessel. This container, which has a secondary containment pan beneath the vessel, has legs to support it above the ground and is regularly inspected for structural integrity. Occasionally, treatment of grains larger than the burn pans may occur on clay pads, directly on the ground. These large grains are treated outside of burn pans quite infrequently.

2.3.2 Caffee Road Thermal Treatment Point (CRTTP)

The CRTTP is used to treat explosive/propellent contaminated bulk metal items, which range in size from small scrap pieces to contaminated storage tanks, pipes, and other large metal objects. In addition, explosive/propellant contaminated scrap of a nonmetallic nature, such as packing wastes and containers are treated at this site. The amount of combustible wastes, or actual energetics which are contained in the waste is small in comparison to the size of the item. Therefore, ignition aids such as fuel oil and wooden

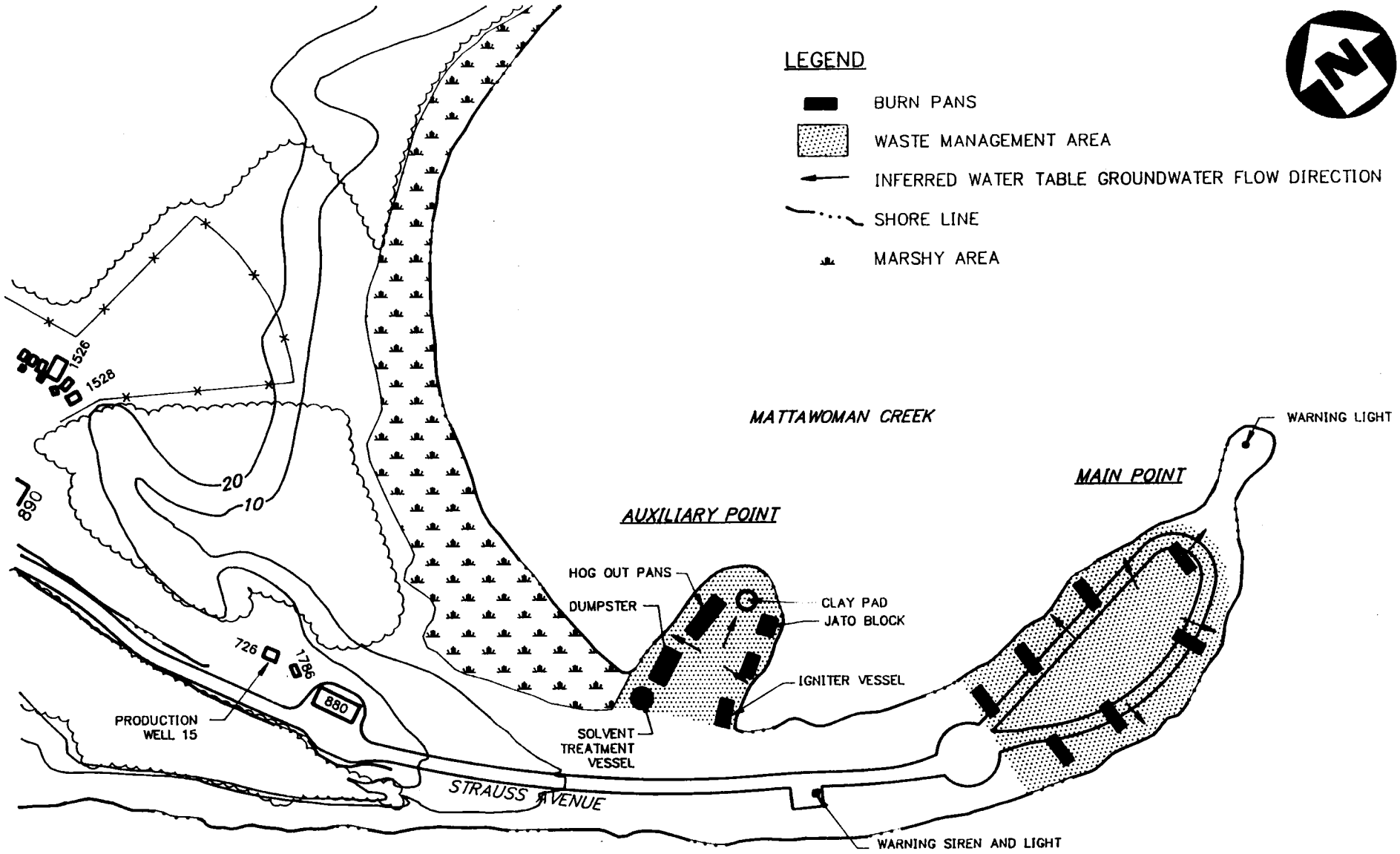

FIGURE 2-2

TOPOGRAPHIC SITE MAP
STRAUSS AVENUE TTP
INDIAN HEAD, MARYLAND

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items may be used to achieve complete decontamination of the items. Figure 2-3 shows a map of the Caffee Road activity.

Thermal treatment activities occur at Caffee Road approximately once every two weeks. After the scrap material has been decontaminated, it is stored on the site until it can be sold for recycling.

2.4 PAST INVESTIGATIONS

The NAVSURFWARCEN IHDIV submitted a Part B application to USEPA in 1988 concerning the OB activities. A revision was recently prepared but not submitted. NAVSURFWARCEN IHDIV has not yet received Notices of Deficiency (NODs) on the initial permit application. A specific investigation of the geology/hydrogeology of the OB sites, including environmental sampling in the vicinity of these activities and laboratory analysis of samples has not been previously undertaken.

2.5 GEOLOGIC SETTING

The Indian Head peninsula lies within the Atlantic Coastal Plain Physiographic Province. The general topography of the area consists of rolling terrain, marshlands, swamps and the shoreline Potomac River and Mattawoman Creek. The maximum elevation on the Indian Head peninsula is approximately 100 feet above sea level.

This area is underlain by the Potomac Group, which consists of (in descending order), the Patapsco, Arundel, and Patuxent Formations. The Patapsco Formation is a sequence of gently dipping, unconsolidated layers of marine and coastal clay, silt, sand and gravel deposits. The average thickness of the Patapsco Formation is approximately 200 to 300 feet (Tech International, 1988, Aware, 1982). Figure 2-4 shows a generalized cross section for the area.

The Patapsco Formation is underlain by the Patuxent-Arundel Formations, which consist of clays and sandy to silty clays with occasional, thin sand layers. These thin sand units within the clay dominated Formation are not laterally continuous, and generally pinch out within two miles or less (Tech International, 1988). The average thickness of the Patuxent-Arundel in the vicinity of Indian Head is approximately 300 feet.

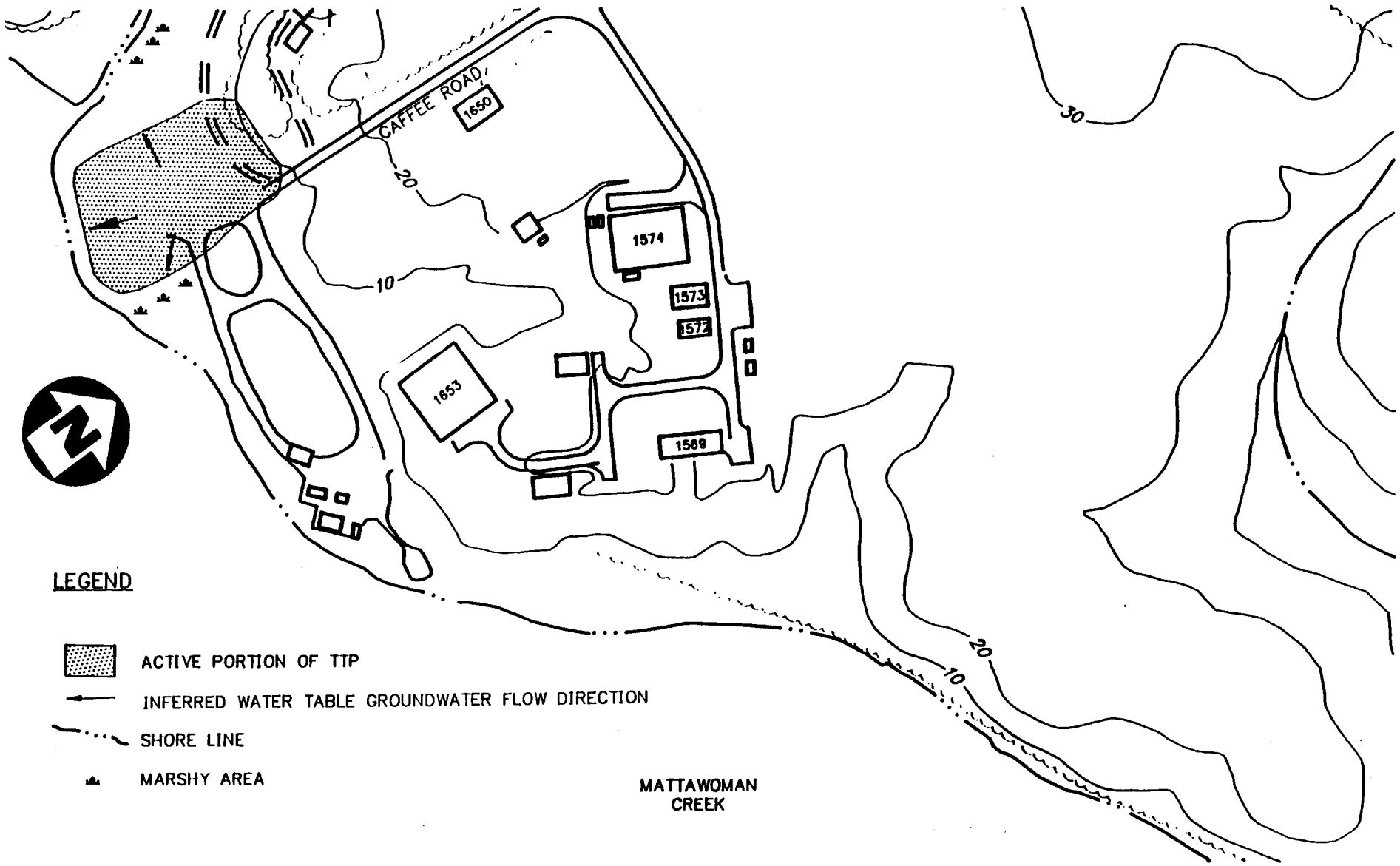

FIGURE 2-3

SITE MAP
CAFFEE ROAD TTP
INDIAN HEAD, MARYLAND

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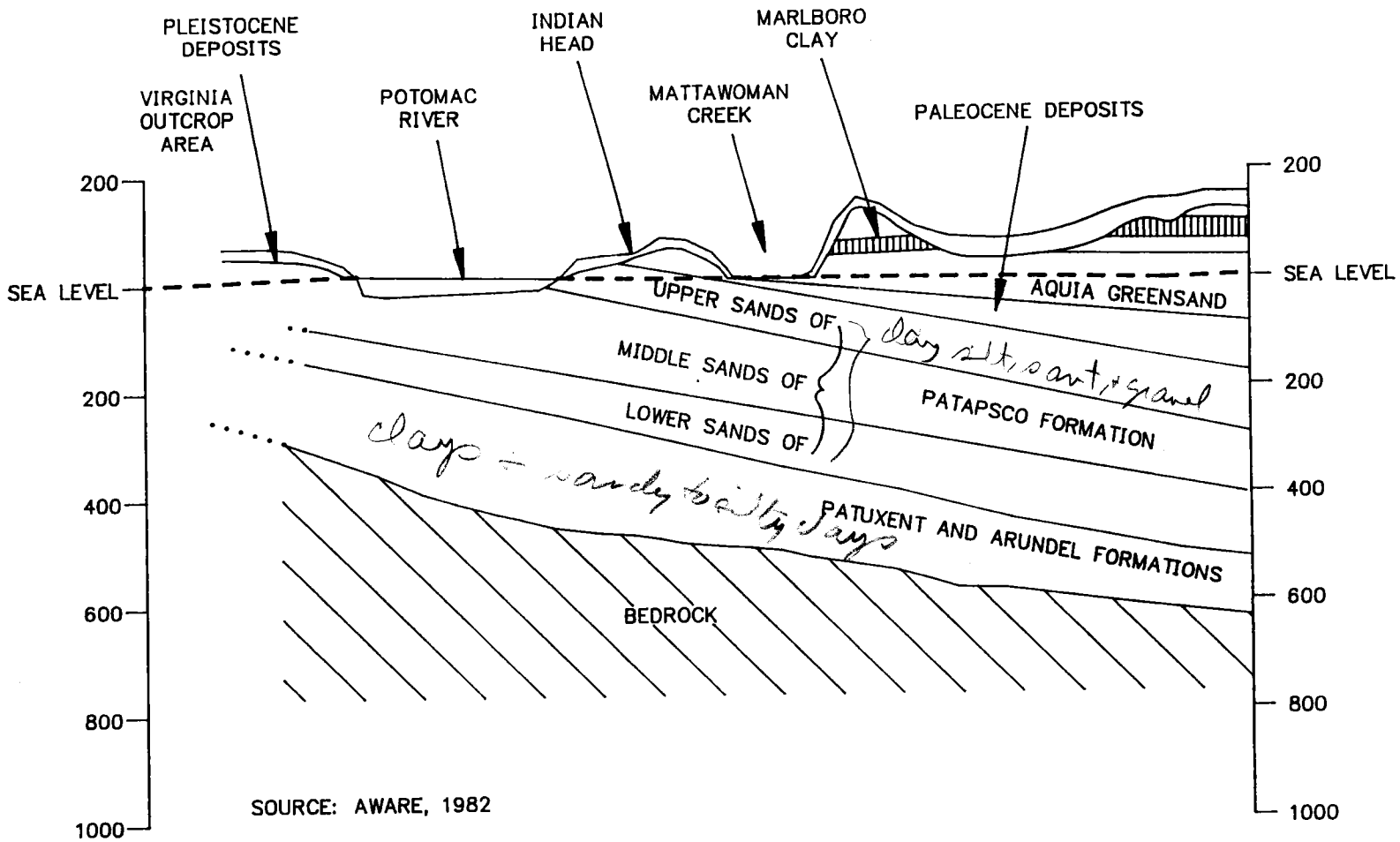

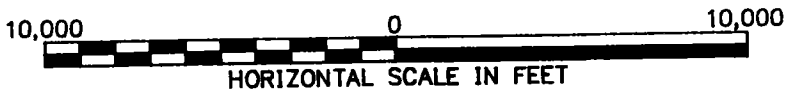

FIGURE 2-4

GENERALIZED CROSS-SECTION OF THE INDIAN HEAD AREA INDIAN HEAD, MARYLAND

HALLIBURTON NUS Environmental Corporation

The Coastal Plain sediments dip to the southeast, at a slope of approximately 50 feet per mile. The total thickness of the Cretaceous units (Patuxent through Patapsco-Arundel Formations) is approximately 500 to 600 feet (Tech International, 1988).

In some areas near the Indian Head peninsula, the Upper Potomac Group sediments were eroded by the ancestral Potomac River system, which deposited paleo-channel and fluvial (river) sediments on top of the Potomac Group. Along the eastern side of the peninsula these Quaternary age fluvial sediments are estimated to extend to approximately 75 feet below sea level (Hiortdahl, 1990). In some areas, the Potomac Group is overlain by younger sedimentary layers which may include the Aquia Greensand, the Columbia Formation, as well as other deposits.

The Coastal Plain sediments are underlain by much older Precambrian bedrock, consisting of igneous and metamorphic crystalline rocks.

2.6 HYDROGEOLOGIC SETTING

2.6.1 Regional Hydrogeology

The Potomac Group aquifer system is the major confined aquifer for the area around Indian Head. It is a multi-aquifer system which contains several confined aquifers within the lower and middle Patapsco group which consist of saturated, poorly consolidated sand and gravel deposits that may range from 1 to 20 feet thick. These water-bearing units are interbedded with clay and fine-grained confining units which confine and isolate the sand units.

Some localized shallow aquifers (i.e., water table aquifers) may exist in the Quaternary fluvial sediments which overlie the Potomac Group, but these units are not used for potable water. (Hiortdahl, 1990).

The Potomac Group produces water of good quality, and has supplied all of the groundwater withdrawn from the 15 production wells in the Indian Head area. The Patapsco Formation contains several water-bearing sand layers, which have been extensively tapped. Three zones within this Formation have been encountered which contain significant permeable units; the Upper Sand, Middle Sand and Lower Sand zones. In the Indian Head area, the Upper Sand zone is thin or absent, and is not a significant water producer. The Middle Sand occurs between 50 and 200 feet below mean sea level, and is not as productive as the Lower Sand zone. The Lower Sand unit generally yields the most water, and is encountered between 200 and 300 feet below mean sea level.

The transmissivity of the Lower Sand zone at the Indian Head area ranges from 270 ft^2/day to 535 ft^2/day, with the combined transmissivity of the entire Patapsco-Raritan Formation estimated at about 1,070 ft^2/day. The clay-rich aquitards of this Formation have very low vertical hydraulic conductivities, in the range of 2×10^{-8} ft/sec to 2×10^{-10} ft/sec (Tech International, 1988). Coefficients of storage for the Patapsco formation range from 0.0004 to 0.0002 ft/ft. The average well yields for wells in this area approximately 250 gpm (Greenhorn and O'Mara, 1990).

The deeper Patuxent Formation contains mostly clay-rich units, although some on-base production wells tap the permeable sand layers which are interbedded with these units. The sand units are not laterally continuous, and most wells find sufficient water yields within the overlying Patapsco Formation.

The NAVSURFWARCEN IHDIV is the largest water user in the Indian Head region, with 15 production wells which together pump over one million gallons per day (gpd). Eight of the production wells are screened exclusively in the Lower Sand zone, with seven wells screened in the Upper and Middle Sand zones as well as the Lower Sand zone. Extensive pumping has occurred at these wells for several decades, and potentiometric water levels around the Indian Head peninsula for the deep aquifer system have declined more than 85 feet over the last 80 to 90 years, due to pumping (Tech International, 1988, Aware, 1982).

Figure 2-5 shows a potentiometric surface map of the area for the lower sand of the Patapsco Formation, and the locations of the on-base production wells. The water level contours show a cone of depression at least 5 miles long and 3 miles wide. The lowered potentiometric surface in the area has induced recharge of the Patapsco Formation with poor-quality water from the Potomac River through the paleo-channel deposits which overlie the Potomac Group, and has increased the vertical gradient from the water table through the confining clay layers (Hiortdahl, 1990). However, the vertical hydraulic conductivities of the thick clay layers within the Patapsco-Raritan Formation are quite low (in the range of 2×10^{-8} ft/sec to 2×10^{-10} ft/sec), and the migration of significant amounts of surface contaminants, if present in the upper portion of the aquifer, into the more productive deeper sand zones is unlikely. – Well drilling

2.6.2 Local Hydrogeology

To date, there have been no hydrogeologic studies performed at the Strauss Avenue or Caffee Road activities, thus the discussion of the local hydrogeology presented here is based on limited site specific information, as well as more available activity-wide information.

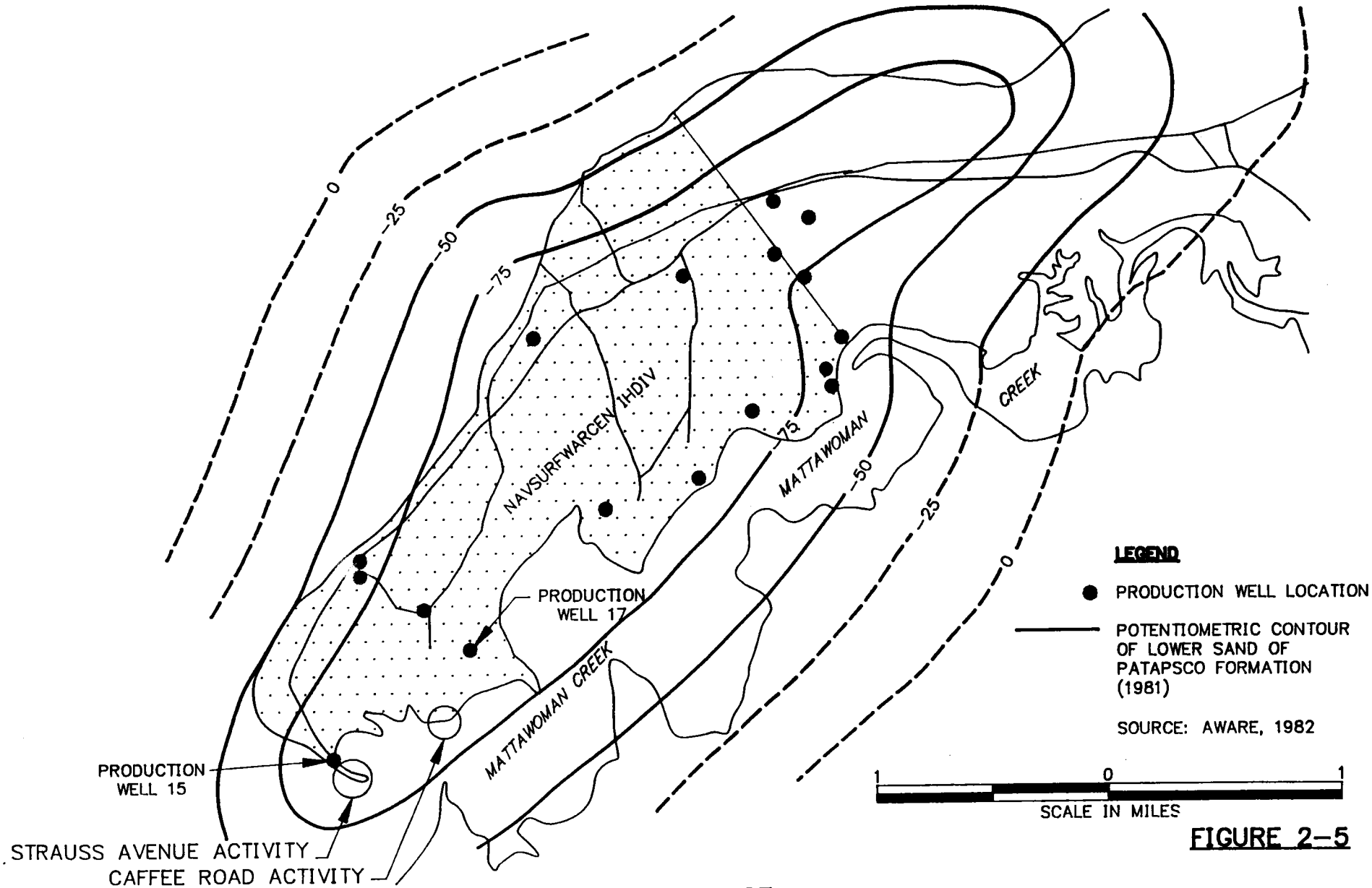

FIGURE 2-5

POTENTIOMETRIC SURFACE MAP OF THE INDIAN HEAD AREA INDIAN HEAD, MARYLAND

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Strauss Avenue Activity

No monitoring wells have been installed at the Strauss Avenue activity, and groundwater elevations have not been measured. Therefore, insufficient data exists to define site-specific groundwater flow directions and gradients. It is anticipated that the groundwater flow direction in the near surface portion of the aquifer in the vicinity of the activity at Strauss Avenue will be dictated by local topography and be towards the adjacent Mattawoman Creek. The activity at the Main Point is located on a peninsula with elevations of up to 7 feet above mean sea level, which is surrounded by Mattawoman Creek near the confluence with the Potomac River. Shallow groundwater would tend to flow towards the bodies of water which surround the site. The expected water level contours at this site should show a concentric mounding pattern with groundwater flowing radially away from the higher elevations on the peninsula. Similarly, shallow groundwater at the Auxiliary Point would be expected to flow away from the higher (central) portion of the smaller peninsula, radially outward towards Mattawoman Creek. Expected groundwater flow directions are illustrated in Figure 2-2.

Currently, production well 15 (Cb 9) is being taken out of service (due to the age of the well) and is being replaced by new production well in the immediate vicinity. Well 15 is the closest production well to SATTP, located approximately 1,300 feet from the SATTP Main Point area, and approximately 2,400 feet from the CRTTP (see Figure 2-5). The new well is screened in four sand layers within the Patapsco Formation, at 190 to 195 feet, 222 to 232 feet, 237 to 242 feet, and 263 to 269 feet. Water obtained from this well will be used by the base power plant for steam generation. Production yields for this well are not established, although the yields will most likely be similar to the older well in the vicinity, approximately 220 gpm. Therefore, pumping activities from this new well are not expected to cause an additional decrease in the potentiometric surface in the area. Also, due to the depth of the screened intervals (190 to 269 feet) and the low vertical hydraulic conductivities of the aquitards in the area, the effects on the near-surface aquifer are expected to be minimal.

Caffee Road Activity

There are no monitoring wells in the vicinity of the Caffee Road site, and direct measurements of groundwater elevations in the area are not possible. However, groundwater flow in the near-surface portion of the aquifer will most likely be dictated by local topography. The expected water level contours specific to this site would show a flow pattern moving southwest down the hill at the base of Caffee Road, towards Mattawoman Creek. Expected groundwater flow directions are illustrated in Figure 2-3. Some

components of groundwater flow are also likely to be moving towards marshy areas, to the northwest and southeast of the site.

3.0 FIELD OPERATIONS

3.1 FIELD OPERATIONS SUMMARY

The field investigation to be performed at NAVSURFWARCEN IHDIV will consist of multimedia environmental sampling at the Strauss Avenue and Caffee Road Thermal Treatment Points. Activities to be conducted at Strauss Avenue TTP include drilling and sampling of 15 soil borings, including installation of 14 monitoring wells, and 1 piezometer. Seven surface water and sediment samples and 1 surface soil sample will be taken at Strauss Avenue TTP, and one staff gauge will be installed. At the Caffee Road TTP, eight soil borings will be completed and six monitoring wells will be installed. One surface soil sample, three surface water and sediment samples will be taken at Caffee Road, and one staff gauge will be installed. Sampling activities are summarized in Table 3-1.

3.2 MOBILIZATION/DEMOBILIZATION

Following approval of the Work Plan, the contractor will prepare drilling specifications, obtain a drilling subcontractor, and begin mobilization activities. All field team members will review the Work Plan, Health and Safety Plan (HASP) and Quality Assurance/Quality Control (QA/QC) Plan. In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

The Field Operations Leader (FOL) will coordinate the mobilization activities upon arrival at the facility. The FOL will also make any equipment purchases required to conduct the field investigation. The equipment required for the field activities will be driven to the site by the FOL and a technician/geologist. After field activities are completed, the FOL will demobilize the equipment.

3.3 BOREHOLE DRILLING

WHAT ABOUT REMOTE DRILLING

Borehole drilling will be conducted to characterize any surface and subsurface soil contamination which may be present, and for the installation of monitoring wells and piezometers. A total of 15 soil borings will be installed at Strauss Avenue and will be converted to 14 monitoring wells and 1 piezometer; 8 will be located on the Main Point, and 7 will be located at the Auxiliary point. Soil boring locations were chosen to determine if any contamination is present in the immediate vicinity of the burn pans at these sites. Eight soil borings will be installed at the Caffee Road site to determine if contamination is present in the central

TABLE 3-1

SAMPLING PLAN FOR
STRAUSS AVENUE AND CAFFEE ROAD TTPs
INDIAN HEAD, MARYLAND

Site	Soil Borings	Monitoring Wells[1]	Piezometers	Surface Water Samples	Sediment Samples	Surface Soil Samples[3]	Staff Gauges
Strauss Avenue							
Main Point	8	8	0	4	4	0	1
Auxiliary Point	7	6	1	3	3	1	0
Caffee Road	8	6	0	4 [2]	4 [2]	1	1

(1) Including one background well at each site.

(2) Includes one background sample from Mattawoman Creek upstream of Caffee Road.

(3) Background sample.

(active) portion of the TTP, or in the area surrounding the site. Six soil borings will be converted to monitoring wells. The proposed locations for soil borings at the two sites are shown on Figures 3-1 and 3-2.

The hollow stem auger drilling method is the preferred method for advancing the soil borings. During drilling operations of overburden material, Standard Penetration Tests and split-spoon sampling shall be performed. Soil samples for chemical analysis will be collected near ground surface and directly above the water table. The use of drilling fluids is prohibited during soil boring activities. Drilling will be done in accordance with HALLIBURTON NUS SOP GH-1.4, Section 5.

HOW IF WE FIND TUN[illegible] SANDS!

A lithologic description will be made of each split-spoon sample and a complete log of each boring will be maintained, in accordance with HALLIBURTON NUS SOP GH-1.5, Sections 5.2, 5.4, and 5.5. A sample boring log is attached in Appendix A. At a minimum, the boring log will contain the following information:

- Sample numbers and types
- Sample depths
- Standard Penetration Test data
- Sample recovery/sample interval
- Soil density or cohesiveness
- Soil color and moisture
- Unified Soil Classification System (USCS) material description and symbol

In addition, depths of changes in lithology, depth to water, OVA/HNu readings, drilling methods, and total depth of each borehole ~~should~~ SHALL be included on each boring log. Each soil sample collected for lithologic description will be placed in an 8-ounce glass jar (to be provided by the drilling subcontractor), labeled, and the pertinent data recorded by the field geologist. The driller shall prepare a separate written boring log for each boring drilled, to be submitted to the field geologist at the conclusion of the field activities.

3.4 SURFACE/SUBSURFACE SOIL SAMPLES

Soil samples will be collected from the well borings every 2 feet, and at least from the 0.0- to 1.0-foot interval, and from directly above the water table. Due to the assumed close proximity of the water table to ground surface, it is estimated that three samples will be taken from each boring~~s~~ at the SATTP Main Point and CRTTP, while two samples will be retrieved from each boring~~s~~ at the SATTP Auxiliary Point. The split-spoon samplers will have a minimum outside diameter of 3 inches and will be at least 2 feet long to fulfill the sample volume requirements for chemical analysis. The use of drilling fluids is prohibited during soil boring activities.

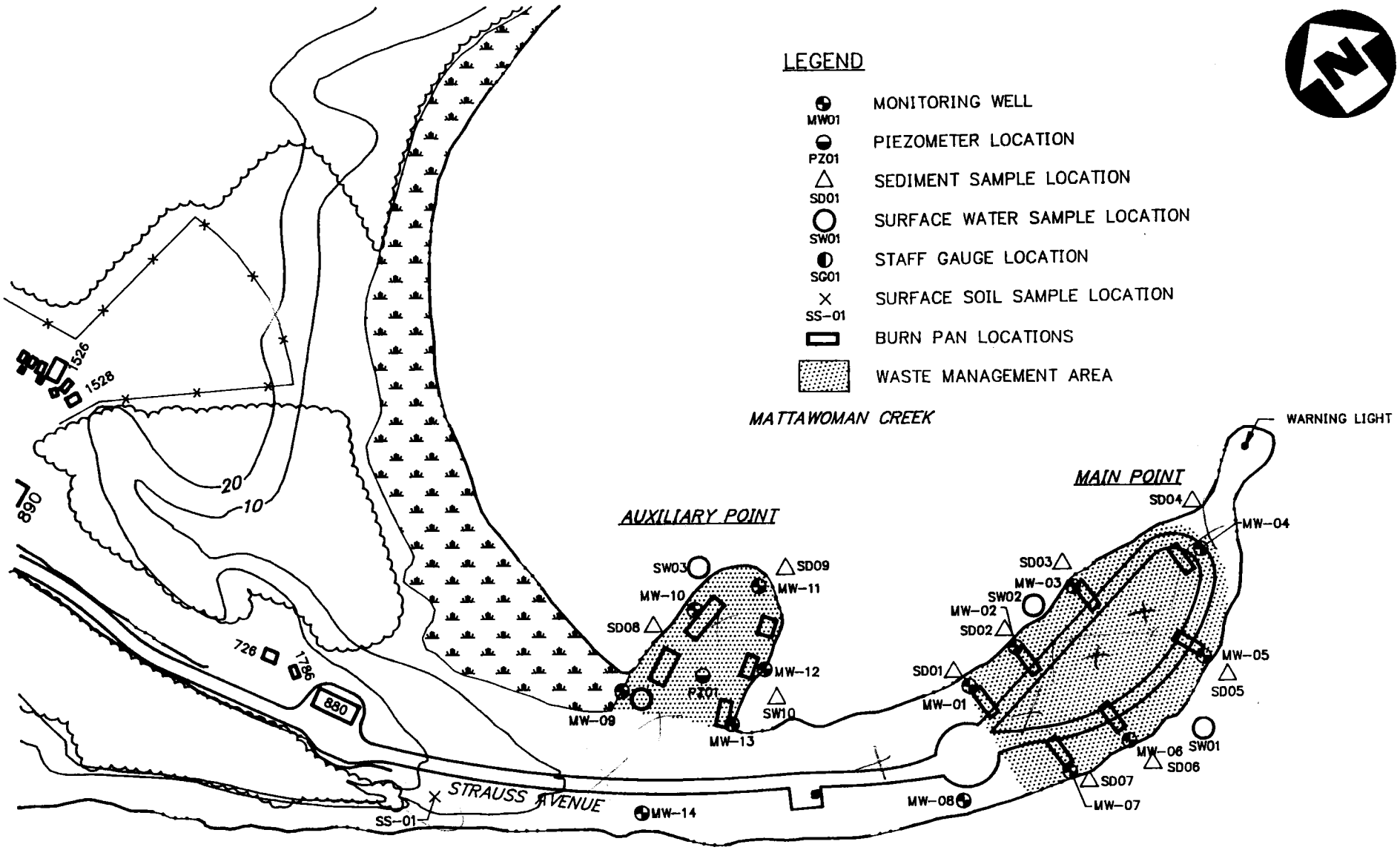

FIGURE 3-1

STRAUSS AVENUE SAMPLING LOCATIONS
INDIAN HEAD, MARYLAND

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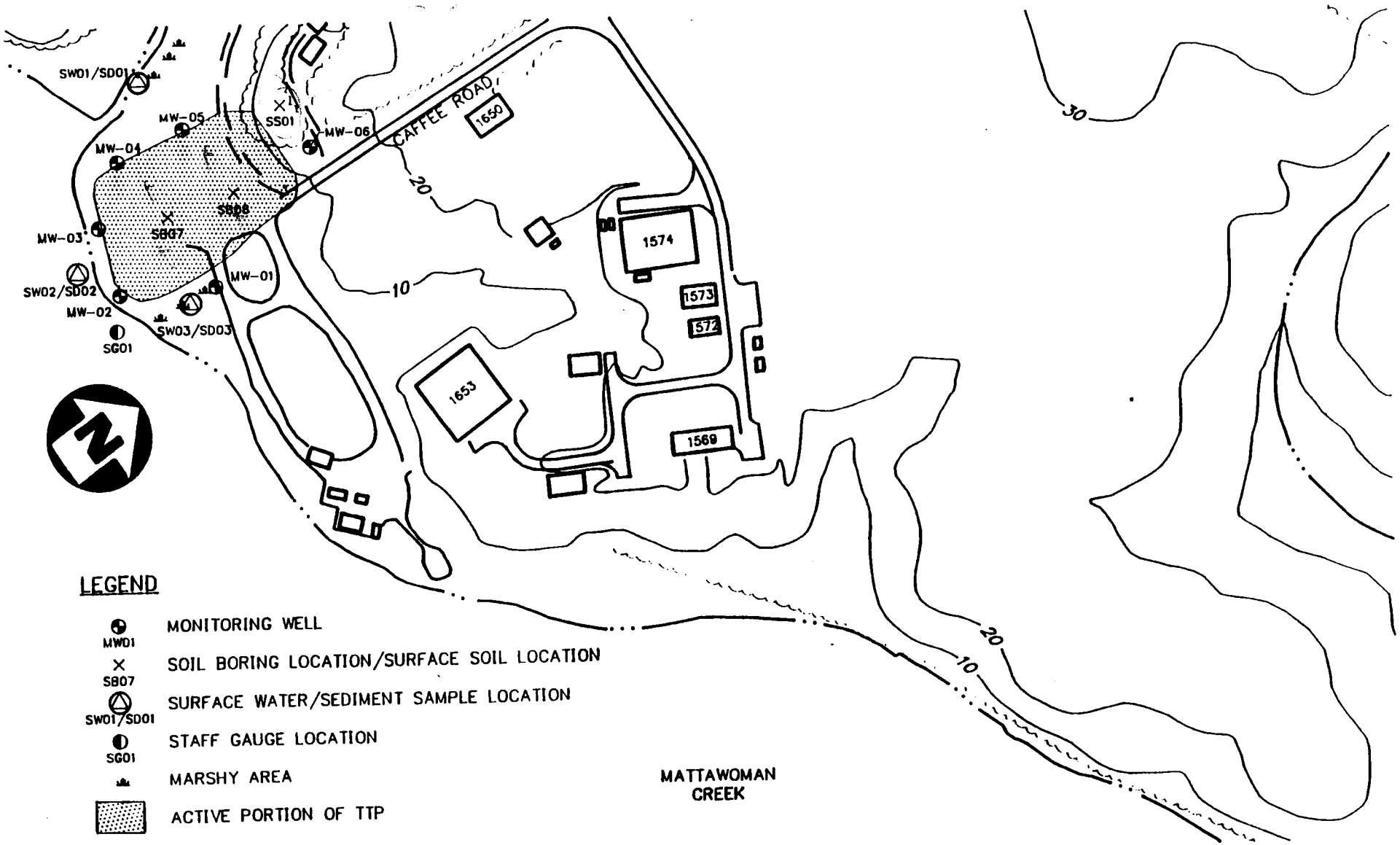

FIGURE 3-2

CAFFEE ROAD SAMPLING LOCATIONS
INDIAN HEAD, MARYLAND

HALLIBURTON NUS
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D49-8-92-2

3.4.1 Background Soil Sample Locations

Background surface soil samples will be collected in the vicinity of each of the two TTPs. At Strauss Avenue, one sample (SA-SS01) will be collected from the west side of Strauss Avenue, as shown in Figure 3-1. At Caffee Road, one background soil sample (CR-SS01) will be collected from north of the site, as shown in Figure 3-2. Background soil samples will be taken at locations which have not likely been affected by site activities, which are relatively undisturbed, and which represent soil characteristics in the immediate vicinity of the TTPs. The soil samples will be collected at approximately 6 inches below ground surface and will be taken below any horizon dominated by plant roots.

All samples obtained from the boreholes shall be monitored with an organic vapor monitor. The samples from each boring will be analyzed for nitroaromatics, propellants, metals, Total Petroleum Hydrocarbons (TPH), cyanide, indicator parameters, and 40 CFR 264 Appendix IX volatiles, semi-volatiles, and pesticides/PCBs. Analytes included in Appendix IX analysis are listed on Table 3-2. Sampling procedures and analytes for surface/subsurface soil samples are detailed in Section 4.2.2.

3.5 MONITORING WELL CONSTRUCTION/INSTALLATION

At Strauss Avenue TTP, 14 monitoring wells will be installed to detect any contamination in the soil or groundwater in the vicinity of the TTP. Eight soil borings will be converted to flush-mount monitoring wells at the Main Point, and six soil borings will be converted to flush-mount monitoring wells at the Auxiliary Point. The remaining soil boring at the Auxiliary Point will be converted to a piezometer. This piezometer will provide additional groundwater elevation data and will serve to further define near-surface groundwater flow at the Auxiliary Point. Due to safety considerations concerning drilling operations in areas where former burning activities have occurred (i.e. the central portion of the Main Point), no piezometer will be installed at the main point. Monitoring well and piezometer locations for the Strauss Avenue site are shown in Figure 3-1. At Caffee Road, six of the eight soil borings will be converted to stickup monitoring wells. Monitoring wells and piezometers will not be installed in the central (active) portion of the Caffee Road site due to the use of large machinery and equipment during thermal treatment activities in this area. Monitoring well locations for the Caffee Road site are shown in Figure 3-2.

The monitoring wells for both Thermal Treatment Points will be located immediately adjacent to the OB activities at the TTPs, and will determine if near-surface groundwater contamination exists in the vicinity of these sites. In addition, these monitoring wells will provide a system for detecting any future groundwater contamination. One monitoring well at each TTP (3 total) will be located up gradient of the treatment

TABLE 3-2

CFR 40, Subpart 264, Appendix IX Compound list

Volatiles	Semivolatiles	Semivolatiles	Pesticides/PCBs	Energetics/Metals
Acetone	Acenaphthene	2,4-Dinitrophenol	Aldrin	Cyclomethylenetetranitramine
Benzene	Acenaphthylene	2,4-Dinitrotoluene	α-BHC	Cyclotrimethylenetrinitramine
Bromodichloromethane	Anthracene	2,6-Dinitrotoluene	ß-BHC	1,3-Dinitrobenzene
Bromoform	Benzo(a)anthracene	Di-n-octylphthalate	δ-BHC	2,4-Dinitrotoluene
Bromomethane	Benzo(a)pyrene	Fluoranthene	γ-BHC	2,6-Dinitrotoluene
2-Butanone	Benzo(b)fluoranthene	Fluorene	Chlordane (total)	Nitrobenzene
Carbon tetrachloride	Benzo(g,h,i)perylene	Hexachlorobenzene	γ-Chlordane	1,3,5-Trinitrobenzene
Carbon disulfide	Benzo(k)fluoranthene	Hexachlorobutadiene	Dieldrin	Trinitrophenylmethylnitramine
Chlorobenzene	bis(2-ethylhexyl)phthalate	Hexachlorocyclopentadiene	4,4'-DDD	2,4,6-Trinitrotoluene
Chloroethane	Benzoic acid	Hexachloroethane	4,4'-DDE	
Chloroform	Benzyl alcohol	Indeno(1,2,3-cd)pyrene	4,4'-DDT	Aluminum
Chloromethane	bis(2-Chloroethoxy)methane	Isophorone	α-Endosulfan	Antimony
Dibromochloromethane	bis(2-Chloroethyl)ether	2-Methylnaphthalene	ß-Endosulfan	Arsenic
1,2-Dichloroethane	4-Bromophenyl phenyl ether	2-Methylphenol	Endosulfan sulfate	Barium
1,1-Dichloroethene	4-Chloro-3-methylphenol	4-Methylphenol	Endrin	Beryllium
1,2-Dichloroethene (total)	4-Chloroaniline	N-nitroso-di-n-propylamine	Endrin ketone	Cadmium
1,2-Dichloropropane	2-Chloronaphthalene	N-nitrosodiphenylamine	Heptachlor	Calcium
cis-1,3-Dichloropropene	2-Chlorophenol	Naphthalene	Heptchlor epoxide	Chromium
trans-1,3-Dichloropropene	4-Chlorophenyl phenyl ether	2-Nitroaniline	Methoxychlor	Cobalt
Ethylbenzene	Chrysene	3-Nitroaniline	Toxaphene	Copper
2-Hexanone	Di-n-butyl phthalate	4-Nitroaniline		Iron
Methylene chloride	Dibenzo(a,h)anthracene	Nitrobenzene	Aroclor 1016	Lead
4-Methyl-2-pentanone	Dibenzofuran	2-Nitrophenol	Aroclor 1221	Magnesium
Styrene	1,2-Dichlorobenzene	4-Nitrophenol	Aroclor 1232	Manganese
1,1,2,2-Tetrachloroethane	1,3-Dichlorobenzene	Pentachlorophenol	Aroclor 1242	Mercury
Tetrachloroethene	1,4-Dichlorobenzene	Phenanthrene	Aroclor 1248	Nickel
Toluene	3,3'-Dichlorobenzidine	Phenol	Aroclor 1254	Potassium
1,1,1-Trichloroethane	2,4-Dichlorophenol	Pyrene	Aroclor 1260	Selenium
1,1,2-Trichloroethane	Diethyl phthalate	1,2,4-Trichlorobenzene		Silver
Trichloroethene	Dimethyl phthalate	2,4,5-Trichlorophenol		Sodium
Vinyl acetate	2,4-Dimethylphenol	2,4,6-Trichlorophenol		Thallium
Vinyl chloride	4,6-Dinitro-2-methylphenol			Vanadium
Xylenes (total)				Zinc

activities. These upgradient wells (SA-MW08, SA-MW14 and CR-MW06) will provide background groundwater quality of the water table system at for each site and will serve as additional groundwater elevation data points.

Due to safety considerations, wells installed at the Strauss Avenue TTP will be flush mounted with protective casing finished at ground level. To prevent damage to monitoring wells from heat generated during the treatment activities at the TTPs, monitoring wells installed at both sites will be constructed of stainless steel, and will utilize non-plastic riser caps. These riser caps will be sealed to prevent water from entering the monitoring wells during any flood events which may occur.

All monitoring wells will be constructed of 2-inch I.D. standard strength stainless steel flush-joint riser pipe and flush-joint factory slotted well screen. Well screen slots shall be no larger than 0.02 inches. Figures 3-3 and 3-4 illustrate typical well construction details for flush mount and stickup monitoring wells.

Well screens will be 10 feet in length. Total well depth will be approximately 10 to 15 feet below ground surface. When possible, the top of the screened interval will be positioned approximately 2 feet above the stabilized water level in the boring. The installation of flush mount wells at Strauss Avenue TTP may prevent the well screen from being emplaced above the water table, due to the close proximity of the water table to ground surface. After the borings are drilled to the desired depth (6-inch minimum diameter boring), the well screen and riser pipe will be installed through the augers or temporary casing to the desired depth. The annulus of the boring around the well screen, and 2 to 3 feet above the well screen, will be backfilled with clean silica sand (No. 20 to 30 U.S. Standard Sieve size or as determined by the site geologist). A bentonite pellet seal with 2-foot minimum thickness for stick-up wells and 1-foot minimum thickness for flush mount wells will then be installed above the sand pack and allowed to hydrate as per the manufacturer's recommendations. The remainder of the boring annulus, from the seal to the ground surface, will then be backfilled with cement/bentonite grout placed using a tremie pipe. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless steel or plastic tape. A monitoring well construction form will be completed for each well installed. Sample well construction forms for flush mount and stickup wells are attached in Appendix A.

A 6- to 8-inch-diameter protective steel casing equipped with a locking steel cap will be installed around each well. For stickup wells, these casings will be grouted a minimum of three feet into the ground and will have at least one drain hole positioned approximately 0.5 feet above the ground surface. A 0.5-foot thick concrete apron measuring 2 feet by 2 feet will be constructed equally portioned around the casing of each well. Flush mount wells will be grouted from the top of the bentonite seal to 4 to 5 inches below ground surface, and will have protective steel casing and cap finished at or near ground surface. Flush mount wells

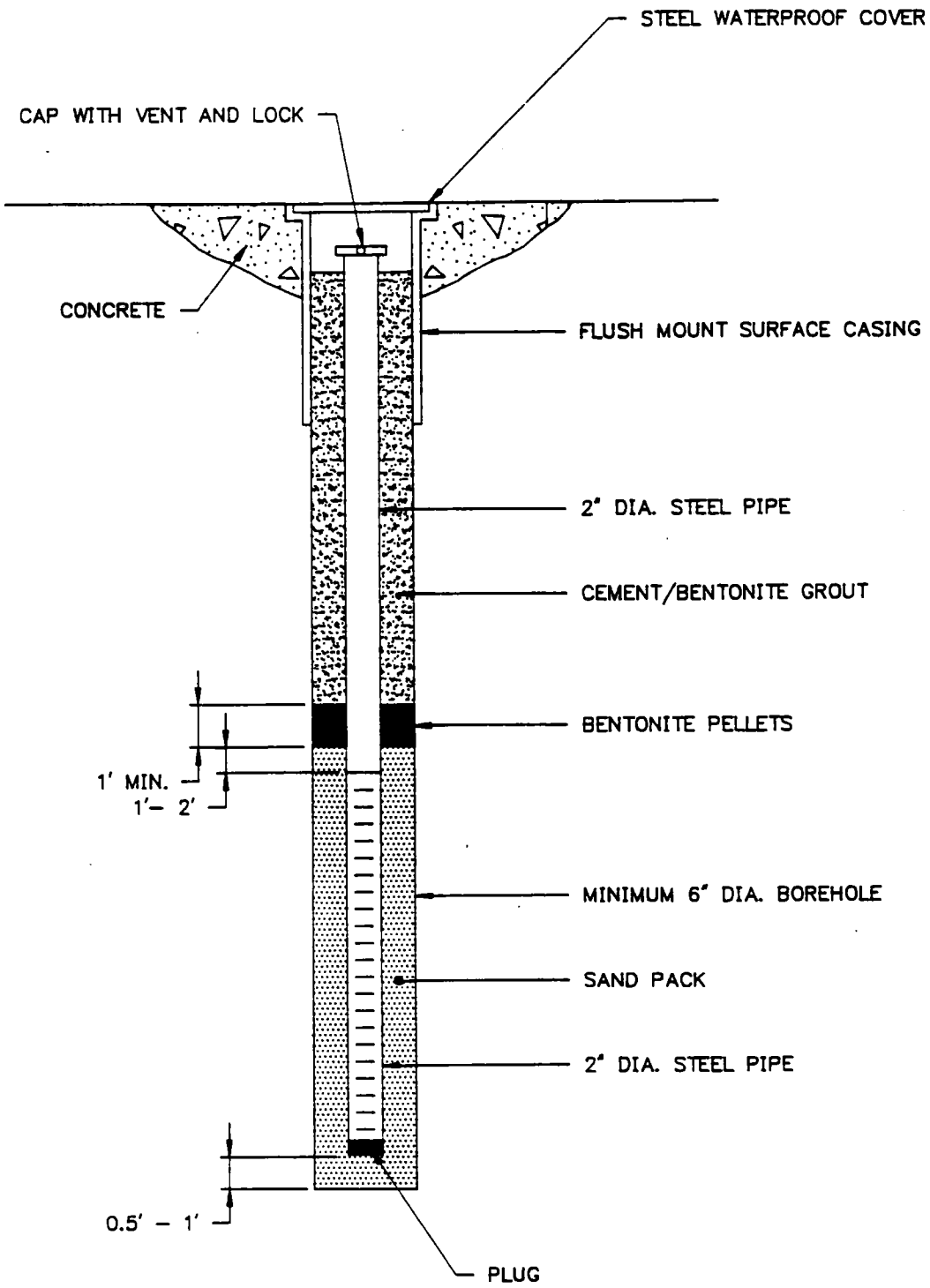

FIGURE 3-3

DETAIL OF TYPICAL WELL
WITH FLUSH MOUNT
INDIAN HEAD, MARYLAND

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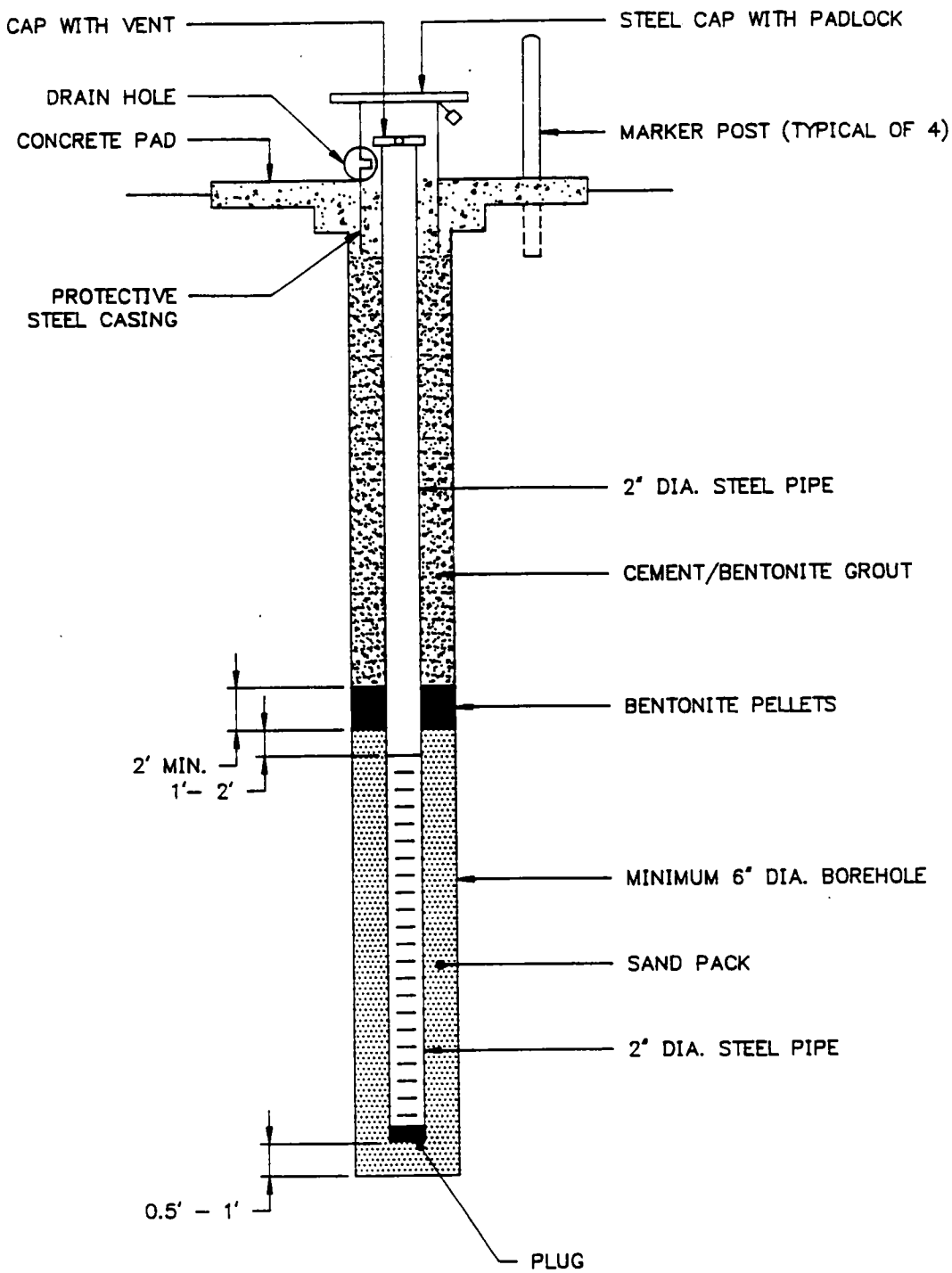

FIGURE 3-4

DETAIL OF TYPICAL STICKUP WELL
INDIAN HEAD, MARYLAND

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will have a protective sleeve with a manhole-type lid, and will be finished with a slightly mounded concrete pad for protection from erosion during flooding. Upon completion of groundwater sampling from monitoring wells, the protective casing will be painted glow-orange. All monitoring wells will be locked and will be keyed alike.

3.5.1 Well Development

The monitoring wells will be developed after installation to remove fine material and sediments from the area around the well screens and to remove drill cuttings and residual fluids from the area around the monitored interval of the boring. Wells will be developed by bailing and surging, or by pumping, as determined by the field geologist. Wells will be developed until water removed is visibly clear of suspended solids or until approved by the field geologist.

3.5.2 Water Level Measurements

One complete round of water level measurements will be obtained from all new monitoring wells. At each site, the round of water level measurements will be taken within a 2-hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Measurements will be taken with an electronic water level indicator using a marked or notched location on the top of the well casing as the reference point for determining depths to water. Water-level measurements will be recorded to the nearest 0.01 foot in the appropriate field logbook and on water level measurement forms (attached in Appendix A).

3.5.3 Aquifer Testing

Monitoring wells will be used for aquifer testing to determine the groundwater flow conditions in the water-bearing zone investigated by each well. The data generated from these tests will be used to define the water-yielding characteristics of the formation, develop groundwater velocity values, and estimate rate of groundwater movement for the aquifer in the vicinity of the monitoring wells that are tested.

In-situ hydraulic conductivity testing (slug tests) will be performed at several newly installed monitoring wells. Due to the proximity of the proposed monitoring wells to each other, and the similar depth of the wells, the slug testing of all monitoring wells will not be necessary. Each newly installed background well (SA-MW08, SA-MW014, and CR-MW06) will be slug-tested and a half of the newly installed monitoring wells (nine total) at the Main Point, Auxiliary Point, and Caffee Road will be slug-tested. The site geologist will determine in the field which of the wells at each TTP will be slug tested.

Procedures for performing slug tests will be in accordance with HALLIBURTON NUS SOP GH-2.4, attached in Appendix B. Pressure transducers and data loggers will be used for data collection to obtain sufficiently accurate field data. Random checks of water levels will be made manually using a M-Scope or equivalent device. At a minimum, the following information will be collected for each well during slug tests:

- Well number/depth/screened interval/inside diameter of the screen/diameter of the sand pack.
- Static water level.
- Method of including water-level change.
- Time/recovery data.
- Total time of test.

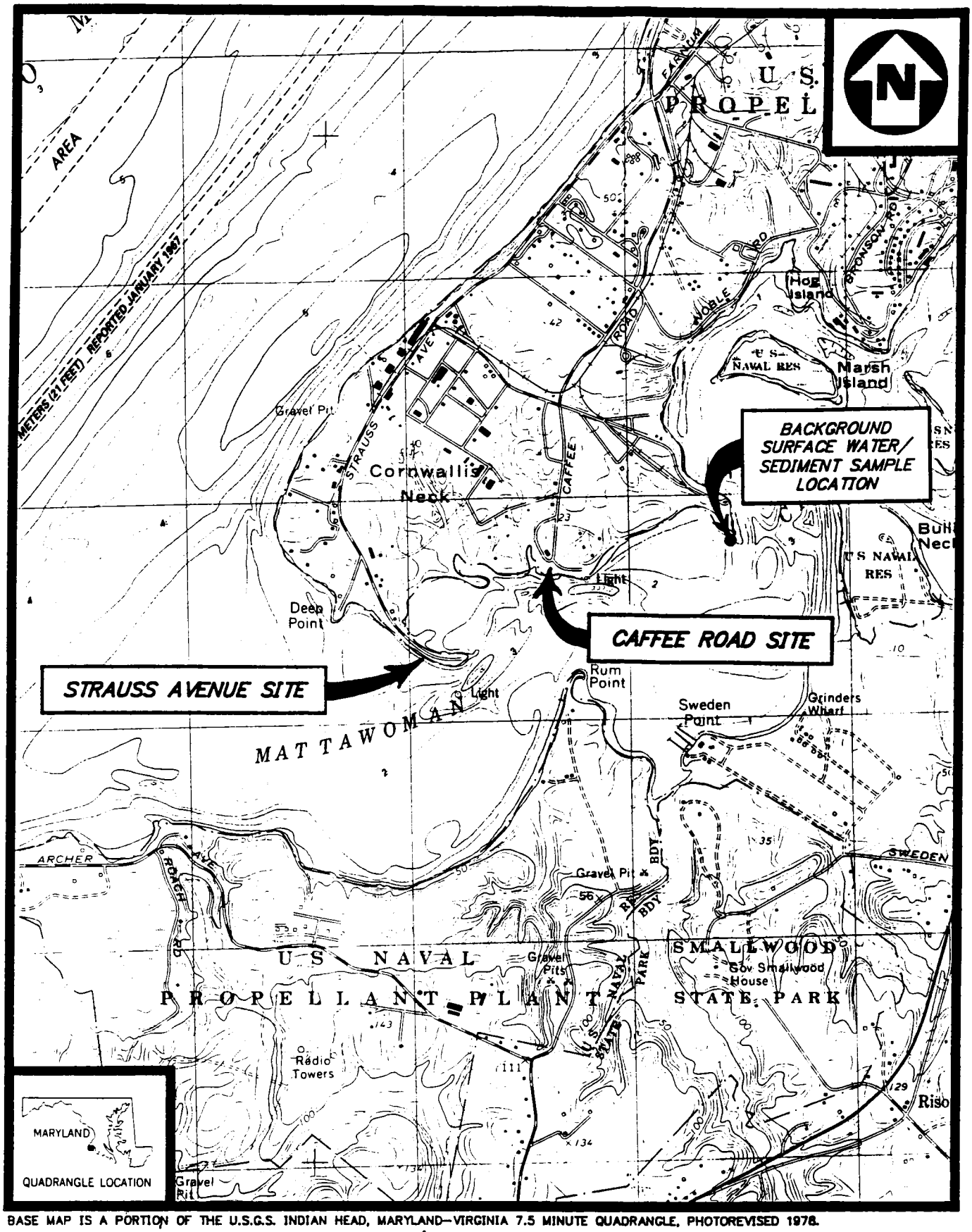
Data recorded during slug test will be recorded on the hydraulic conductivity form attached in Appendix A.

3.6 SURFACE WATER/SEDIMENT SAMPLES

Surface water is in close proximity to both the Strauss Avenue TTP and the Caffee Road TTP. Any surface runoff from these sites will flow directly into Mattawoman Creek. A total of three surface water samples will be obtained from Mattawoman Creek in the vicinity of the Strauss Avenue site, one from east and west side of the Main Point (two total), and one will be collected from the west side of the Auxiliary Point peninsula. At the Caffee Road site, three surface water samples will be taken, one from the wetlands to the south which receives surface drainage from the site, one from Mattawoman Creek immediately adjacent to the site, and one from the wetlands to the north. Sample locations are presented in Figures 3-1 and 3-2. Surface water samples will be analyzed for nitroaromatics, propellants, metals, cyanide, indicator parameters, TPH, and Appendix IX volatiles, semi-volatiles, and pesticides/PCBs. Section 4.2.3 details the sampling procedures for the surface waters.

Ten sediment samples will be obtained during the investigation of Strauss Avenue TTP. At the Main Point, one sediment sample will be collected from the vicinity of each burn pan. While at the Auxiliary Point, one sediment sample will be collected from each of the three sides of the Peninsula. Three sediment samples will be obtained from the same locations as the surface water samples at the Caffee Road site. Sediment sample locations are presented in Figure 3-1 and 3-2.

One background surface water and one back- diment sample will be taken from Mattawoman Creek, upstream from the Strauss A TTPs. These background samples will represent the chemical charac from an area not affected by activities at the Thermal Tr shown in Figure 3-5.



BASE MAP IS A PORTION OF THE U.S.G.S. INDIAN HEAD, MARYLAND–VIRGINIA 7.5 MINUTE QUADRANGLE, PHOTOREVISED 1978.

BACKGROUND SURFACE WATER/SEDIMENT SAMPLING LOCATION INDIAN HEAD, MARYLAND

FIGURE 3–5

0 2000 4000
SCALE IN FEET

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All sediment samples will be analyzed for nitroaromatics, propellants, metals, mercury, cyanide, indicator parameters, TPH, Appendix IX volatiles, semi-volatiles, and pesticides/PCBs. Section 4.2.2 details the sampling procedures for sediments.

3.7 STAFF GAUGE INSTALLATION

Staff gauges will be installed at Strauss Avenue (SA-SG01) and at Caffee Road (CR-SG01) to determine the surface water elevation of Mattawoman Creek immediately adjacent to the Thermal Treatment Points. Metal gauges, with marked 0.1-foot increments will be installed in Mattawoman Creek in the vicinity of each TTP. The top of each staff gauge will be surveyed after installation. These gauges will not interfere with activities at the TTPs, and will be tall enough to record high water elevations. Refer to Figures 3-1 and 3-2 for specific locations.

3.8 SURVEYING

All monitoring wells, piezometers, and staff gauges will be surveyed following installation. Existing survey monuments within NAVSURFWARCEN IHDIV may be utilized as reference points.

The horizontal locations of all monitoring wells, piezometers, and staff gauges will be surveyed to the nearest 0.01 foot. Vertical elevations will be referenced to the 1929 North American Datum. For monitoring wells the elevation shall be surveyed to the nearest 0.01 foot at the measuring point where the uncapped riser pipe is notched. Ground surface elevations will also be surveyed to the nearest 0.01 foot. The top of the staff gauge will be surveyed for reference elevation.

3.9 DECONTAMINATION

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

3.9.1 Major Equipment

All downhole drilling equipment and sampling tools shall be steam cleaned prior to beginning work, between well borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program. In addition, well casing and screens shall be steam cleaned prior to being installed into the borings.

These decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place at a location determined during mobilization. It is assumed that the base will provide a suitable location for decontamination operations along with potable water and electricity. Additional requirements for drilling equipment decontamination can be found in HALLIBURTON NUS SOP GH-1.6: Section 5.

3.9.2 Sampling Equipment

All equipment used for collecting samples will be decontaminated both prior to beginning field sampling and between samples. The following decontamination steps will be taken:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Distilled/deionized water rinse
- Nitric acid rinse
- Distilled/deionized water rinse
- Methanol double rinse
- Distilled/deionized water rinse
- Air dry

Field analytical equipment such as pH, conductivity and temperature instrument probes will be rinsed first with analyte-free water, then with the sample liquid. Decontamination of sampling equipment will be done in accordance with NUS SOP SF-2.3, Section 5. HALLIBURTON NUS will provide all decontamination fluids except potable water for rinsing.

3.10 WASTE HANDLING

All development and purge liquids will be collected, containerized, and stored on site in DOT approved (Specification 17-C), 55-gallon drums (provided by the Drilling Subcontractor). All drill cuttings will also be collected and stored on site in the DOT approved drums. All drums will be sealed and labeled with site location, drum contents, well/boring number, and date. NAVSURFWARCEN IHDIV will take possession of the drums upon project completion, provide a storage area for these drums, and will determine whether offsite disposal and/or treatment is required after receiving analytical results from the sampling.

4.0 ENVIRONMENTAL SAMPLING

4.1 SAMPLE ANALYSIS SUMMARY

Samples collected at the site will be submitted for the laboratory analyses presented in Tables 4-1, 4-2, 4-3, 4-4 and 4-5. These tables indicate the analytical parameters, preservation methods, holding times, bottle requirements, and analytical methods for each sample.

4.2 SAMPLING PROCEDURES

This section discusses the procedures for performing environmental sampling at the Strauss Avenue and Caffee Road Thermal Treatment Points. Sampling to be performed includes groundwater, surface soil, subsurface soil, surface water and sediment.

4.2.1 Groundwater Sampling

Groundwater samples will be obtained from the fourteen newly installed groundwater monitoring wells at SATTP (wells SA-MW01 through SA-MW14). Six groundwater wells (CR-MW01 through CR-MW06) will be sampled at CRTTP. Groundwater sampling will be conducted in accordance with HALLIBURTON NUS SOP SA-1.1.

Prior to obtaining samples, water levels will be measured and the wells will be purged using a dedicated bailer or a suction pump. Approximately three to 6 well volumes will be purged. If the wells are purged dry with less than 3 well volumes removed, the water level in the well will be allowed to recover to at least 70 percent of the original level prior to sampling. In the event that recovery is slow, samples will be collected within 24 hours of purging. Field measurements of pH, temperature, and specific conductance will be taken for each well volume during purging according to HALLIBURTON NUS SOP SF-1.1, Section 5. Stabilization of the above parameters is defined as follows: temperature $\pm$ 1°C, pH $\pm$ 0.2 units, SC $\pm$5 percent. If these parameters do not stabilize after 3 volumes, up to 6 volumes may be removed, as determined by the field geologist. Dedicated stainless steel or disposable PVC bailers with dedicated polyethylene rope as bailing line will be used for sample collection.

TABLE 4-1

GROUNDWATER SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD INDIAN HEAD, MARYLAND

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Groundwater	Nitroamines: [5]	UW25-HPLC	14/6	0/0	2/1	0/0	1/1	17/8
	Explosives: [6] nitrocellulose	UFO5	14/6	0/0	2/1	0/0	1/1	17/8
	nitroglycerine	UW27	14/6	0/0	2/1	0/0	1/1	17/8
	nitroguanidine	UW29	14/6	0/0	2/1	0/0	1/1	17/8
	Dissolved Metals: aluminum	EPA 200.7	14/6	0/0	2/1	0/0	1/1	17/8
	antimony	EPA 204.2	14/6	0/0	2/1	0/0	1/1	17/8
	arsenic	EPA 206.2	14/6	0/0	2/1	0/0	1/1	17/8
	barium	EPA 208.1	14/6	0/0	2/1	0/0	1/1	17/8
	beryllium	EPA 210.1	14/6	0/0	2/1	0/0	1/1	17/8
	cadmium	EPA 213.1	14/6	0/0	2/1	0/0	1/1	17/8
	chromium	EPA 218.1	14/6	0/0	2/1	0/0	1/1	17/8
	cobalt	EPA 219.1	14/6	0/0	2/1	0/0	1/1	17/8
	copper	EPA 220.1	14/6	0/0	2/1	0/0	1/1	17/8
	lead	EPA 239.1	14/6	0/0	2/1	0/0	1/1	17/8
	mercury	EPA 245.1	14/6	0/0	2/1	0/0	1/1	17/8
	nickel	EPA 249.1	14/6	0/0	2/1	0/0	1/1	17/8
	selenium	EPA 270.2	14/6	0/0	2/1	0/0	1/1	17/8
	silver	EPA 272.1	14/6	0/0	2/1	0/0	1/1	17/8
	thallium	EPA 279.1	14/6	0/0	2/1	0/0	1/1	17/8
	tin	EPA 282.1	14/6	0/0	2/1	0/0	1/1	17/8
	vanadium	EPA 286.1	14/6	0/0	2/1	0/0	1/1	17/8
	zinc	EPA 289.1	14/6	0/0	2/1	0/0	1/1	17/8

TABLE 4-1
GROUNDWATER SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD
INDIAN HEAD, MARYLAND
PAGE TWO

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Groundwater (Continued)	Appendix IX: Volatiles	EPA 624	14/6	3/2	2/1	0/0	1/1	20/10
	Appendix IX: Semi-volatiles	EPA 625	14/6	0/0	2/1	0/0	1/1	17/8
	Appendix IX: Pesticides/PCBs Extractables	EPA 608	14/6	0/0	2/1	0/0	1/1	17/8
	Cyanides	A412D	14/6	0/0	2/1	0/0	1/1	17/8
	TPH	EPA 418.1	14/6	0/0	2/1	0/0	1/1	17/8
	Perchlorates: Ammonium	IC [7]	14/6	0/0	2/1	0/0	1/1	17/8
	Potassium	IC [7]	14/6	0/0	2/1	0/0	1/1	17/8
	Indicator Parameters: Sulphate	SW846; 9035	14/6	0/0	2/1	0/0	1/1	17/8
	Phosphate	EPA 365.1	14/6	0/0	2/1	0/0	1/1	17/8
	TOX	SW 846; 9020	14/6	0/0	2/1	0/0	1/1	17/8
	TOC	SW 846; 9060	14/6	0/0	2/1	0/0	1/1	17/8
	Nitrate/Nitrite	EPA 353.3	14/6	0/0	2/1	0/0	1/1	17/8

TABLE 4-1
GROUNDWATER SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD
INDIAN HEAD, MARYLAND
PAGE THREE

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Groundwater (Contined)	Total Kjeldahl Nitrogen	EPA 351.3	14/6	0/0	2/1	0/0	1/1	17/8
	Ammonia Nitrogen	EPA 350.3	14/6	0/0	2/1	0/0	1/1	17/8

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organics (VOA) samples. One trip blank per each cooler containing VOCs. Trip Blanks are only analyzed for VOCs.

(2) Equipment Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but analyzed every other day unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event. Field blanks are included on soil sample table.

(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

(5) Nitroamines compound list consists of HMX, RDX, TMETN (1,1-trimethylolethane trinitrate), TEGDN (triethelene glycoldinitrate), and BDNPAF (bis(2,2-dinitropropyl) acetal/formal).

(6) Explosives list consists of nitrocellulose, nitroglycerine, nitroguanidine. All three explosives to be collected in same bottle.

(7) Analysis performed by Ion Chromatography. No EPA method available.

TABLE 4-2

SOIL SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD THERMAL TREATMENT POINTS INDIAN HEAD, MARYLAND

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Estimated Number of Samples Strauss Avenue/ Caffee Road
Soil	Nitroamines: [5]	UW25-HPLC	39/24	0/0	3/3	2/0	4/3	48/30
	Propellents: [6] nitrocellulose	UFO5	39/24	0/0	3/3	2/0	4/3	48/30
	nitroglycerine	UW27	39/24	0/0	3/3	2/0	4/3	48/30
	nitroguanidine	UW29	39/24	0/0	3/3	2/0	4/3	48/30
	Metals (total): aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium,, silver, thallium, vanadium, and zinc	SW846 3050/6010	39/24	0/0	3/3	2/0	4/3	48/30
	mercury	SW846 7471	39/24	0/0	3/3	2/0	4/3	48/30
	tin	SW846 3050/7870	39/24	0/0	3/3	2/0	4/3	48/30
	Cyanides	SW846 9010	39/24	0/0	3/3	2/0	4/3	48/40
	pH	SW846; 9045	39/24	0/0	3/3	2/0	4/3	48/30
	Appendix IX: Volatiles	SW846 8240	39/24	6/6	3/3	2/0	4/3	54/36
	Appendix IX: Semivolatiles	SW846 8270	39/24	0/0	3/3	2/0	4/3	48/30
	Appendix IX: Pesticides/PCBs	SW846 8080	39/24	0/0	3/3	2/0	4/3	48/30
	TPH	EPA 418.1	39/24	0/0	3/3	2/0	4/3	48/30

TABLE 4-2
SOIL SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD
THERMAL TREATMENT POINTS
INDIAN HEAD, MARYLAND
PAGE TWO

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Estimated Number of Samples Strauss Avenue/ Caffee Road
Soils (Cont'd)	Perchlorates:							
	Ammonium	IC [8]	39/24	0/0	2/2	2/0	4/3	48/30
	Potassium	IC [8]	39/24	0/0	2/2	2/0	4/3	48/30
	Soil Analysis: [7]							
	Grain Size	ASTM D422	4/2	0/0	0/0	0/0	0/0	4/2
	Moisture Content	ASTM D2216	4/2	0/0	0/0	0/0	0/0	4/2
	Bulk Density	Agronomy No. 9	4/2	0/0	0/0	0/0	0/0	4/2
	Permeability of Undisturbed Sample	SW 9100	4/2	0/0	0/0	0/0	0/0	4/2
	Soil Classification	ASTM D2487	4/2	0/0	0/0	0/0	0/0	4/2

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing VOCs. Trip Blanks are only analyzed for VOCs.

(2) Equipment Blank - Samples obtained by pouring analyte-free water over sample collection equipment (splitspoon, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but analyzed every other day unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event.

(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

(5) Nitroamines compound list consists of HMX, RDX, TMETN (1,1-trimethylolethane trinitrate), TEGDN (triethelene glycoldinitrate), and BDNPA/F (bis(2,2-dinitroproply) acetal/formal).

(6) Propellents list consists of nitrocellulose, nitroglycerine, and nitroguanidine. All three propellents to be collected in same bottle.

(7) A total of six soil samples will be collected. Three samples will be from background wells and two will be from the Strauss Avenue site and one will be from the Caffee Road site.

(8) Analysis performed by Ion Chromatography. No EPA method available.

TABLE 4-3

SUMMARY OF BOTTLE REQUIREMENTS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES INDIAN HEAD, MARYLAND

Parameter	Media	Container Material and Sample Volume	Preservation	Holding Time
Nitroamines:	Groundwater/ Surface Water	1-L amber glass bottle	Cool to 4°C	7 days
	Soil/Sediment	1 pint glass jar	Cool to 4°C	7 days
Explosives: nitrocellulose, nitroglycerine, nitroguanidine	Groundwater/ Surface Water	1-L amber glass bottle	Cool to 4°C	7 days
	Soil/Sediment	1 pint glass jar	Cool to 4°C	7 days
Metals: (1)	Groundwater/ Surface Water	1 liter plastic bottle	4°C; HNO_3 to pH <2	6 months; Hg 28 days
	Soil/Sediment	8 oz. glass jar	Cool to 4°C	6 months; Hg 28 days
Appendix IX: Volatiles	Groundwater/ Surface Water	3 40 ml VOA vials	HCl to pH < 2	14 days
	Soil/Sediment	2 60 ml VOA vials	Cool to 4°C	14 days
Appendix IX: Pesticides/PCBs, Semi-volatiles	Groundwater/ Surface Water	1 80 oz. amber glass bottle with Teflon lined cap(3)	Cool to 4°C	Extract 7 days; analyze 40 days
	Soil/Sediment	2-60ml	Cool to 4°C	Extract 7 days; analyze 40 days
pH	Groundwater/ Surface Water	analyzed in the field	None	None
	Soil/Sediment	4 oz. plastic bottle	Cool to 4° C	None
Conductivity	Groundwater/ Surface Water	analyzed in the field	None	None

TABLE 4-3
SUMMARY OF BOTTLE REQUIREMENTS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES
INDIAN HEAD, MARYLAND
PAGE 2

Parameter	Media	Container Material and Sample Volume	Preservation	Holding Time
Cyanides	Groundwater/ Surface Water	1 liter plastic bottle	4°C; NaOH to pH >12	14 days
	Soil/Sediment	collected with metals	Cool to 4°C	14 days
TPH	Groundwater/ Surface Water	1 L glass bottle	HCl to pH >2, cool to 4 to 4°C	28 days
	Soil/Sediment	1 L wide mouth jar w/teflon liner	Cool to 4°C	28 days
Perchlorates: Ammonium	Groundwater/ Surface Water	Collected with explosives	Cool to 4°C	7 days
Potassium	Soil/Sediment		Cool to 4°C	7 days
Indicator Parameters: Sulphate	Groundwater/ Surface Water	500 ml PE bottle	Cool to 4°C	28 days
TOX	Groundwater/ Surface Water	1 L PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days
Phosphate, TOC, Nitrate/Nitrite	Groundwater/ Surface Water	500 ml PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days
Total Kjeldahl Nitrogen	Groundwater/ Surface Water	1 L PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days
Ammonia Nitrogen	Groundwater/ Surface Water	1 L PE bottle	H_2SO_4 to pH <2, Cool to 4°C	28 days

TABLE 4-3
SUMMARY OF BOTTLE REQUIREMENTS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES
INDIAN HEAD, MARYLAND
PAGE 3

Parameter	Media	Container Material and Sample Volume	Preservation	Holding Time
Soil Characteristics: Bulk Density	Soil only	1 quart glass jar	None	None
Moisture Content	Soil only	1 quart glass jar	None	None
Permeability of Undisturbed Sample	Soil only	Shelby tube	None	None
Soil Classification	Soil only	1 quart glass jar	None	None
Grain Size	Soil only	1 quart glass jar	None	None

(1) All metals except mercury will be collected in one container. These metals include: aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, tin, vanadium, and zinc.

TABLE 4-4

SURFACE WATER SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD INDIAN HEAD, MARYLAND

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Surface Water	Nitroamines: [5]	UW25-HPLC	3/4	0/0	1/1	0/0	1/1	5/6
	Propellents: [6] nitrocellulose	UFO5	3/4	0/0	1/1	0/0	1/1	5/6
	nitroglycerine	UW27	3/4	0/0	1/1	0/0	1/1	5/6
	nitroguanidine	UW29	3/4	0/0	1/1	0/0	1/1	5/6
	Dissolved Metals: aluminum	EPA 200.7	3/4	0/0	1/1	0/0	1/1	5/6
	antimony	EPA 204.2	3/4	0/0	1/1	0/0	1/1	5/6
	arsenic	EPA 206.2	3/4	0/0	1/1	0/0	1/1	5/6
	barium	EPA 208.1	3/4	0/0	1/1	0/0	1/1	5/6
	beryllium	EPA 210.1	3/4	0/0	1/1	0/0	1/1	5/6
	cadmium	EPA 213.1	3/4	0/0	1/1	0/0	1/1	5/6
	chromium	EPA 218.1	3/4	0/0	1/1	0/0	1/1	5/6
	cobalt	EPA 219.1	3/4	0/0	1/1	0/0	1/1	5/6
	copper	EPA 220.1	3/4	0/0	1/1	0/0	1/1	5/6
	lead	EPA 239.1	3/4	0/0	1/1	0/0	1/1	5/6
	mercury	EPA 245.1	3/4	0/0	1/1	0/0	1/1	5/6
	nickel	EPA 249.1	3/4	0/0	1/1	0/0	1/1	5/6
	selenium	EPA 270.2	3/4	0/0	1/1	0/0	1/1	5/6
	silver	EPA 272.1	3/4	0/0	1/1	0/0	1/1	5/6
	thallium	EPA 279.1	3/4	0/0	1/1	0/0	1/1	5/6
	tin	EPA 282.1	3/4	0/0	1/1	0/0	1/1	5/6
	vanadium	EPA 286.1	3/4	0/0	1/1	0/0	1/1	5/6
	zinc	EPA 289.1	3/4	0/0	1/1	0/0	1/1	5/6

TABLE 4-4
SURFACE WATER SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD
INDIAN HEAD, MARYLAND
PAGE TWO

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Surface Water (Continued)	Appendix IX: Volatiles	EPA 624	3/4	0/0	1/1	0/0	1/1	5/6
	Appendix IX: Semivolatiles	EPA 625	3/4	0/0	1/1	0/0	1/1	5/6
	Appendix IX: Pesticides/PCBs Extractables	EPA 608	3/4	0/0	1/1	0/0	1/1	5/6
	TPH	EPA 418.1	3/4	0/0	1/1	0/0	1/1	5/6
	Perchlorates: Ammonium	IC [7]	3/4	0/0	1/1	0/0	1/1	5/6
	Potassium	IC [7]	3/4	0/0	1/1	0/0	1/1	5/6
	Indicator Parameters: Sulphate	SW 846; 9035	3/4	0/0	1/1	0/0	1/1	5/6
	Phosphate	EPA 365.1	3/4	0/0	1/1	0/0	1/1	5/6
	TOX	SW 846; 9020	3/4	0/0	1/1	0/0	1/1	5/6
	TOC	SW 846; 9060	3/4	0/0	1/1	0/0	1/1	5/6
	Nitrate/Nitrite	EPA 353.3	3/4	0/0	1/1	0/0	1/1	5/6
	Total Kjeldahl Nitrogen	EPA 351.3	3/4	0/0	1/1	0/0	1/1	5/6

TABLE 4-4
SURFACE WATER SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD
INDIAN HEAD, MARYLAND
PAGE THREE

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Surface Water (Continued)	Ammonia Nitrogen	EPA 350.3	3/4	0/0	1/1	0/0	1/1	5/6
	Cyanides	A412D	3/4	0/0	1/1	0/0	1/1	5/6

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing VOCs. Trip Blanks are only analyzed for VOAs. Note: Trip blank for surface water is included with sediment samples.

(2) Equipment Blank - Samples obtained by pouring analyte-free water over sample collection equipment (sampling bucket, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but analyzed every other day unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event. Field blanks are included on soil sampling table.

(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

(5) Nitroamines compound list consists of HMX, RDX, TMETN (1,1-trimethylolethane trinitrate), TEGDN (triethelene glycoldinitrate), and BDNPA/F (bis(2-2,dinitropropyl) acetal/formal).

(6) Propellents list consists of nitrocellulose, nitroglycerine, and nitroguanidine. All three propellents to be collected in same bottle.

(7) Sample analysis by Ion Chromatography. No EPA method available.

TABLE 4-5

SEDIMENT SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD THERMAL TREATMENT POINTS INDIAN HEAD, MARYLAND

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Sediment	Nitroamines: [5]	UW25-HPLC	13/4	0/0	1/0	0/0	2/1	16/5
	Propellents: [6] nitrocellulose	UFO5	13/4	0/0	1/0	0/0	2/1	16/5
	nitroglycerine	UW27	13/4	0/0	1/0	0/0	2/1	16/5
	nitroguanidine	UW29	13/4	0/0	1/0	0/0	2/1	16/5
	Metals(total): aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium,, silver, thallium, vanadium, and zinc	SW846 3050/6010	13/4	0/0	1/0	0/0	2/1	16/5
	mercury	SW846 7471	13/4	0/0	1/0	0/0	2/1	16/5
	tin	SW846 3050/7870	13/4	0/0	1/0	0/0	2/1	16/5
	pH	SW846; 9045	13/4	0/0	1/0	0/0	2/1	16/5
	Appendix IX: Volatiles	SW846 8240	13/4	0/0	1/0	0/0	2/1	17/6
	Appendix IX: Semi-volatiles	SW846 8270	13/4	0/0	1/0	0/0	2/1	16/5

TABLE 4-5
SEDIMENT SAMPLING PROGRAM FOR STRAUSS AVENUE AND CAFFEE ROAD THERMAL TREATMENT POINTS
INDIAN HEAD, MARYLAND
PAGE TWO

Media	Analysis	Analytical Method	No. of Samples Strauss Avenue/ Caffee Road	Trip Blank[1] Strauss Avenue/ Caffee Road	Equipment Blank[2] Strauss Avenue/ Caffee Road	Field Blanks[3] Strauss Avenue/ Caffee Road	Duplicates[4] Strauss Avenue/ Caffee Road	Total Samples Strauss Avenue/ Caffee Road
Sediment (Cont'd)	Appendix IX: Pesticides/PCBs	SW846 8080	13/4	0/0	1/0	0/0	2/1	16/5
	TPH	EPA 418.1	13/4	0/0	1/0	0/0	2/1	16/5
	Perchlorates: Ammonium	IC [7]	13/4	0/0	1/0	0/0	2/1	16/5
	Potassium	IC [7]	13/4	0/0	1/0	0/0	2/1	16/5
	Cyanides	SW846 9010	13/4	0/0	1/0	0/0	2/1	16/5

(1) Trip Blanks - Samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples. One trip blank per each cooler containing VOCs. Trip Blanks are only analyzed for VOCs.

(2) Equipment Blank - Samples obtained by pouring analyte-free water over sample collection equipment (bailer, etc.) after decontamination. Assesses the effectiveness of field decontamination procedure. Obtained at a frequency of 1/day/media/analysis but analyzed every other day unless positive detection are recorded. Number of samples reflects the number of actual laboratory analyses performed.

(3) Field Blank - Samples consisting of the source water used in (1) steam cleaning and/or (2) decontamination. Obtained at a frequency of 1/event. Field blanks are included on soil sampling table.

(4) Duplicates - A single sample split into two portions during a single act of sampling. Assess the overall precision of the sampling and analysis program. Obtained at a frequency of 10 percent of the number of samples.

(5) Nitroamines compound list consists of HMX, RDX, TMETN (1,1-trimethylolethane trinitrate), TEGDN (triethelene glycoldinitrate) and BDNPA/F (bis(2,2-dinitropropyl) acetal/formal).

(6) Propellents list consists of nitrocellulose, nitroglycerine, and nitroguanidine. All three propellents to be collected in same bottle.

(7) Sample analysis by Ion Chromatography. No EPA method available.

All groundwater samples will be analyzed for nitroaromatics, propellants, metals, cyanide and Appendix IX volatiles, semivolatiles, and pesticides/PCBs. Groundwater samples will be poured directly from the bailer into the appropriate sample bottles for analysis.

All pertinent field data shall be recorded using the appropriate sample log sheet (see HALLIBURTON NUS SOP SA-6.3) and the field log book. A groundwater sample log sheet is attached in Appendix A.

Table 4-1 summarizes the groundwater sampling program. Samples will be preserved in accordance with HALLIBURTON NUS SOP SF-1.2. Sample handling and preservation requirements are shown in Table 4-3. Chain-of-Custody requirements are discussed in the QA/QC Plan attached as Appendix C.

4.2.2 Surface/Subsurface Soil Sampling

Surface and subsurface soil samples will be collected from the 15 soil borings installed at the Strauss Avenue TTP (SA-SB01 through SA-SB15) and from the eight soil borings installed at Caffee Road (CR-SB01 through CR-SB08). Soil samples will be collected in accordance with HALLIBURTON NUS SOP GH-1.3. All samples obtained from the boreholes shall be monitored with an organic vapor monitor and two samples from each boring will be collected for laboratory analysis. Soil samples for laboratory analysis will be collected every 2 feet, with samples collected at least from 0.0 to 1.0 feet below the ground surface and from above the water table (two soil samples minimum per boring). Upon sample retrieval, the material to be analyzed will be homogenized and distributed to the required sample containers. Surface soil samples (for background analysis) will be collected with stainless steel trowels, from approximately zero to 6 inches below ground surface.

Split-spoon samplers will be decontaminated between samples as described in Section 3-9. Sample handling and chain-of-custody requirements are addressed in Sections 4.4 and 4.5. All pertinent field data will be recorded using the appropriate sample log sheet (see HALLIBURTON NUS SOP GH-1.3) and the field log book. A soil sample log sheet is attached in Appendix A.

Table 4-2 summarizes the surface and subsurface soil sampling program. Samples will be preserved in accordance with HALLIBURTON NUS SOP SF-1.2. Sample handling and preservation requirements are shown in Table 4-3.

4.2.3 Surface Water/Sediment Sampling

Surface water samples at Strauss Avenue (SA-SW01 through SA-SW07) and Caffee Road (CR-SW01 through CR-SW03), and background surface water samples will be obtained from Mattawoman Creek, as described in Section 3.6. Samples will be obtained by using a stainless steel sampling pail. Surface water sampling will be conducted in accordance with HALLIBURTON NUS SOP SA-1.2 Section 5.3.

In addition, field measurements will be obtained on the surface water samples prior to sample collection. These field measurements include:

- pH
- Specific conductance
- Temperature

Color and turbidity shall also be noted on the sample log form for each surface water sample. Procedures for obtaining these field measurements will be in accordance with HALLIBURTON NUS SOP SF-1.1.

All surface water samples will be analyzed for nitroaromatics, propellants, metals, cyanide, indicator parameters, and Appendix IX volatiles, semivolatiles, and pesticides/PCBs. Surface water samples will be poured directly from the stainless steel sampling pail into the appropriate sample bottles for analysis. For those samples requiring filtering, the initial sample bottle will be unpreserved. Once filtered, the sample will then be preserved as specified in Table 4-4.

Surface water samples will be collected during a outgoing tide, to obtain a sample representative of water draining from Mattawannan Creek.

Sediment samples will be obtained at the same locations as surface water samples as described in Section 3.6. Sediment sample locations at Strauss Avenue (SA-SD01 through SA-SD07) and sample locations at Caffee Road (CR-SD01 through CR-SD03) are shown in Figures 3-1 and 3-2. Background sample locations are shown on Figure 3-5. Sediment sampling will be conducted in accordance with HALLIBURTON NUS SOP SA-1.2 Section 5.4.

Sediment characteristics shall be noted on the sample log form for each sediment sample. All sediment samples will be analyzed for nitroaromatics, propellants, mercury, cyanide, indicator parameters, Appendix IX volatiles, semivolatiles, and pesticides/PCBs.

Tables 4-4 and 4-5 summarize the surface water and sediment sampling program. All pertinent field data shall be recorded using sample log sheets and the field log book. Surface water and sediment sample forms are attached in Appendix A. Samples will be preserved in accordance with HALLIBURTON NUS SOP SF-1.2. Sample handling and preservation requirements are shown in Table 4-3.

4.3 SAMPLE HANDLING

Sample handling includes the field-related considerations concerning the selection of sample containers, preservatives, allowable holding times and analyses requested. In addition, sample identification, packaging and shipping will be addressed in this section.

The EPA User's Guide to the Contract Laboratory Program (EPA, December 1986), and the Federal Register (EPA, October 26, 1984) address the topics of containers and sample preservations. Table 4-3 provides a summary of these sample handling considerations.

4.3.1 Sampling Identification System

Each sample collected will be assigned a unique sample tracking number. The sample tracking number will consist of a four-segment, alpha-numeric code that identifies the site, sample medium and location, sample depth (in the case of soil samples), and QA designation, if required. Any other pertinent information regarding sample identification will be recorded in the field log books.

The alpha-numeric coding to be used in the sample system is explained in the diagram and the subsequent definitions:

(AA)	-	(AANN)	-	(NNNN)	-	(A)
(Site Location)		(Medium & Location)		(Sample depth)		(QA designation)

Character Type:

A = Alpha

N = Numeric

Site:

SA = Strauss Avenue

CR = Caffee Road

Medium:

GW = Groundwater from monitoring well

SB = Soil sample from soil borings

SW = Surface water

SD = Sediment

SS = Surface soil

Sample Location:

Surface soil / subsurface soil = well number

Surface water / sediment = Surface water / sediment sample location number.

Groundwater sample = well number.

Sample Depth:

For soil samples = Start/finish depth of sample (in feet).

Not used for groundwater or surface water/sediment samples.

QA Sample Designation:

D = Duplicate

B = Equipment Rinsate Blank

F = Field Blank

For example, a groundwater sample collected from Strauss Avenue monitoring well 4 would be designated as:

SA-GW04

A duplicate sample from that well would be:

SA-GW04-D

A subsurface soil sample and its duplicate taken from Caffee Road well boring number 4 at a depth of 10 to 12 feet would be:

CR-SB04-1012 and CR-SB04-1012-D

Information regarding sample labels and tags to be attached before shipment to a laboratory is contained in Section 5.2 of the HALLIBURTON NUS SOP SA-6.1.

4.3.2 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with HALLIBURTON NUS SOP SA-6.2. The FOL will be responsible for completion of the following forms:

- Sample Labels
- Chain-of-Custody Forms
- Appropriate Labels Applied to Shipping Coolers
- Chain-of-Custody Labels
- Federal Express Air Bills

4.4 SAMPLE CUSTODY

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. Section 5.3 of HALLIBURTON NUS SOP SA-6.1 provides a description of the chain-of-custody procedures to be followed. A sample chain-of-custody form is attached in Appendix A.

4.5 QUALITY CONTROL SAMPLES

In addition to regular calibration of field equipment and appropriate documentation, quality control (QC) samples will be collected or generated during environmental sampling activities. QC samples include trip blanks, field duplicates, field blanks, and equipment rinsate blanks. Tables 4-1, 4-2, 4-4, and 4-5 present the type and number of required QC samples. Each type of field QC sample is defined as follows:

- Trip Blanks - Trip blanks are used to determine whether contamination of sample or bottleware has occurred in the field. Trip blanks consist of analyte-free water taken from the laboratory to the site, and returned. Trip blanks are taken at the rate of one per cooler of organics analysis and will be analyzed for TCL VOCs only.

- Field Duplicates - Field duplicates are two samples collected either; (1) independently at a sampling location in the case of groundwater or surface water, or (2) a single sample split into two portions in the case of soil or sediment. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Ten percent of all samples for each media shall be field duplicates. Duplicates shall be analyzed for the same parameters in the laboratory.

- Equipment Rinsate Blanks - Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (bailer, split spoon, corer, etc.) after decontamination and placing it in the appropriate sample containers for analysis. Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of non-dedicated sampling equipment used and will be submitted at a frequency of one per day per media. Equipment blanks however will only be analyzed every other day. Those not analyzed will be retained by the laboratory until completion of field activities. It will be the responsibility of the FOL to communicate to the laboratory whether an equipment blank is, or is not, to be analyzed as stated above.

- Field Blanks - Field blanks are obtained by sampling the water(s) used for decontamination during the field investigation. Samples consist of the source water used in (1) steam cleaning of large equipment and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures, and to determine if the analyte-free water or the potable water (used for steam cleaning) may be contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event.

5.0 FIELD MEASUREMENTS

Certain field measurements will be recorded during sampling activities including temperature, pH and specific conductance. All instruments used in the field will be calibrated according to the procedures described below.

5.1 EQUIPMENT CALIBRATION

Several monitoring instruments may be used during field activities; these include:

- HNu photoionization indicator device
- Temperature probe
- Specific conductance meter
- pH meter
- Electronic water-level meter

The electronic water-level meter will be calibrated prior to mobilization and periodically at the discretion of the FOL. The remaining instruments will be calibrated daily or according to the manufacturer's operating manual.

Calibration will be documented on an equipment calibration log. A sample calibration log is attached in Appendix A. 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 the defective parts are repaired or replaced.

5.2 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. Equipment will be calibrated periodically.

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

6.0 RECORD KEEPING

In addition to chain-of-custody records certain standard forms will be completed for sample description and documentation. These shall include sample log sheets (for soil, surface water, sediment, and groundwater samples), boring logs, well completion diagrams, daily record of subsurface investigation reports, and logbooks.

A bound/weatherproof field notebook shall be maintained by each sampling event leader. All information related to sampling or field activities will be recorded in the field notebook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, descriptions of photographs, etc.

A bound/weatherproof site logbook shall be maintained by the FOL. The requirements of the site logbook are outlined in HALLIBURTON NUS SOP SA-6.3, Section 5 and 7. 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 Record of Subsurface Investigation Report. This report 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 materials used. A sample of the Daily Record is attached in Appendix A.

At the completion of field activities, the FOL shall submit to the Project Manager all field records, data, field notebooks, logbooks, chain-of custody receipts, sample log sheet, drilling logs, daily logs, etc.

7.0 SITE MANAGEMENT

7.1 BASE SUPPORT

The CLEAN Remedial Project Manager (RPM) is

Javier Garcia
CHESNAVFACENGCOM
Code 181
Bldg. 212
Washington, DC 2037-2121
(202) 433-3760

The NAVSURFWARCEN IHDIV point of contact is:

Sherry McCahill
Code 0965
NAVAL SURFACE WARFARE CENTER INDIAN HEAD DIVISION
Building D-28
Indian Head, MD 20640-5000
(301) 743-6745

Throughout the duration of the site inspection activities, various support functions will be provided by NAVSURFWARCEN IHDIV personnel as described below:

- Locate underground utilities and issue digging or other appropriate permits prior to the commencement of digging or drilling operations.

- Take custody of any drill cuttings, well development fluids, decontamination fluids, or samples returned from a laboratory suspected to be hazardous and requiring proper disposal according to applicable state and/or Federal regulations.

- Provide existing engineering plans, drawings, diagrams, aerial photographs, digitized map files, etc., to facilitate evaluation of the site under investigation.

- Provide all historical data, background geological and hydrogeological information, and initial site investigation documents.

In addition, NAVSURFWARCEN IHDIV personnel will aid in arranging the following:

- Secure staging areas for decontamination operations and for storing equipment and supplies.

- A supply (e.g., fire hydrant, stand pipe, etc.) of large quantities of potable water for equipment cleaning etc.

- A temporary office area, equipped with a telephone for local and long distance telephone calls. HALLIBURTON NUS will pay for any long distance telephone calls from this phone.

7.2 CONTINGENCY PLAN

In the event of problems which may be encountered during the site inspection activities, the HALLIBURTON NUS Project Manager will be notified immediately, followed by the NAVSURFWARCEN IHDIV Point of Contact. The Project Manager will determine a course of action so as to not interfere with the schedule or budget. All contingency plans will be approved through the NAVSURFWARCEN IHDIV Point of Contact and the RPM before being enacted.

8.0 SCHEDULE

Schedule for and list of deliverables CTO 56, Task 4.0 - Work Plan:

Task/ Subtask	Description	Completion Date	Duration
Subtask 4.1	Site Visit	07/15/92 to 07/16/92	Two days
Subtask 4.2	Review Existing Data / Perform Scoping Meeting to Identify Data Needs	07/15/92 to 07/16/92	Two days
Subtask 4.3	Prepare and Submit Draft Work Plan[1]	08/14/92	Four weeks
	Navy Comments on Draft Work Plan[1]	08/28/92	Two weeks
	HALLIBURTON NUS Response to Navy Comments, Submit Final Work Plan[1]	09/11/92	Two weeks
Subtask 4.5	Site-specific Health and Safety Report[1]	08/14/92	Four weeks

[1] Deliverable item.

REFERENCES

AWARE Corporation, 1982. Final Report, Portable Water Improvement Study, Naval Ordnance Station, Indian Head, Maryland, prepared under Contract No. 62477-81-C-0170 for Chesapeake Division, Naval Facilities Engineering Command, Washington, D.C. 201p.

Greenhorne and O'Mara, Inc., 1990, Indian Head Hydrogeologic Study, Phase I Survey Report.

Hiortdahl, S. N., 1990, Changes in ground water quality caused by river-water intrusion in the Potomac Group aquifer system of northwestern Charles County, Maryland. in Groundwater Management, proceedings of the FOCUS Conference on Eastern Regional Ground Water Issues, 1990.

Tech International, 1988, Draft RCRA Part B, Subpart X Permit application for Indian Head Naval Ordnance Station.

U.S. EPA, 1986. Test Methods for Evaluating Solid Waste - SW846.

APPENDIX A

FORMS FOR FIELD INVESTIGATION OF STRAUSS AVENUE AND CAFFEE ROAD THERMAL TREATMENT PLANTS

NAUSURFWARCEN IHDIV

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO _____

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA: _____

(Date, Time & Conditions) _____

SAMPLE NO. & 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	MATERIAL DESCRIPTION: COLOR	MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION	USCS	REMARKS

REMARKS _____

BORING _____

PAGE ____ OF ____

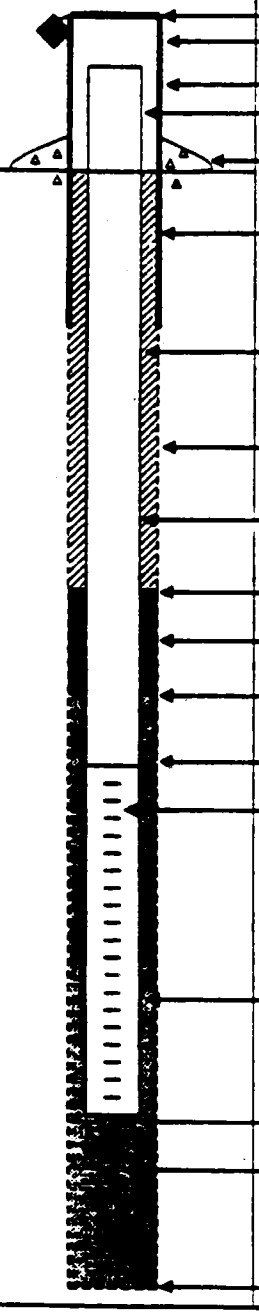
HALLIBURTON NUS
Environmental Corporation

BORING NO _____

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____ / _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____ / _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____ / _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____ / _____

HALLIBURTON NUS
Environmental Corporation

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____
Project No.: _____
Personnel: _____
Date: _____

LOCATION

Municipality: _____
County: _____
State: _____
Street or Map Location (If Off-Site) _____

WEATHER CONDITIONS

Temperature Range: _____
Precipitation: _____
Barometric Pressure: _____

Equipment No.: _____
Equipment Name: _____
Latest Calibration Date: _____

Tidally-Influenced: [ ] Yes [ ] No

Well or Piezometer Number	Date/Time	Elevation of Reference Point (Feet)*	Water Level Indicator Reading (Feet)*	Adjusted Depth (Feet)*	Groundwater Elevation (Feet)*

* All elevations to nearest 0.01 foot.

HALLIBURTON NUS
Environmental Corporation

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page _____ of _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Total Well Depth:	Purge Data				
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					
Sample Date & Time:	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:					
Signature(s):	Observations / Notes:				

Type of Sample
- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

SAMPLE LOG SHEET

Page _____ of _____

HALLIBURTON NUS
Environmental Corporation

- ☐ Surface Soil
- ☐ Subsurface Soil
- ☐ Sediment
- ☐ Lagoon / Pond
- ☐ Other _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Sample Method:	Composite Sample Data		
	Sample	Time	Color · Description
Depth Sampled:			
Sample Date & Time:			
Sampled By:			
Signature(s):			
Type of Sample ☐ Low Concentration ☐ High Concentration ☐ Grab ☐ Composite ☐ Grab - Composite			

Sample Data	
Color	Description: (Sand, Clay, Dry, Moist, Wet, etc.)

Analysis:	Preserv. :

Observations / Notes

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

HALLIBURTON NUS
Environmental Corporation

SAMPLE LOG SHEET

☐ Spring
☐ Lake
☐ Stream
☐ Other _____

Page _____ of _____
Case # _____
By _____

Project Site Name _____ Project Site Number _____
NUS Source No. _____ Source Location _____

Sample Method:	Sample Data			
	pH	S.C.	Temp. (°C)	Color & Turbidity
Depth Sampled:				
Sample Date & Time:				
Sampled By:				
Signatures:				

Type of Sample
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

Analysis:	Preservative

	Organic	Inorganic
Traffic Report #		
Tag #		
AB #		
Date Shipped		
Time Shipped		
Lab		
Volume		

HALLIBURTON NUS

CHAIN OF CUSTODY RECORD

PROJECT NO.:

SITE NAME:

SAMPLERS (SIGNATURE):

STATION NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS							REMARKS

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:	

NUS 440 34 0484

HALLIBURTON NUS
Environmental Corporation

EQUIPMENT CALIBRATION LOG

Instrument (Name/Model No./Serial No.): _____

Manufacturer _____ Date Purchased _____

Calibration Date	Initial Settings	Standard/Gas Used	Procedure	Adjustments Made	Final Settings	Signature	Comments

DAILY ACTIVITIES RECORD - FIELD INVESTIGATION **HALLIBURTON NUS**

PROJECT NAME: _____ PROJECT NO.: _____
CLIENT: _____ LOCATION: _____
DATE: _____ ARRIVAL TIME: _____ DEPARTURE TIME: _____
CONTRACTOR: _____ DRILLER: _____
BORING NO.: _____ NUS REPRESENTATIVE: _____

ITEM (1)	ORIGINAL QUANTITY (2) ESTIMATE	QUANTITY (2) TODAY	PREVIOUS TOTAL (2) QUANTITY	CUMULATIVE QUANTITY (2) TO DATE

COMMENTS: _____

(1) AS LISTED IN SPECS
(2) INCLUDE QUANTITY AND UNITS
(Ex. 20 ft., 6 hrs.)

APPROVED BY:

_____
NUS FIELD REPRESENTATIVE

_____
DRILLER OR REPRESENTATIVE

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET — HALLIBURTON NUS CORPORATION

PROJECT NAME: ..... WELL/BORING NO.: .....

PROJECT NO.: ..... GEOLOGIST: .....

WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....

STATIC WATER LEVEL (Depth/Elevation): ..... DATE: .....

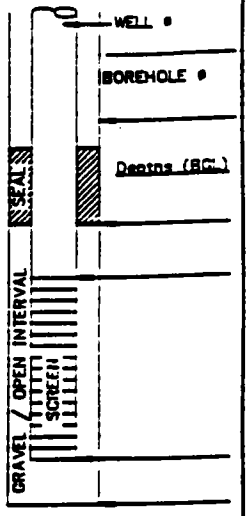
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....

METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ..... OF .....

REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): .....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)

WELL SCHEMATIC



▽ Indicate SWL Depth on Drawing

REMARKS:

CALCS.SKETCH MAPS, ETC.:

APPENDIX B

STANDARD OPERATING PROCEDURES

GH-1.3, Section 5:	Soil and Rock Sampling
GH-1.5, Section 5:	Borehole and Sample Logging
GH-1.6, Section 5:	Decontamination of Drilling Rigs and Sample Equipment
GH-1.7, Section 5:	Groundwater Monitoring Point Installation
GH-2.4, Section 5:	In-Situ Hydraulic Conductivity Testing
SA-1.1, Section 5:	Groundwater Sample Acquisition
SA-1.2, Section 5:	Surface Water and Sediment Sampling
SA-6.1, Section 5:	Sample Identification and Chain-of-Custody
SA-6.2, Section 5:	Sampling Packaging and Shipping
SA-6.3, Section 5	Site Logbook
SF-1.1, Section 5:	On-Site Water Quality Testing
SF-1.2, Section 5:	Sample Preservation
SF-2.3, Section 5:	Decontamination of Chemical Sampling and Field Analytical Equipment

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.3	Page 1 of 13
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK SAMPLING		Approved D. Senovich	

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5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)
5.1.4 Continuous Core Soil Samples
5.2 SURFACE SOIL SAMPLES
5.3 WASTE PILE SAMPLES
5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)
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1.0 PURPOSE

The purpose of this procedure is to identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

The methods described within this procedure are applicable while collecting surface and subsurface soil samples; obtaining rock core samples for lithologic and hydrogeologic evaluation; excavation/foundation design and related civil engineering purposes.

3.0 GLOSSARY

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

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches O.D. and 18 to 54 inches long. A stationary piston device may be included in the sampler to reduce sampling disturbance and increase sample recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split spoon sampler (used for performing Standard Penetration Tests) is 2 inches outside diameter (OD) and 1-3/8 inches inside diameter (ID). This standard spoon typically is available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. These split-spoon samplers range in size from 2-inch O.D. to 3-1/2-inch O.D., depending upon manufacturer. The larger sizes are commonly used when a larger volume of material is required.

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternate for conventional coring, this is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for overall management of field activities and ensuring that the appropriate sampling procedures are being implemented.

Site Geologist - The site geologist directly oversees the sampling procedures, classifies soil and rock samples, and directs the packaging and shipping of soil samples. Such duties may also be performed by geotechnical engineers, field technicians, or other qualified field personnel.

5.0 PROCEDURES

5.1 SUBSURFACE SOIL SAMPLES

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, DQOs, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

5.1.1 Equipment

The following equipment is used for subsurface soil sampling and test boring:

- Drilling equipment, provided by subcontractor.
- Split barrel (split spoon) samplers, OD 2 inches, ID 1-3/8 inches, either 20-inch or 26 inches long. Larger O.D. samplers are available if a larger volume of sample is needed. A common size is 3-inch O.D. (2-1/2-inch I.D.).
- Thin walled tubes (Shelby), O.D. 2 to 5 inches, 18 to 54 inches long.
- Drive weight assembly, 140-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 30 inches (± 1 inch).
- Drive weight assembly, 300-lb. (± 2 lb.) weight, driving head and guide permitting free fall of 18 inches (± 1 inch).
- Accessory equipment, including labels, logbook, paraffin, and sample jars.

5.1.2 Split Barrel (Split Spoon) Sampling (ASTM D1586-84)

The following method will be used for split barrel sampling:

- Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation. In saturated sands and silts, withdraw the drill bit slowly to prevent loosening of the soil around the hole and maintain the water level in the hole at or above groundwater level.

- Side-discharge bits are permissible. A bottom-discharge bit shall not be used. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

- Install the split barrel sampler and sampling rods into the boring to the desired sampling depth. After seating the sampler by means of a single hammer blow, three 6-inch increments shall be marked on the sampling rod so that the progress of the sampler can be monitored.

- The 2-inch OD split barrel sampler shall be driven with blows from a 140-lb. (± 2 lb.) hammer falling 30 inches (± 1 inch) until either a total of 50 blows have been applied during any one of the three 6-inch increments, a total of 100 blows have been applied, there is no observed advance of the sampler for 10 successive hammer blows, or until the sampler has advanced 18 inches without reaching any of the blow count limitation constraints described herein. This process is referred to as the Standard Penetration Test.

- A 300-lb. weight falling 18 inches is sometimes used to drive a 2-1/2-inch or 3-inch O.D. spoon sampler. This procedure is used where dense materials are enountered or when a large volume of sample is required. However, this method does not conform the ASTM specifications.

- Repeat this operation at intervals not greater than 5 feet in homogeneous strata, or as specified in the sampling plan.

- Record the number of blows required to effect each 6 inches of penetration or fraction thereof. The first 6 inches is considered to be seating drive. The sum of the number of blows required for the second and third 6 inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last 1 foot penetrated.

- Bring the sampler to the surface and remove both ends and one half of the split barrel so that the soil recovered rests in the remaining half of the barrel. Describe carefully the sample interval, recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil then put a representative portion of each sample into a jar, without ramming. Jars with samples not taken for chemical analysis shall be sealed with wax, or hermetically sealed (using a teflon cap liner) to prevent evaporation of the soil moisture, if the sample is to be later evaluated for moisture content. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms. Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area. Pertinent data which shall be noted on the label or written on the jar lid for each sample includes the project number, boring number, sample number, depth interval, blow counts, and date of sampling.

- An addition to the sampler mentioned above is an internal liner, which is split longitudinally and has a thin-wall brass, steel, or paper liner inserted inside, which will preserve the sample. However, since the development of the thin-walled samplers (mentioned below) the split barrel sampler with liner has declined in use.

5.1.3 Thin Walled Tube (Shelby Tube) Sampling (ASTM D1587-83)

When it is desired to take undisturbed samples of soil, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method will be used:

- Clean out the borehole to the sampling depth, being careful to minimize the chance for disturbance of the material to be sampled. In saturated materials, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and maintain the water level in the hole at or above groundwater level.

- The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

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

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

- Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape in the caps place, and dip the ends in wax.

- Affix labels to the tubes as required and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and mark the end of the sample. Complete Chain-of-Custody and other required forms. 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 Denison 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 increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt shall be made with a split barrel sampler at the same depth so that at least a sample can be obtained for classification purposes.

5.1.4 Continuous Core Soil Samples

The CME continuous sample tube system provides a method of sampling soil continuously during hollow stem augering. The 5-foot sample barrel fits within the lead auger of a hollow auger column. The sampling system can be used with a wide range of I.D. hollow stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailigs, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required.

5.2 SURFACE SOIL SAMPLES

For loosely packed earth or waste pile samples, stainless steel scoops or trowels can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

- Use a soil auger for deep samples (6 to 24 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collection of soil. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site.

- Use a new or freshly-decontaminated sampler for each sample taken. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, Chain-of-Custody record, and other required forms.

- Pack and ship accordingly.

- When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles shall be full) shall be placed in a decontaminated stainless steel bucket, mixed thoroughly using a stainless steel spatula or trowel, and a composite sample collected.

5.3 WASTE PILE SAMPLES

The use of stainless steel scoops or trowels to obtain small discrete samples of homogeneous waste piles is usually sufficient for most conditions. Layered (nonhomogeneous) piles require the use of tube samplers to obtain cross-sectional samples.

- Collect small, equal portions of the waste from several points around the pile, penetrating it as far as practical. Use numbered stakes, if possible, to mark the sampling locations and locate sampling points on the site sketch.

- Place the waste sample in a glass container. Attach a label and identification tag. Record all the required information in the field logbook and on the sample log sheet and other required forms.

For layered, nonhomogeneous piles, grain samplers, sampling triers, or waste pile samplers must be used at several representative locations to acquire a cross-section of the pile. The basic steps to obtain each sample are

- Insert a sampler into the pile at a 0- to 45-degree angle from the horizontal to minimize spillage.

- Rotate the sampler once or twice to cut a core of waste material. Rotate the grain sampler inner tube to the open position and then shake the sampler a few times to allow the material to enter the open slits. Move the sampler into position with slots upward (grain sampler closed) and slowly withdraw from the pile.

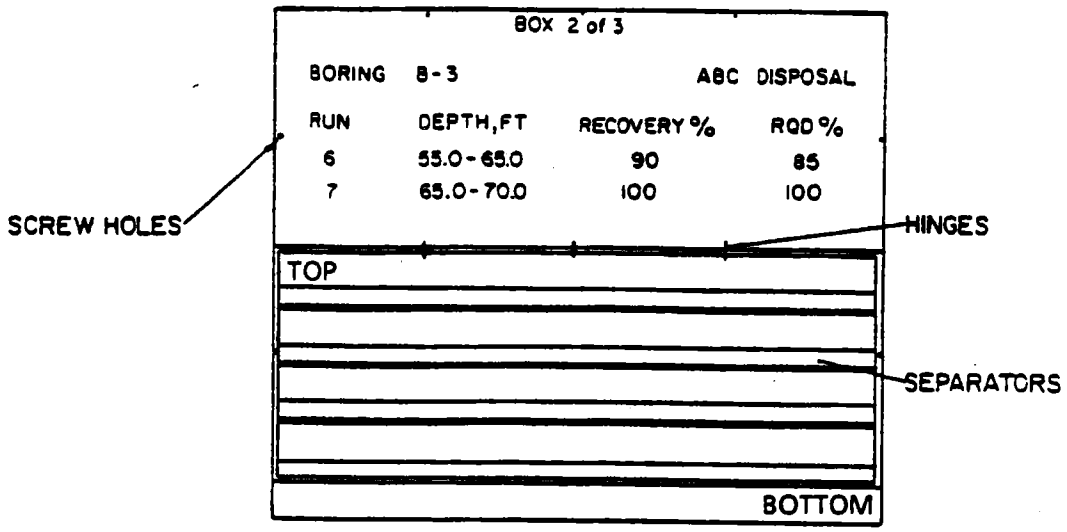
5.4 ROCK SAMPLING (CORING) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. It can, however, proceed for thousands of feet continuously, depending on the size of the drill rig. It yields better quality data than air rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Downhole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

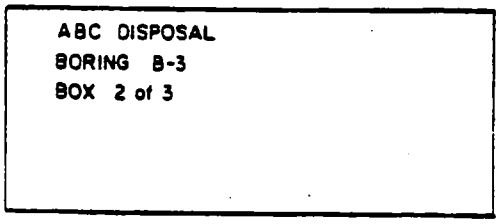
Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Attachment No. 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross contamination of aquifers.

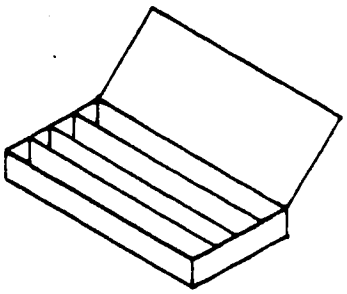
ATTACHMENT 2

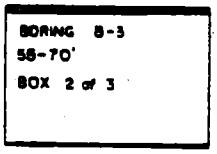


CORE BOX (OBLIQUE VIEW)



CORE BOX (TOP VIEW)





CORE BOX (END VIEW)

TYPICAL ROCK CORE BOX

NOT TO SCALE

NUS CORPORATION
A Halliburton Company

6.0 REFERENCES

American Society for Testing and Materials, 1985. Method for Penetration Test and Split Barrel Sampling of Soils. ASTM Method D 1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

American Society for Testing and Materials, 1985. Thin-Walled Tube Sampling of Soils. Method D-1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

Acker Drill Co., 1958. Basic Procedures of Soil Sampling. Acker Drill Co., Scranton, Pennsylvania.

American Society for Testing and Materials, 1989. Standrd Practice for Diamond Core Drilling for Site Investigation. ASTM Method D2113-83 (reapproved 1987), Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U.S. Department of the Interior, 1974, Earth Manual, A Water Resources Technical Publication, 810 pages.

Central Mine Equipment Company, Drilling Equipment, St. Louis, Missouri.

7.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.4	Page 1 of 20
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK DRILLING METHODS		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to describe the methods, the sequence of operations and the equipment necessary to perform soil and rock borings.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

3.0 GLOSSARY

Boulders - Rounded, semi-rounded or naturally angular particles of rock larger than 12 inches in diameter.

Clay - Fine grained soil or portions of soil having certain physical properties, composition and texture. Clay exhibits plastic properties within a range of water contents and exhibits considerable strength when air dried. Clay consists usually of fragments of hydrous aluminum or magnesium silicate minerals, and it consists predominantly of grains with diameters of less than 0.005 mm.

Cobbles - Rounded, semi-rounded or naturally angular particles of rock between 3 inches and 12 inches in diameter.

Gravel - Rounded or semirounded particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm). Coarse gravel is larger than 3/4-inches, while fine gravel is finer than 3/4-inches.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch sieve (7.62 cm) and be retained on a No. 4 U.S. standard sieve (4.76 mm).

Rock - Any consolidated or coherent and relatively hard, naturally formed mass of mineral matter.

Sand - Particles of rock that will pass a No. 4 U.S. standard sieve (4.76 mm) and be retained on a No. 200 U.S. standard sieve (0.074 mm). Coarse sand is larger than a No. 10 sieve, and fine sand is finer than a No. 40 sieve (0.42 mm).

Silt - Material passing the No. 200 U.S. standard sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air dried.

Soil - Sediments or other unconsolidated accumulations of solid particles that are produced by the physical and chemical disintegration of rock and that may contain organic matter.

Undisturbed Sample - A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Water Table - A surface in an aquifer where groundwater pressure is equal to atmospheric pressure.

4.0 RESPONSIBILITIES

Site Manager - In consultation with the project geologist, responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and geologic conditions at the site. He should also determine the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Site Geologist/Rig Geologist - Responsible for insuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see Attachment A of Procedure GH-1.7). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan.

Field Operations Leader - Responsible for overall supervision and scheduling of drilling activities.

Drilling Subcontractor - Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the Field Operations Leader within 24 hours, and must provide advance written notification for any changes in field procedures describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the Field Operations Leader.

The drilling subcontractor will be responsible for following decontamination procedures specified in the Work Plan. Upon completion of the work, the Drilling Subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 GENERAL

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site, and
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned using appropriate decontamination procedures (see Procedure GH-1.6 and SF-2.3) between samples and borings. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the rig geologist as they proceed (see Procedure GH-1.5) unless the FSAP specifically states that

logging is not required. Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the rig geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 DRILLING METHODS

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, purpose of drilling, waste conditions at the site, and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of screwing augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations will require the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.

- No drilling fluids are required.

- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least four inches greater than the well casing. Use of such large diameter hollow stem augers is more expensive than the use of small diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet. Hollow stem auger drilling is the preferred method of drilling. Most alternative

methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods great care must be taken to ensure that the method does not interfere with the collection of a representative sample which is the object of the construction. With this in mind, the preferred order of choice of drilling method after hollow stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The hollow stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

When taking soil samples for chemical analysis, the hollow-stem auger shall be plugged until the desired sampling depth is reached. Samples can be taken using split-spoon or thin wall tube samplers driven into the formation in advance of the auger (see Procedure GH-1.3). If the sample is to be taken at a relatively deep point, the auger may be advanced without a plug to within five feet of the sample depth. Then clean out the auger stem, insert a plug and continue to the sampling depth. The plug is then removed and samples taken as specified by the rig geologist. Samples should be taken according to the specifications of the sampling plan. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. The sequence shall be repeated for each sample desired.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation.

When drilling below the water table, specially-designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see GH-1.7 for Well Development Procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader, when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations it may be prudent to also grout borings which only penetrate the water table aquifer, since loose soil backfill in the boring would still provide a preferred pathway for surface liquids to reach the water table.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This method is similar to hollow-stem augering. Practical application of this method is severely restricted as compared with hollow stem augers. Split barrel (split-spoon) sampling cannot be done without pulling the augers which may allow the hole to collapse. The method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable as in the case of the hollow stem auger, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, the technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air rotary drill rigs are large and heavy.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split barrel (split-spoon) or thin-wall tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow stem auger method if split barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This will require either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Ground water samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Soil samples shall be taken as specified by the Work Plan or more frequently if requested by the field geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the site geologist.

5.2.4 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud rotary rig with a large diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells because of the use of drilling muds and the large diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are very rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.5 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig or an air hammer and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage). A continuous record is kept of the blows per foot in driving the casing (see Procedure GH-1.5). The casing is normally advanced by a 300-pound

hammer falling freely through a height of 30-inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations between which water is used in driving the casing should be recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least four inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.6 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water need be added.

When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skille operators.

- The cable-tool rig ca erate satisfactorily in all formations, but is best suited for caving, boulder, ca or coa avel type formations (e.g., glacial till) or formations with large cavities abo. ne wat le (such as limestones).

- When casing is used, casing seals formation water out of the hole, preventing down-hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.

- Split barrel (split spoon) or thin-wall tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.

- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.

- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required, such as use of a hollow stem auger.

- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.7 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2 to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch diameter casing in shallow, unconsolidated sand formations but has been used to install 3- to 4-inch diameter casings to 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches; therefore, samples must be obtained by methods applicable to small diameter casings.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.8 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the Work Plan. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). This technique is slow but effective where larger pieces of equipment do not have access and where very shallow holes are desired (less than 5 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.9 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond studded bit attached to the outer core barrel in a double tube core barrel. The use of single tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation to this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the Work Plan. The most common core barrel diameters are listed in Attachment A. Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole, causing unsatisfactory coring, the hole should be reamed and a flush joint casing installed to a point below the broken formation. The size of the flush joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in wnich the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).

- Depth to water cannot accurately be determined if water is used for drilling.

- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.10 Drilling & Support Vehicles.

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment, and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain, to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand-carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers
  - Retractable plug samplers-driven by hand (hammer)
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment uses a jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided

with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on and off the road vehicle having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles includes:

  - Barrel float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallc drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.11 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8" or 7-7/8" bits will nominally drill 6" and 8" holes, respectively).

For obtaining split-barrel samples of a formation, samplers are manufactured in sizes ranging from 2-inches to 4-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used, and driven by a 140-pound (± 2 pound) hammer dropping 30-inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the Work Plan.

5.2.12 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30' to 50') boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud Rotary Drilling	100' (cuttings samples)
Reverse Circulation Rotary	100' (cuttings samples)
Skid Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 PREVENTION OF CROSS-CONTAMINATION

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe, (a method similar to the rock coring method described in Section 5.2.9, except that larger casing is used) or a driven-casing method (see Section 5.2.5 of this guideline), and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing usually of 8-inch diameter is installed followed by installation of the well casing (6-inch diameter is common for 2-inch wells). This well casing is driven into the confining layer to insure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end is installed to the surface.

Clean sand is placed in the annulus around and to a point about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 CLEANOUT OF CASING PRIOR TO SAMPLING

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward directed jet which will disturb the underlying soil. When clean-out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split barrel (split-spoon) sampler with the ball check valve removed as the clean out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the cleanout auger, a split-barrel sample can be taken to remove it. Bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions on the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the rig geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string; then to measure the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches for cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 MATERIALS OF CONSTRUCTION

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in FT-7.01. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods are procedures for their use must be provided by the site geologist and approved by the site manager. The specific slurry composition and the concentration of selected chemicals for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field at the judgment of the site geologist and noted in the Site Logbook, and only after approval by the site manager, a vegetable oil or silicone based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

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7.0 ATTACHMENTS

Attachment A - Drilling Equipment Sizes

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D. (in)	Coupling I.D. (in)
Hollow-Stem Augers (Ref 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	-
	7 1/4	6 1/4	3 1/4	-
	13 1/4	12	6	-
Thin Wall Tube Samplers (Ref 7)	-	2	1 7/8	-
	-	2 1/2	2 3/8	-
	-	3	2 7/8	-
	-	3 1/2	3 3/8	-
	-	4 1/2	4 3/8	-
	-	5	4 3/4	-
Drill Rods (Ref 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (in)
Driven External Coupled Extra Strong Steel* Casing (Ref 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (in)	O.D. (in)	I.D (in)	Coupling I.D. (in)
Flush Coupled Casing (Ref 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref 7)	EWM	1 1/2	7/8 **	
	AWM	1 7/8	1 1/8 **	
	BWM	2 3/8	1 5/8 **	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 X 3 7/8	3 7/8	2 11/16	
	4 X 5 1/2	5 1/2	3 15/16	
	6 X 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16 **	
	BQ (wireline)	2 23/64	1 7/16 **	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small diameter core (1 3/8") is not recommended.

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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite 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 HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) 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 Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

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

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

5.2.2 Color

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

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

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

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

5.2.3 Relative Density and Consistency

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

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.2. Those designations are:

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

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140 pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, and SC (see Exhibit 4-2).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Exhibit 4-3. Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Exhibit 4-2).

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 as follows:

Consistency	Unc. Compressive Str. Tons/Square Foot	Standard Penetration Resistance (Blows per 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
Very stiff	1.0 to 2.0	8 to 15	Readily indented by thumb
Hard	2.0 to 4.0	15 to 30	Readily indented by thumbnail
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail

5.2.4 Weight Percentages

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

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
trace	0 - 10 percent
some	11 - 30 percent
and or 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 Exhibit 4-4.

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, including sedimentary, igneous and metamorphic rocks. 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. ractures irregularly. Medium thick to thick bedded.

- Claystone - Vary 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. These include conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

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

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

5.3.1 Rock Type

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

Grain size is the basis for the classification of clastic sedimentary rocks. Exhibit 4-5 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a handlens, the rock is a siltstone. If the grains are not distinguishable with a handlens, the rock is a claystone.

5.3.2 Color

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

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

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification will also be used for rock classification.

5.3.4 Hardness

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

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

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

5.3.5 Fracturing

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

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

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

Method of Calculating RQD
(After Deere, 1964)

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

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

l = Total length of the coring run.

5.3.6 Weathering

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

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.

- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.

- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.

- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified)
- Description of any filled cavities or vugs.
- Cementation (calcoreous, 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 inch or less), probably continuous layer.

- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."

- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."

- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."

- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

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

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.

- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.

- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.

- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.

- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse grained dark igneous rock.

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

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

5.4 ABBREVIATIONS

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

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

5.5 BORING LOGS AND DOCUMENTATION

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceeding sections shall be used to complete the logs. A sample boring log has been provided as Exhibit 4-6. The field geologist/engineer shall use this example as a guide in completing each borings log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided on the back of the boring log, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.
- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology a 13.7 feet, shall be lined off at the proportional location between the 13 and 14 foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart of back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

- Enter color of the material in the appropriate column.

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

  - Trace 0 - 10 percent
  - Some 11 - 30 percent
  - And 31 - 50 percent

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

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

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

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

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, 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 HNu or OVA reading if applicable.

  - Indicate any change in lithology by drawing in line through the lithology change column and indicate the depth. This will help later on when cross-sections are 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 Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

  - Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokeness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of Rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

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

- Obtain cutting samples at approximately 5 foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date etc.). Cuttings shall be closely examined to determine general lithology.

- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.

- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.

- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.

- Record this and any other useful information onto the boring log as provided in Exhibit 4-1.

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.

EXHIBIT 4-1

BORING LOG ***NUS CORPORATION***

PROJECT: ..... BORING NO.: .....
PROJECT NO.: ..... DATE: ..... DRILLER: .....
ELEVATION: ..... FIELD GEOLOGIST: .....
WATER LEVEL DATA : .....
(Date, Time & Conditions) .....

SAMPLE NO. & TYPE OR ROD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR ROD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth,ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION			BORE LOCK SCREW CONES	REMARKS
					SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		

REMARKS _____

BORING _____

PAGE ____ OF ____

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" & basing fractions on estimated weights)	GROUP SYMBOL	TYPICAL NAMES
GRAVELS 50%(+)>¼"	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%(+)<¼"	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" & basing fractions on estimated weights)			GROUP SYMBOL	TYPICAL NAMES
	Identification procedures on fraction smaller than No. 40 sieve size				
	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
SILTS & 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 & 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 dense	11-30
Dense	31-50
Very dense	Over 50

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNC. COMPRESSIVE STR. 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 TERMS	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 TERMS	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" O.D. Split Barrel Sample
U - 3" O.D. Undisturbed Sample
O - Other Sampler, Specify in Remarks

ROCK SAMPLES - TYPES

N - 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 & Dept

EXHIBIT 4-2

EXHIBIT 4-3

CONSISTENCY FOR COHESIVE SOILS

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

EXHIBIT 4-4

BEDDING THICKNESS CLASSIFICATION

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

(Weir, 1973 and Ingram, 1954)

EXHIBIT 4-5

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

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-21-87 — DRILLER: B. GOLLIHUE
ELEVATION: 510.07 — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA (Date, Time & Conditions): WL 26.35 - TPVC 10-16-87

SAMPLE NO. & TYPE/ RQD	DEPTH (Ft.) / RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY / SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, Ft.) OR SCREEN INT	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR USCS	REMARKS
S-1	0.0	3/6	1.5/1.5		STIFF	BRN	CLAYEY SILT - TR SHALE	ML	0-6" TOPSOIL MOIST 0PPM
	1.5	6					FRAG - TR ORG.		RESIDUAL SOIL.
	5.0								
S-2	6.0	11/100/.5	0.8/1.0	5.5/6.0	M. SOFT	GRAY BRN	DEC SHALE AND SILT	VBR	DAMP 0PPM
					TO				REFUSAL @ 6' 5.5 TOP OF DEC ROCK
					M. HARD				AUGERED TO 15'. W/SOLID STEM AUG.
									CUTTING MOIST @ ≈8' WATER @ 11'±
									WL @ 12:10 PM WAS ≈ 9' FROM G.S.
									SET 4" PVC CAS. @ 15.0'
9-21	15.0								
9-22					M. HARD	BRN GRAY	SILTY SHALE - FEW	VBR	SEVERAL 0 PPM
							QUARTZ PCS		Fe STAINED JOINTS ON CORE
									THRUOUT RUN. JOINTS AND BREAKS
									ARE HORIZ TO LO ∠. W/VUGS ON LOWER
0.7/10.0	①	0%/0	7.9/10.0						PORTION 23 TO 25 OF CORE
	25.0								

REMARKS: ACKER AD II RIG - SOLID STEM AUGERS USED TO ADVANCE BORING - 140 LB WT & 30" DROP - TO TAKE 2" Φ SP. SPOON SAMPLES - SET UP OVER HOLE @ 11:10 AM. WILL SAMPLE THIS HOLE - SET 4" CASING THEN DO SHALLOW WELL. STARTED TO CORE 9-22-87 USING THE WIRE-LINE CORING METHOD.

* See Legend on Back

BORING MW 3A

PAGE 1 OF 3

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE
PROJECT NO.: 619Y
DATE: 9-22-87
BORING NO.: MW 3A
DRILLER: B. GOLLIHUE
ELEVATION:
FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA:
(Date, Time & Conditions)

	SAMPLE NO & TYPE RQD	DEPTH (Ft.) RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
9-22		25.0				M.HARD	GRAY	SILTY SHALE	VBR	SHALE IS VBR W/ HORIZ TO 1.0 & JNTS
								(SILTSTONE)		≈26 TO 27 2-VERT
								- FEW QUARTZ		JOINTS. IRON STAINS ON JNTS
								SEAMS		ROCK BECOMES AND BREAKS MORE LIKE
										A SILTSTONE WITH DEPTH.
	0/10.0	②	0%	8.7/10.0						
									BR	≈32 TO 33 FEW QUARTZ PIECES W/
									VBR	VUGS. SL. MICACEOUS
										VF QUARTZ GRAINS IN MATRIX - 30X MAG.
		35.0								≈34 TO 35 - 2 VERT JOINTS
						M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	35.0-35.5 QUARTZ PIECES
								- FEW QUARTZ	BR	
								SEAMS	VBR	BECOMES SL. CALCAR. @ 37± THIN CALCITE
										LAMINATIONS. WATER STAINED JNTS
									BR	THRUOUT RUN MORE SO 35-37±
	1-0/10.0	③	10%	9.3/10.0					VBR	39.5 → 42.0
										42.7 → 43.0 HI ∠ JNT
									BR	42.4 → 42.7 VERT JNT
		45.0							VBR	
										45.3 → 45.5 VERT JNT. & VBR
										47.5 VERT JOINT
									BR	48. HI ∠ JOINT
										SLIGHTLY CALCAREOUS MORE CALCITE
										PRESENT

REMARKS

BORING MW 3A

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* See Legend on Back

BORING LOG — **NUS CORPORATION**

PROJECT: HEBELKA SITE — BORING NO.: MW 3A
PROJECT NO.: 619Y — DATE: 9-22-87 — DRILLER: B. GOLLIHUE
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA
(Date, Time & Conditions)

SAMPLE NO. & TYPE	DEPTH (ft.)	BLOWS 6" OR ROD (ft.)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS	REMARKS
1.9/10.0	4	19%	10.0/10.0		M.HARD	GRAY	SILTY SHALE (SILTSTONE)	VBR	50.5 → 51.0 VBR
							SL. CALCAREOUS	BR	51.5 → 54.0 BR w/ SEV LO & JOINTS
	55.0								
								VBR	POOR RECOVERY w/ SOFT ZONES.
0/10	5	0%	1.8/10.0						
	65.0								
				66					
									68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
0/10	6	0%	1.3/10.0						POOR RECOVERY
									FEW CALCAREOUS ZONES.
	75.0			76					

REMARKS AT 75' @ 1:45 PM - PULLING TOOLS - TO REAM HOLE.
AT 1:50 PM. CORED HOLE TO 75' REAMED TWICE
DUE TO RUNNING SAND (FRACTURE) AT ≈ 68. REAMED
2ND TIME TO 81'. SET WELL 66'-76'.

BORING MW 3A
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* See Legend on Back

EXHIBIT 4-6

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473 Y — DATE: 7-7-87 — DRILLER: B ERICSON
ELEVATION: 1462.37 — FIELD GEOLOGIST: S.J CONTI — PENN - DRILL
WATER LEVEL DATA 5.54' @ 8:50 AM 7-23-87 T-PVC — ACKER AD-II
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (ft) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft) OR SCREEN INT.	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR USCS	REMARKS (HNU) (HEAD SP)
	0.0	5/3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDER	ML	MOIST (0PPM)
S-1		2					TR- COAL FRAG		3/4" Φ FRAG - NEAR OLD
							TR- CC FRAG		R.R. LINE.
							(FILL)		
	5.0					RED			
S-2		1/1	1.3/1.5	6.0	V. LOOSE	BRN TO	SANDY SILT - TR GRAVEL	SM	MOIST TO WET (0PPM)
	6.5	3				GRAY	SILTY SAND - TR GRAVEL		GRAY SAND @ 6' ±
									INCREASING 1.0X ± NATURAL
									DRILLER NOTE H2O 8-10'
	10.0								
S-3		11/23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (0PPM)
	11.5	27					FRAGS. (GRAVEL)		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		7/47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	GM	WET (0PPM)
	16.5	43					AND GRAVEL		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	20.0								
S-5	20.9	17/50/6"	.6/.9		V. DENSE	ORANG BRN	SILTY SAND - SOME	GM	WET (0PPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM
									OF SAMPLE

REMARKS START @ 1:15 PM - 7-7-87 USING 4 1/4" ID HOLLOW STEMS
S-4 @ 3:30 PM TO ADVANCE THE BORING USING
S-5 @ 4:30 PM ACKER DRILL - MOUNTED ON FORD 8000 TRUCK

SAMPLES TAKEN USING 140 lb WT AND 30 INCH DROP.

BORING MW 013

PAGE 1 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 473Y — DATE: 7-7-87 — DRILLER: E EDISON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA: (Date, Time & Conditions)

	SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth, ft.) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	GRAPHICS ROCK OR USCS	REMARKS (HNU)
	S-6	25.0	6/17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	GM	DRY 0 PPM
		26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS FRIABLE FIRST SHOWS IN
								TR. SS. FRAG		COLOR. NOT ENOUGH CLAY TO BE CONFINING
										NOTE: MAY SET ZONE 2
7/7		30.0					MOTTLED			CASING @ 28'
7/8	S-7		17/27	1.4/1.5		V. DENSE	BRN BLUE GRAY	SILTY SAND - SOME GRAVEL	SM/GM	MOIST > DRY (OPPM)
		31.5	36					TR. SS. FRAG		COHESIVE IS BLUE GRAY & FRIABLE.
								TR CLAY		SUBROUNDED GRAVEL
										NOT HIGH CLAY - BUT MAY BE SEMI-CONFINING.
		35.0								
	S-8	35.9	30/50/4	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/GM	MOIST → WET (OPPM)
								SOME GRAVEL		V. SL. TR. CLAY - LESS
								TR. SS. FRAG.		THAN S-7 1" Ø FRAG - MORE
										DENSE. SAND THAN ABOVE.
		40.0					BLUE			POSSIBLE 35 TO 45 SCREEN LOC. SQUEEZED
	S-9		31/34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	HOLES TOGETHER WHEN MOIST → WET (OPPM)
		41.5	24					SOME GRAVEL - TR	GM	LITTLE MORE CLAY THAN
								CLAY		S-8 SUBROUNDED GRAVEL
										VERY SLOW DRILLING 40-45 (RIG STALLS)
		45.0					BLUE			LESS CLAY LAST 3" OF SAMPLE
	S-10		13/34	1.2/1.5		V. DENSE	BRN GRAY	SILTY SAND (FINE TO M.)	SM	MOIST → WET (OPPM)
		46.5	50					SOME GRAVEL - TR	GM	1" Ø SIZE - HOLDS TOGETHER WHEN SQUEEZED
								CLAY		BUT NOT COHESIVE CLASSIFICATION
										SLOW DRILLING TO 50'

REMARKS S-6 @ 4:40 PM
S-8 @ 8:36 AM 7-8-87
S-10 @ 10:40 AM S-11 @

BORING MW013

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BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473Y — DATE: 7-8-87 — DRILLER: B. ERICSON
ELEVATION: — FIELD GEOLOGIST: SJ CONTI
WATER LEVEL DATA: (Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.) OR SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR SOIL USCS	REMARKS
S-11	50.0	15 / 41	1.9/1.3		V. DENSE	MOTTLED BLUE	SILTY SAND - SOME GR.	SM	MOIST - (OPPM)
	51.3	50/.3				BRN GRAY	TR CLAY	SM	MOTTLED W/ PCS OF BLACK COAL/LIGNITE
									MORE CLAY THAN ABOVE PORTIONS OF SAMPLE - COHESIVE CLASSIF.
	55.0			55.0					
S-12		11 / 15 / 26	1.1/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND SOME GRAVEL	SC	MOIST → WET (OPPM)
	56.5								NOTE COLOR CHANGE ALSO - MORE CLAY THAN ANY SAMPLE - SUB-ROUNDED GRAINS
									FIRST COHESIVE TYPE CLASSIF.
	60.0	40							
S-13	60.9	50/.4	0.7/0.9		V. DENSE	ORANG BRN	SANDY CLAY / CLAYEY SAND - SOME GRAVEL	SC / GW	MOIST → WET (OPPM)
									NOT AS MUCH CLAY AS S-12 BUT VERY COHESIVE. SUBROUNDED GRAINS
									SET CAS. @ 62'.
	65.0								
7/13 S-14	65.8	37 / 50/.3	0.7/0.8		V. DENSE	BRN ORANG	SILTY SAND - SOME GR. AND ROCK FRAG -	SM / GW	MOIST (OPPM)
									MORE CLAY TOWARDS TOP OF SAMPLE MAX 3/4" D SIZE
				68.0			TR. CLAY		
						YELLOW BRN			COLOR CHANGE AT ≈ 68' MORE SAND PER DRILLER - BOTH OF SEMI CONF LAYER ?
	70.0								
7/14 S-15		39 / 39 / 41	1.9/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO C.) SOME GRAVEL - TR ROCK FRAG.	SC / GC	MOIST → WET (OPPM)
	71.5								1" MAX GRAVEL
									MORE GRAVEL @ 72' PER DRILLER

REMARKS: USING HOLLOW STEM TO ADVANCE BORING - WASHING OUT THRU AUGERS, WHEN DEEPER TO OBTAIN SAMPLE
S-12 @ 1:46 PM
S-13 → 3:32 PM - LOGGED IN BY 3:47 PM
SET 6" Φ STEEL CASING TO 62' - WILL DRILL BELOW CASING AFTER GROUT SETS UP. S-14 @ 3:20 PM 7-13-87
S-15 - 7:57 AM 7-14-87

BORING MW 013
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BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 437Y — DATE: 7-13-87 / 7-14-87 — DRILLER: B. ERICSON
ELEVATION: — FIELD GEOLOGIST: S.J. CONTI
WATER LEVEL DATA:
(Date, Time & Conditions)

SAMPLE NO. & TYPE OR RQD	DEPTH (Ft.) OR RUN NO	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth (ft.) OR SCR. INT)	MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR BRIGHTNESS USCS	REMARKS (HNU)
S-16	75.0	28 50/.5	0.9/1.0	75	V. DENSE	GRAY ORANG BRN	FINE TO C. CLAYEY SAND - SOME	SC	WET (0PPM)
	76.0						GRAVEL - TR		NOT AS MUCH CLAY AS S-15 - BOTM OF
							ROCK FRAG (S.S.)		SAMPLE BECOMES MORE SANDY
									MAX 1" Ø RC.
	80.0								NO SAMPLE @ 80'-
									DECIDED TO GO TO 85'.
	85.0	50/.4	0.4/0.4		V. DENSE	GRAY ORANG BRN	SILTY F. TO C. SAND - SOME	GW	WET (0PPM)
S-17	85.4			85			GRAVEL - TR		SUBROUNDED GRAINS
							S.S. FRAG - TR		V. SL. TR CLAY - WILL
							CLAY		SET SCREEN ~ 75' TO 85' IN THIS
									BORING.
							BOTM OF HOLE		
							@ 85.0'		

REMARKS: S-17 @ 2:20 PM 7-14-87 - METHOD BELOW 6" CASING SPUN 4" Ø - 5 7/8" OD CASING TO BOTM. USING WATER AS DRILLING FLUID

BORING MW 013

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NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.6	Page 1 of 3
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS		Approved D. Senovich	

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2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES

6.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the appropriate procedures to be followed when conducting decontamination activities of drilling equipment and monitoring well materials used during field investigations.

2.0 SCOPE

This procedure addresses only drilling equipment and monitoring well materials decontamination, and shall not be considered for use with chemical sampling and field analytical equipment decontamination.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for ensuring that project specific plans and the implementation of field investigations are in compliance with these procedures.

5.0 PROCEDURES

To insure that analytical chemical results are reflective of the actual concentrations present at sampling locations, various drilling equipment involved in field investigations must be properly decontaminated. This will minimize the potential for cross-contamination between sampling locations, and the transfer of contamination off site.

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 sample. 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.

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-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

In certain cases, due to budget constraints, 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. The location of the steam cleaning area shall be on site in order to minimize potential impacts at certain sites.

Guidance to be used when decontaminating 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.

Rinsate samples of well casing and screens may be necessary if specifically required for a given site. If required, at least 1 percent, and no more than 5 percent of steam cleaned lengths of casing and screens combined shall be sampled.

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. A drilling rig left at the drilling location does not need to be steam cleaned until it is finished drilling at that location.

6.0 RECORDS

None.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.7	Page 1 of 17
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject GROUNDWATER MONITORING POINT INSTALLATION		Approved D. Senovich	

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6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

This procedure describes methods for proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of permanent monitoring wells at hazardous waste sites. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be ascertained during the development of the investigation and any required permits which may have to be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is properly screened (if screening is necessary), cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored.

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

Potentiometric Surface - The surface to which water in an aquifer would rise by hydrostatic pressure.

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

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force to perform all phases of proper monitoring well installation and construction. He may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Rig Geologist - The rig geologist supervises well installation and construction by the Driller, documents all phases of well installation and construction, and insures that well construction is adequate to provide representative ground water data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed while 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 engineers 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, these can be determined through the review of geologic data and the site terrain. In addition, 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 phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored internal 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. Conversly, a fully penetrating well is usually not used to quantify or vertically locate a contamination 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 water bearing zone. The well diameter would depend upon the hydraulic characteristics of the water bearing zone. Sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following information:

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

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

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

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

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

Casing Inside Diameter, Inch	Standing Water Depth to Obtain 1 Gal Water (feet)	Total Depth of Standing Water for 4 Gal. (feet)
2	6.13	25
4	1.53	6
6	0.68	3

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

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

5.2.2 Riser Pipe and Screen Materials

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

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials in which 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 discussion on this topic). The two most commonly used materials are PVC and stainless steel for wells in which screens are installed and 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 to be used 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 recommended for metal analyses, as zinc and cadmium levels in groundwater samples may be elevated from the zinc coating.

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

When the water bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary and the screened interval is artificially packed with a fine sand. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The rig geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. (For example, as a standard procedure, a Morie No. 1 or Ottowa sand may be used with a 0.010-inch slot screen, however, with a 0.020-inch slot screen, the filter pack material must be the material retained on a No. 20 to No. 30 U.S. standard sieve.)

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a fine to medium grained well graded, silica sand. The quantity of sand placed in the annular space is dependent upon the length of the screened interval but should always extend at least 1 foot above the top of the screen. At least one to three feet of bentonite pellets or equivalent shall be placed above the sand pack. The cement-bentonite grout or equivalent extends from the top of the bentonite pellets to the ground surface.

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

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

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of two assemblages of material, i.e., a cement-bentonite grout. A cement bentonite grout normally is a mixture of cement, bentonite and water at a ratio of one 90-pound bag of Portland Type I cement, 3-5 pounds of granular or flake-type bentonite and 6 gallons of water. A neat cement is made up of one ninety-pound bag of Portland Type I cement and 6 gallons of water.

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

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is often placed over the top for 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.

A 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 5 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 set 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.

5.3 MONITORING WELL INSTALLATION

5.3.1 Monitoring Wells in Unconsolidated Sediments

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

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineers rule to ensure proper well placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, then the sand pack can be installed. A weighted tape measure must be used during the procedure in order to carefully monitor installation progress. The sand is poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur.

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

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

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

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large diameter boring through the upper aquifer, 1 to 3 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting the outer casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells, with the exception of not using a temporary casing during installation. Sufficient time which will be determined by the rig geologist, must be allowed for setting of the grout prior to drilling through the confined layer. A typical confining layer monitoring well sheet is shown in Attachment C.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 feet into the bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout is cured, a smaller diameter boring is continued through the bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. However, if a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be installed temporary until final well installation is completed. Typical well construction forms for bedrock monitoring wells are shown in Attachment C.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be driven to depths exceeding 10 feet.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only one or two small-diameter tubes extending to the surface. Manufacturers of these types of samplers claim that four samplers can be installed in a 3-inch diameter borehole. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross contamination from sampling equipment. These samplers also perform well when the water table is within 25 feet from the surface (the typical range of suction pumps). Two manufacturers of these samplers are Timco Manufacturing Company, Inc., of

Prairie du Sac, Wisconsin, and BARCAD Systems, Inc., of Concord, Massachusetts. Each offers various construction materials.

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

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

5.4 WELL DEVELOPMENT METHODS

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

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

Surging with a Surge Plunger - A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is used to agitate the water, causing it to move in and out of the screens. This movement of water rpulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Compressed Air - Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level

to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping the well is subsequently done with the air lift method.

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

6.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989 p.

7.0 RECORDS

A critical part of monitoring well installation is recording of significant details and events in the field notebook. The Geologist must record the exact depths of significant hydrogeological features screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (Attachment C) shall be used which allows the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information (shall) include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. The documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded.depending on whether the well is completed in overburden, 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 determine the driller's final fee.

ATTACHMENT A

TABLE 7-4 RELATIVE COMPATIBILITY OF RIGID WELL-CASING MATERIAL (PERCENT)

	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless steel 304	Stainless steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Miner Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials

1 Teflon®
2 Stainless Steel 316
3 Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel
* Trademark of DuPont

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

	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/High Solids	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials

1 Teflon®
2 Polypropylene (PP)
3 PVC flexible/PE linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene
Source: Barcelona et al., 1983
* Trademark of DuPont

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 not critical.
Weight	Relatively heavier	Lightweight, 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 HC
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work in the field.
Preparation for Use	Should be steam-cleaned for organics sampling	Never use glue fittings--pipes should be threaded or pressure-fitted. Should be steam cleaned if 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.

ATTACHMENT C

NUS CORPORATION
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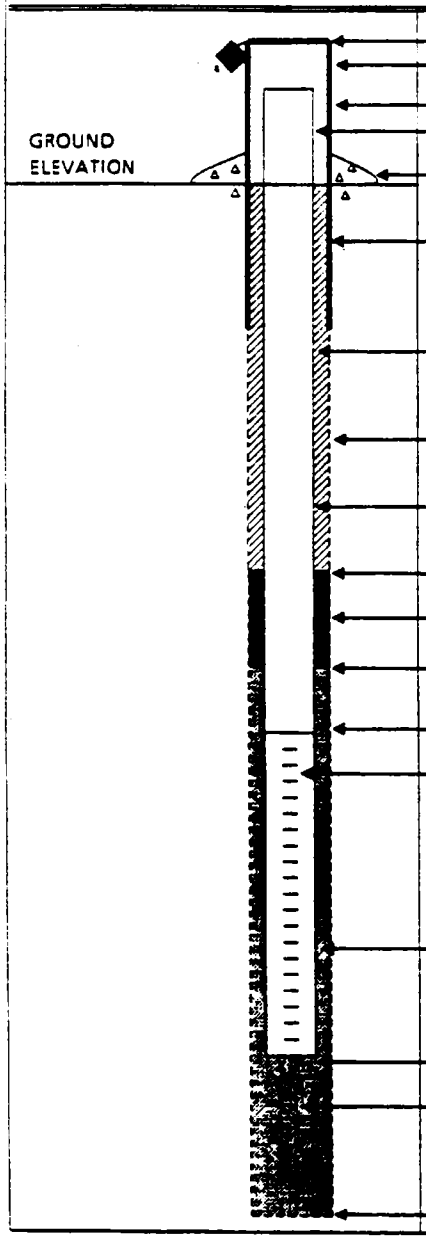
BORING NO _____

OVERBURDEN
MONITORING WELL SHEET

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



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

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

TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____

TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION / DEPTH TOP OF SCREEN: _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

I.D. OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE TWO

NUS CORPORATION

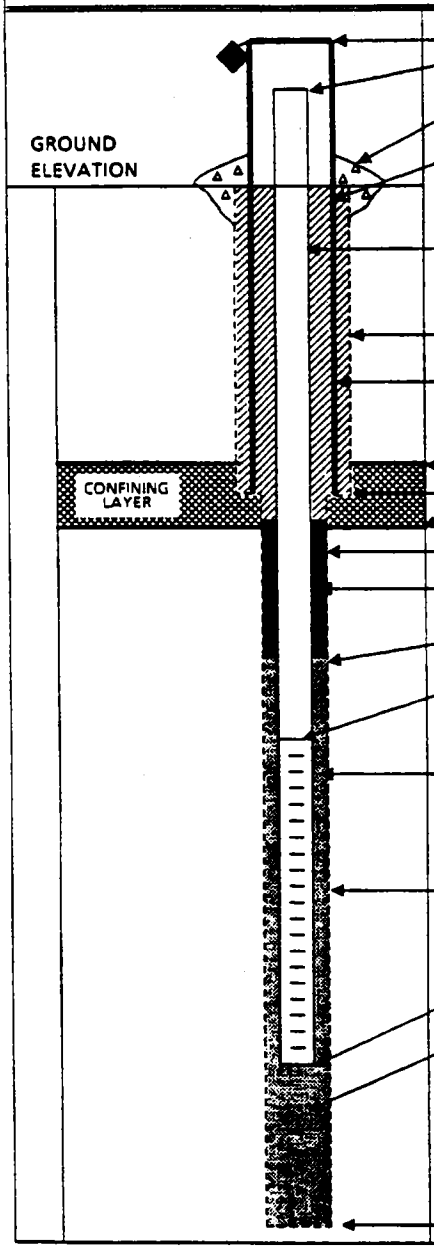
BORING NO.: _____

CONFINING LAYER
MONITORING WELL SHEET

11/5/87

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF PERM. CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____

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

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

BOREHOLE DIAMETER: _____

PERM. CASING I.D. _____
TYPE OF CASING & BACKFILL: _____

ELEVATION / DEPTH TOP CONFINING LAYER: _____
ELEVATION / DEPTH BOTTOM OF CASING: _____
ELEVATION / DEPTH BOT. CONFINING LAYER: _____

ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____

DEPTH TOP OF SAND PACK: _____

ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____

TYPE OF SAND PACK: _____

BOREHOLE DIA. BELOW CASING: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE THREE

NUS CORPORATION
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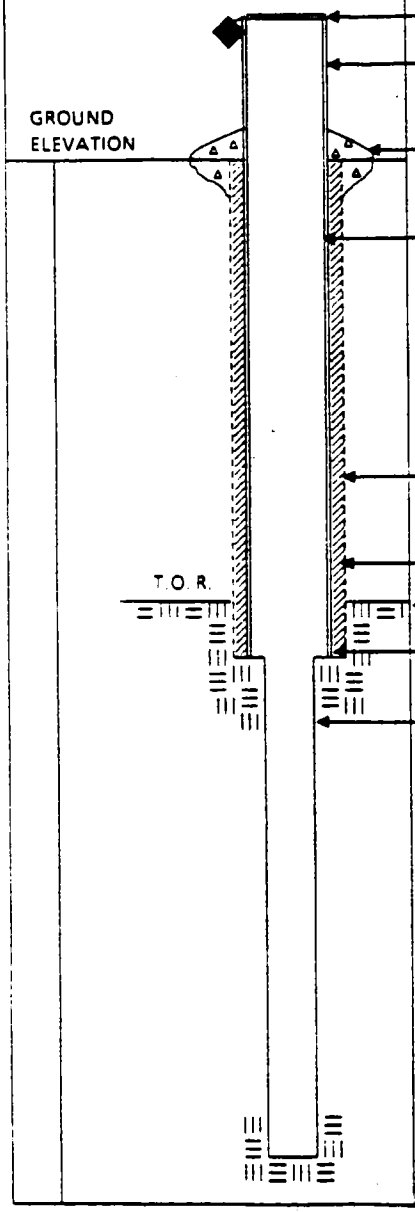
BORING NO.: _____

BEDROCK MONITORING WELL SHEET
OPEN HOLE WELL

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF CASING: _____

STICK UP OF CASING ABOVE GROUND SURFACE: _____

TYPE OF SURFACE SEAL: _____

I.D. OF CASING: _____

TYPE OF CASING: _____

TEMP. / PERM.: _____

DIAMETER OF HOLE: _____

TYPE OF CASING SEAL: _____

DEPTH TO TOP OF ROCK: _____

DEPTH TO BOTTOM CASING: _____

DIAMETER OF HOLE IN BEDROCK: _____

DESCRIBE IF CORE / REAMED WITH BIT:

_____

DESCRIBE JOINTS IN BEDROCK AND DEPTH:

_____

ELEVATION / DEPTH OF HOLE: _____

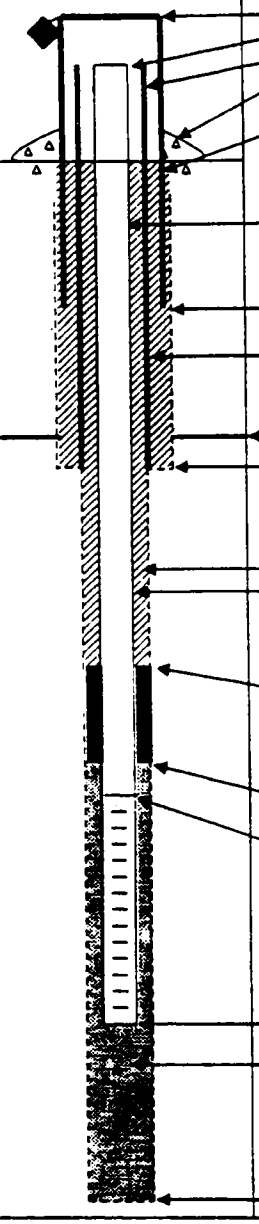
ATTACHMENT C
PAGE FOUR

BORING NO.: _____

BEDROCK
MONITORING WELL SHEET
WELL INSTALLED IN BEDROCK

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

DRILLER _____
DRILLING METHOD _____
DEVELOPMENT METHOD _____



ELEVATION OF TOP OF SURFACE CASING : _____
ELEVATION OF TOP OF RISER PIPE: _____
ELEVATION TOP OF PERM. CASING: _____
TYPE OF SURFACE SEAL: _____

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

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

BOREHOLE DIAMETER: _____

PERM. CASING I.D. _____
TYPE OF CASING & BACKFILL: _____

ELEVATION / DEPTH TO BEDROCK: _____
ELEVATION/DEPTH BOTTOM OF CASING: _____

BOREHOLE DIA. BELOW CASING: _____
TYPE OF BACKFILL: _____

ELEVATION / DEPTH TOP OF SEAL: _____
TYPE OF SEAL: _____

ELEVATION / DEPTH TOP OF SAND PACK: _____

ELEVATION/DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____

TYPE OF SAND PACK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: _____

ELEVATION / DEPTH BOTTOM OF SAND PACK: _____
TYPE OF BACKFILL BELOW OBSERVATION WELL: _____

ELEVATION / DEPTH OF HOLE: _____

ATTACHMENT C
PAGE FIVE

NUS CORPORATION
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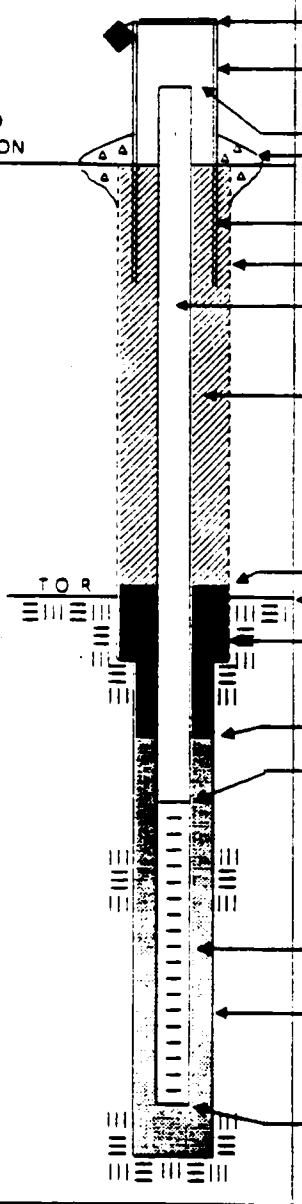
BORING NO _____

BEDROCK MONITORING WELL SHEET

WELL INSTALLED IN BEDROCK

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



ELEVATION OF TOP OF SURFACE CASING: _____
STICK UP OF CASING ABOVE GROUND SURFACE: _____
ELEVATION TOP OF RISER: _____
TYPE OF SURFACE SEAL: _____
I.D. OF SURFACE CASING: _____
DIAMETER OF HOLE: _____
RISER PIPE I.D. _____
TYPE OF RISER PIPE: _____
TYPE OF BACKFILL: _____
ELEVATION / DEPTH TOP OF SEAL: _____
ELEVATION / DEPTH TOP OF BEDROCK: _____
TYPE OF SEAL: _____
ELEVATION / DEPTH TOP OF SAND: _____
ELEVATION / DEPTH TOP OF SCREEN: _____
TYPE OF SCREEN: _____
SLOT SIZE x LENGTH: _____
I.D. SCREEN: _____
TYPE OF SAND PACK: _____
DIAMETER OF HOLE IN BEDROCK:
CORE / REAM: _____
ELEVATION / DEPTH BOTTOM SCREEN: _____
ELEVATION / DEPTH BOTTOM OF HOLE: _____

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-2.4	Page 1 of 7
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject IN-SITU HYDRAULIC CONDUCTIVITY TESTING		Approved D. Senovich	

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1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly describe :

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are less accurate than pumping tests, as a much more localized area is involved, so a number of slug tests are performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests in regards to the quality of data obtained and time/cost considerations. A disadvantage to constant-head tests is that a significant volume of water may be added to the formation, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity x saturated thickness.

Slug-test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

The project geologist shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project geologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

The field geologist is responsible for performing the planned field tests as specified in the planning documents, or as directed by the project geologist shall the field program require modification, and generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies required and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN WELLS

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume to change the water level (slug test) is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system, which might raise doubts regarding the representativeness of future groundwater samples. A bailer or pump can be used to withdraw water from the well. (If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery.) Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow

recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape, coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water levels need to be taken during the performance of a slug test.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well and boring radii
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data
- Gravel pack porosity

A variation of the slug test is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level, and is called a constant-head test. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements shall be recorded in place of time/recovery data for approximately 10 to 20 minutes, then the hydraulic conductivity calculated from this. This type of test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN BORINGS

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies with drilling, geologic, and general site conditions and shall be selected after a careful evaluation of the above factors.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level shall be measured and recorded. The water level shall then be raised (falling head test) or lowered (rising head test) and the change in water level measured at time intervals as determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water-level measurements will vary according to the formation's hydraulic conductivity. The faster the rate

of recovery expected, the shorter the time intervals between measurements shall be. A predetermined pattern of time intervals shall be used during each test. The rate of change of water level will be used to calculate hydraulic conductivity. The test shall be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method consists of placing a temporary well with a short screen into the cleaned out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. this method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity calculated from this. This method is the most accurate method depicted in this section and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 DATA ANALYSIS

There are a number of data analysis methods available for use to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973), have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/ piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, factors in partial/full penetration, and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling-head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) may be used as the

screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project file.

6.0 REFERENCES

Cedergren, H. R., 1967. Seepage, Drainage, and Flow Nets. John Wiley and Sons Inc., New York, pp. 78-76.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos, 1967. Response of a Finite-Diameter Well to an Instantaneous Change of Water. Water Resources Research, V. 3, No. 1, pp. 263-269.

Hvorslev, M. J., 1951. Time Lag and Soil Permeability in Ground Water Observations. U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D.C., Bull. No. 36.

Papadopulos, I. S., J. D. Bredehoeft, and H. H. Cooper, 1973. On the Analysis of Slug Test Data. Water Resources Research, V. 9, No. 4, pp. 1087-1089.

Bouwer, H. and R. C. Rice, 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells." Water Resources Research, 12:423-28.

United States Department of the Interior, 1981. Ground Water Manual. U.S. Government Printing Office, Denver, Colorado.

7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A*. Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the field logbook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the field logbook.

* If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

ATTACHMENT A
HYDRUALIC CONDUCTIVITY TESTING DATA SHEET

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET ***NUS CORPORATION***

PROJECT NAME: ..... WELL/BORING NO.: .....
PROJECT NO.: ..... GEOLOGIST: .....
WELL DIAMETER: ..... SCREEN LENGTH/DEPTH: ..... TEST NO.: .....
STATIC WATER LEVEL (Depth/Elevation): ...../..... DATE: .....
TEST TYPE (Rising/Falling/Constant Head): ..... CHECKED: .....
METHOD OF INDUCING WATER LEVEL CHANGE: ..... PAGE ___ OF ___

TIME	ELAPSED TIME (min. or sec.)	MEASURED DEPTH TO WATER (ft.)	CORRECTION	DEPTH TO WATER (ft.)	DRAWDOWN OR HEAD (ft.)	REMARKS

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		Applicability EMG	
		Prepared Earth Sciences	
Subject GROUNDWATER SAMPLE ACQUISITION		Approved D. Senovich	

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Hydrogeologist or Geochemist - responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, documenting these in the Project Operations Plan (POP), and properly briefing the site sampling personnel.

Site Geologist - The Site Geologist is primarily responsible for the proper acquisition of the groundwater samples. When appropriate, such responsibilities may be performed by other qualified personnel (engineers, field technicians).

Site Manager - The Site Manager is responsible for reviewing the sampling procedures used by the field crew and for performing in-field spot checks for proper sampling procedures.

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 testing 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 for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, 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 preferred.

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, 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 decreases. 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 may be used to collect the sample for chemical analysis.

- The inlet line of the sampling pump (or the submersible pump itself) shall be placed near the bottom of the screened section, and approximately one casing volume of water shall be pumped from the well at a rate equal to the well's recovery rate.

Stratification of contaminants may exist in the aquifer formation, both in terms of a concentration gradients due to mixing and dispersion processes in a homogeneous layer, and in layers of variable permeability into which a greater or lesser amount of the contaminant plume has flowed. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, and thus result in the collection of a non-representative sample.

5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

Sample containers shall conform with EPA regulations for the appropriate contaminants.

The following equipment shall be on hand when sampling ground water wells:

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate packing containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Thermometer; pH paper/meter; camera and film; tags; appropriate keys (for locked wells); engineers rule; water-level indicator; where applicable, specific-conductivity meter.

- Pumps

  - Shallow-well pumps--Centrifugal, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps--submersible pump and electrical power generating unit, or air-lift apparatus where applicable.

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

- Pails - Plastic, graduated.

- Decontamination solutions - Distilled water, Alconox, methanol, acetone.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, sterilized, and reused, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well flushing and sample collection.

5.3 CALCULATIONS OF WELL VOLUME

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the field logbook and on the field data form (Attachment A):

- 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 (if not known from past records) 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 ($V = 0.163Tr^2$).

  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.

- Determine the minimum amount to be evacuated before sampling.

5.4 EVACUATION OF STATIC WATER (PURGING)

5.4.1 General

The amount of flushing 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, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from other areas. Generally three to five well volumes are considered effective for purging a well.

The site hydrogeologist, geochemist and risk assessment personnel shall define the objectives of the groundwater sampling program in the Work Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment B provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

5.4.2.1 Bailers

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

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- There is minimal outgassing of volatile organics while the sample is in the bailer.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

5.4.2.2 Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (therefore not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

5.4.2.3 Gas-Lift Samplers

This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics.

5.4.2.4 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 is difficult and time-consuming.

5.5 SAMPLING

5.5.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the POP prior to the field work:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

- Sample preservation requirements.

- Working schedule.

- List of team members.

- List of observers and contacts.

- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.5.2 Sampling Methods

The collection of a groundwater sample is made up of the following steps:

1. HSO or designee will first open the well cap and use volatile organic detection equipment (HNU or OVA) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data in a well sampling data sheet (Attachment A); then calculate the fluid volume in the well pipe.

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select appropriate purging equipment (see Attachment B). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower 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. Lower the purging device, as required, to maintain submergence.

6. Measure rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters.

7. Observe 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.

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 sampling level before filling (this requires use of other than a 'bucket-type' bailer).

Purged water shall be collected in a designated container and disposed of in an acceptable manner.

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. 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), sample collection can be delayed until the following day. If the well has been bailed 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 in the logbook.

12. Add preservative if required. Label, tag, and number the sample bottle(s).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping. Attach a custody seal to the front and back of the shipping package. Make sure that traffic reports and chain-of-custody forms are properly filled out and enclosed or attached.

15. Decontaminate all equipment

5.5.3 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory.

5.5.4 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. Procedure SF-1.2 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Procedure SA-4.3 describes the preservation requirement for microbial samples.

5.5.5 Handling and Transporting Samples

After collection, samples shall be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it shall be bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged and thus possibly become cross-contaminated. All sample containers shall be enclosed in plastic bags or cans to prevent cross-contamination. Samples shall be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SA-6.2.

5.5.6 Sample Holding Times

Holding times (i.e. allowed time between sample collection and analysis) for routine samples are given in Procedure SF-1.2.

5.6 RECORDS

Records will be maintained for each sample that is taken. The sample log sheet will be used to record the following information:

- Sample identification (site name, location, project number; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Purge data - prior to removal of each casing volume and before sampling, pH, electrical conductance, temperature, color, and turbidity shall be measured and recorded.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method).
- Sample disposition (preservatives added; lab sent to, date and time; lab sample number, EPA Traffic Report or Special Analytical Services number, chain-of-custody number.
- Additional remarks - (e.g., sampled in conjunction with state, county, local regulatory authorities; samples for specific conductance value only; sampled for key indicator analysis; etc.).

5.7 CHAIN-OF-CUSTODY

Proper chain-of-custody procedures play a crucial role in data gathering. Procedure SA-6.1 describes the requirements for a correct chain-of-custody.

6.0 REFERENCES

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7.0 ATTACHMENTS

Attachment A - Well Sampling Data Sheet
Attachment B - Purging Equipment Selection

ATTACHMENT A
SAMPLE LOG SHEET

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SAMPLE LOG SHEET

- ☐ Monitoring Well Data
- ☐ Domestic Well Data
- ☐ Other _____

Page _____ of _____

Case # _____

By _____

Project Site Name _____ Project Site Number _____

NUS Source No. _____ Source Location _____

Total Well Depth:	Purge Data				
Well Casing Size & Depth:	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level:					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.)					
Total Amount Purged (gal.):					
Monitor Reading:					
Purge Method:					
Sample Method:					
Depth Sampled:					
Sample Date & Time:	Sample Data				
	pH	S.C.	Temp. (°C)	Color & Turbidity	
Sampled By:					
Signature(s):	Observations / Notes:				

Type of Sample
- ☐ Low Concentration
- ☐ High Concentration
- ☐ Grab
- ☐ Composite
- ☐ Grab - Composite

Analysis:	Preservative		Organic	Inorganic
		Traffic Report #		
		Tag #		
		AB #		
		Date Shipped		
		Time Shipped		
		Lab		
		Volume		

ATTACHMENT B
PURGING EQUIPMENT SELECTION

Purging Equipment Selection

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-inch								
Water level <25 ft		X	X	X	X			
Water level >25 ft				X				
2-inch								
Water level <25 ft	X	X	X	X	X	X		
Water level >25 ft	X			X		X		
4-inch								
Water level <25 ft	X	X	X	X	X	X	X	X
Water level >25 ft	X			X		X	X	X
6-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X
8-inch								
Water level <25 ft				X	X		X	X
Water level >25 ft				X			X	X

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & 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 ft 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	1076 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	app. 1 liter for each 10 ft 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	0-2800 mL/min	1500-3000	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 vol.	1100	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, Delrin® acetal	0-150	0-7500 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	0-4500 mL/min	3500	DC operated
Leonard Mold and Die Works, Inc.	GeoFilter Small Dia. Well Pump (#0500)	portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3500 mL/min	1400-1500	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, Delrin®	no limit	app. 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	0-2000 mL/min	300-400	requires compressed gas; piezometric level indicator; other materials available

Source: Barcelona et al., 1983

Manufacturer	Model name/ number	Principle of operation	Maximum outside diameter/length (inches)	Construction materials (w/lines & tubing)	Lift range (ft)	Delivery rates or volumes	1982 price (dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	portable; peristaltic (suction)	<0.5/N/A	(not submersible) rubber, Tygon®, or Neoprene®	0-30	see comments	1200-1300	flow rate dependent on motor and tubing selected, AC operated; other models available
Robert Bennett Co.	Model 180	portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin®, PP, Viton®, acrylic, PE	0-500	0-1800 mL/min	2600-2700	requires compressed gas; water level indicator and flow meter; custom models available
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1100	250 mL/flushing cycle	250-350	requires compressed gas; SS available; piezometer model available; dedicated model available
Solinst Canada Ltd.	5W Water Sampler	portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	600 mL	1300-1800	requires compressed gas; custom models available
TIMCO Mfg. Co., Inc.	Std. Bailer	portable; grab (positive displacement)	1.66/ custom	PVC, PP	no limit	250 mL/ft of bailer	20-60	other sizes, materials, models available; optional bottom-emptying device available; no solvents used
TIMCO	Air or Gas Lift Sampler	portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	100-200	requires compressed gas; other sizes, materials, models available; no solvents used
Tote Devices Co.	Sampling Pump	portable, bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4000 mL/min	800-1000	compressed gas required; DC control module; custom built

Construction Materials Abbreviations

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
SS	Stainless Steel
PC	Polycarbonate
EPDM	Ethylene-Propylene Diene (synthetic rubber)

Other Abbreviations

NA	Not Applicable
AC	Alternating Current
DC	Direct Current

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

Source: Barcelona et al., 1983

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1.0 PURPOSE

This procedure describes methods and equipment commonly-used for collecting environmental samples of surface water and aquatic sediment for either on-site examination and chemical testing or for laboratory analysis.

2.0 SCOPE

The information presented in this guideline is generally applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.4), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions and equipment different from those described herein.

3.0 GLOSSARY

Environmental Sample - low concentration sample typically collected offsite and not requiring DOT hazardous waste labeling or CLP handling as a high concentration sample.

Hazardous Waste Sample - medium to high concentration sample (e.g., source material, sludge, leachate) requiring DOT labeling and CLP handling as a high concentration sample.

4.0 RESPONSIBILITIES

Field Operations Leader - has overall responsibility for the correct implementation of surface water and sediment sampling activities, including review of the sampling plan with, and any necessary training of, the sampling technician(s). The actual collection, packaging, documentation (sample label and log sheet, chain-of-custody record, CLP traffic reports, etc.) and initial custody of samples will be the responsibility of the sampling technician(s).

5.0 PROCEDURES

5.1 INTRODUCTION

Collecting a representative sample from surface water or sediments is difficult because of water movement, stratification or patchiness. To collect representative samples, one must standardize sampling bias related to site selection; sampling frequency; sample collection; sampling devices; and sample handling, preservation, and identification.

Representativeness is a qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important quality not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been taken. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are not better than the confidence that can be placed in the representativeness of the samples.

5.2 DEFINING THE SAMPLING PROGRAM

Many factors must be considered in developing a sampling program for surface water or sediments including study objectives; accessibility; site topography; flow, mixing and other physical characteristics of the water body; point and diffuse sources of contamination; and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on the vertical and lateral mixing within the body of water. For sediments, dispersion depends on bottom current or flow characteristics, sediment characteristics (density, size) and geochemical properties (which affect an adsorption/desorption). The hydrologist developing the sampling plan must therefore, know not only the mixing characteristics of streams and lakes, but also must understand the role of fluvial-sediment transport, deposition, and chemical sorption.

5.2.1 Sampling Program Objectives

The objective of surface water sampling is to determine the surface water quality entering, leaving or remaining within the site. The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or in a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., spills). The major pathways for surface water contamination (not including airborne deposition are: (a) overland runoff; (b) leachate influx to the waterbody; (c) direct waste disposal (solid or liquid) into the water body; and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) which encompass the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the location of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc., shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation are: (1) move the site far enough downstream to allow for adequate mixing, or (2) collect integrated samples in a cross section. Also, nonhomogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to be absorbed by particulate matter. Nitrogen, phosphorus, and the heavy metals may also be transported by particulates. Samples will be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

5.2.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and description of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes and reservoirs, as well as those on larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Sampling in marshes or tidal areas may require the use of an all-terrain-vehicle (ATV). The same precautions mentioned above with regard to sediment disturbance will apply.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed in order to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of streamflow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Streamflow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrologist shall explore the possibility of obtaining streamflow data by direct or indirect methods.

5.2.3 Frequency of Sampling

The sampling frequency and the objectives of the sampling event will be defined by the work plan. For single-event site- or area-characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of the contaminant between the solid and aqueous phases it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes, consisting of repetitive, continuing measurements to define variations and trends at a given location, water samples shall be collected at a pre-established and constant interval as specified in the work plan (often monthly or quarterly) and during droughts and floods. Samples of bottom material shall be collected from fresh deposits at least yearly, and preferably during both spring and fall seasons.

The variability in available water-quality data shall be evaluated before deciding on the number and collection frequency of samples required to maintain an effective monitoring program.

5.3 SURFACE WATER SAMPLE COLLECTION

5.3.1 Streams, Rivers, Outfalls and Drainage Features (Ditches, Culverts)

Methods for sampling streams, rivers, outfalls and drainage features at a single point vary from the simplest of hand sampling procedures to the more sophisticated multipoint sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the water course taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, discharge and on the suspended sediment the river's transports. The greater number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well-mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross-section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of DO, pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected.

5.3.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have as much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, the measurement of DO, pH, temperature, etc., is to be conducted on each aliquot of the vertical composite. In naturally-formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample. These verticals are often taken along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline which is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer which is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several verticals with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality since it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in-situ using sensors and automatic readout or recording devices. Single and multiparameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

5.3.3 Estuaries

Estuarine areas are by definition zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Estuaries are generally categorized into three types dependent upon freshwater inflow and mixing properties. Knowledge of the estuary type is necessary to determine sampling locations:

- Mixed estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically this type of estuary is shallow and is found in major freshwater sheetflow areas. Being well mixed, the sampling locations are not critical in this type of estuary.

- Salt wedge estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally, back and forth, with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic estuary - characterized by salinities approaching full strength oceanic waters. Seasonally, freshwater inflow is small with the preponderance of the fresh-saline water mixing occurring near, or at, the shore line.

Sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides (i.e. when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1 to 5 foot increments coupled with vertical dissolved oxygen and temperature profiles.

5.3.4 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type required. The most frequently used samplers are:

- Open tube
- Dip sampler
- Hand pump
- Kemmerer
- Depth-Integrating Sampler

The dip sampler and the weighted bottle sampler are used most often.

The criteria for selecting a sampler include:

- Disposable and/or easily decontaminated
- Inexpensive (if the item is to be disposed of)
- Ease of operation
- Nonreactive/noncontaminating - Teflon-coating, glass, stainless steel or PVC sample chambers are preferred (in that order)

Each sample (grab or each aliquot collected for compositing) shall be measured for:

- Specific conductance
- Temperature
- pH (optional)
- Dissolved oxygen (optional)

as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

5.3.4.1 Dip Sampling

Water is often sampled by filling a container either attached to a pole or held directly, from just beneath the surface of the water (a dip or grab sample). Constituents measured in grab samples are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration that is distributed throughout the water column and in the cross section. Therefore, whenever possible it is recommended to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

5.3.4.2 Weighted Bottle Sampling

A grab sample can also be taken using a weighted holder that allows a sample to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of a stopped glass or plastic bottle, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The procedure for sampling is:

- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
- Pull out the stopper with a sharp jerk of the sampler line.
- Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
- Raise the sampler and cap the bottle.
- Decontaminate the outside of the bottle. The bottle can be used as the sample container (as long as original bottle is an approved container).

5.3.4.3 Kemmerer

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. "Messenger" is sent down the line when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles.

5.3.5 Surface Water Sampling Techniques

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following suggestions are made to help ensure that the samples obtained are representative of site conditions:

- The most representative samples are obtained from mid-channel at 0.6 stream depth in a well-mixed stream.
- Even though the containers used to obtain the samples are previously laboratory cleaned, it is suggested that the sample container be rinsed at least once with the water to be sampled before the sample is taken.
- For sampling running water, it is suggested that the farthest downstream sample be obtained first and that subsequent samples be taken as one works upstream. Work from zones suspected of low contamination to zones of high contamination.
- To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one sample, or several grids are selected at random.
- Care should be taken to avoid excessive agitation of the water that results in the loss of volatile constituents.
- When obtaining samples in 40 ml septum vials for volatile organics, analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner faces in after the bottle is filled and capped. The bottle can be turned upside down to check for air bubbles.
- Do not sample at the surface unless sampling specifically for a known constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the month of the bottle facing upstream.

5.4 SEDIMENT SAMPLING

5.4.1 General

Sediment samples are usually collected at the same verticals at which water samples were collected. If only one sediment sample is to be collected, the site shall be approximately at the center of water body. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir. Bed sediments near the center will be composed of fine-grained materials which may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations

of contaminants. The shape, flow pattern, bathometry (depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled while areas likely to show net erosion (high-velocity, turbulent areas) and suspension of fine solid materials shall be avoided.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are below detection limits). It is therefore important to minimize the loss of low-density "fines" during any sampling process.

5.4.2 Sampling Equipment and Techniques

A bottom-material sample may consist of a single scoop or core or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using on-shore or off-shore techniques.

When boats are used for sampling, life preservers must be provided and two individuals must undertake the sampling. An additional person shall remain on-shore in visual contact at all times.

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers

5.4.2.1 Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

5.4.2.2 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permitting direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the change of metal contamination from the frame of the device.

6.0 REFERENCES

Feltz, H. R., 1980. Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

Kittrell, F. W., 1969. A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135p.

U.S. EPA, 1980. Standard Operating Procedures and Quality Assurance Manual. Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, Georgia.

U.S. Geological Survey, 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Virginia.

7.0 ATTACHMENTS

None.

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		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY		Approved D. Senovich	

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1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- It is in your actual possession.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

5.0 PROCEDURES

5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

- **Concentration**: The expected concentration (i.e., low, medium, high).
- **Sample Type**: Grab or composite.
- **Preservation**: Type of preservation added and pH levels.
- **Analysis**: VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By**: Printed name of the sampler.
- **Case Number**: Case number assigned by the Sample Management Office.
- **Traffic Report Number**: Number obtained from the traffic report labels.
- **Remarks**: Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a wr[illegible], waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or w[illegible] or attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and i[illegible]ovided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the la[illegible]tory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code**: Work Assignment Number.
- **Station Number**: The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year**: Same as Date on Sample Label.
- **Time**: Same as Time on Sample Label.
- **Designate - Comp/Grab**: Composite or grab sample.
- **Station Location**: Same as Station Location on Sample Label.
- **Samplers**: Same as Sampled By on Sample Label.
- **Preservative**: Yes or No.
- **Analyses**: Check appropriate box(es).

- **Remarks**: Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).

- **Lab Sample Number**: For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

5.3 CHAIN-OF-CUSTODY PROCEDURES

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and Chain-of-Custody Record exactly.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Sampling Plan).

- Sign, date, and enter the time under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

ATTACHMENT A
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION I
(Original is 8-1/2 by 11)

	PROJECT NAME					NO. OF CON-TAINERS	REMARKS
SAMPLERS: *(Signature)*							
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION		

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

ATTACHMENT B
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION II
(Original is 8 by 10-1/2)

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY – REGION II
SURVEILLANCE & ANALYSIS DIVISION
EDISON, NEW JERSEY 08837

Name of Unit and Address		
Sample Number	Number of Containers	Description of Samples

Person Assuming Responsibility for Samples	Time	Date

Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody
Sample Number	Relinquished By:	Received By:	Time	Date	Reason for Change of Custody

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III
(Original is 8-1/2 x 11-3/4")

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 3
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME	NO. OF CONTAINERS							REMARKS
SAMPLERS: (Signature)									
STA. NO	DATE	TIME	COMP	GRAB	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	

Distribution: Original Accompanies Shipment, Copy to Coordinator Field Files

3-15966

ATTACHMENT D
CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION IV
(Original is 8-1/2 by 14)

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION 4

CHAIN OF CUSTODY RECORD

ENVIRONMENTAL SERVICES DIVISION
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613

PROJ. NO. | PROJECT NAME

SAMPLERS (Signature)

STA. NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	Water/Wastewater																		Soil/Sed			Sdg/Waste		Misc	REMARKS/TAG NUMBERS
							Cal G (not oil)	Cal G (Lt)	Gl or cal (VOA)	Cal P (BOD, COD, TSS)	Pl G (phenol)	Pl P (metals, Hg)	Pl P (Cl⁻)	Pl P (TOC, COD)	Gl G (O&G & Fuel)	Gl P (CN)	Gl G (not oil, TP)	Gl G (VOA)	Pl P (Hg, CN, S⁻⁻)	Gl or G (not O&G, VOA, not Hg, CN)	Gl or G (Gl P, ⅛" P)									

Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)	Remarks
Relinquished by (Signature)	Date/Time	Received by (Signature)	Relinquished by (Signature)	Date/Time	Received by (Signature)	

DISTRIBUTION: Original and Pink copies accompany sample shipment to laboratory. Pink copy retained by laboratory. Yellow copy retained by samplers. Blue copy extra copy as needed.

№ 4 3526

ATTACHMENT E
SAMPLE LABEL

NUS CORPORATION PROJECT: _____

STATION LOCATION: _____

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

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

ANALYSIS	PRESERVATION
VOA ☐ BNA's ☐	Cool to 4°C ☐
PCB's ☐ PESTICIDES ☐	HNO_3 to pH <2 ☐
METALS: TOTAL ☐ DISSOLVED ☐	NAOH to pH>12 ☐
CYANIDE ☐	_____ ☐
_____ ☐	

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

ATTACHMENT F
SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Designate: Grab / Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signatures)

Station Location

Preservative:
Yes ☐ No ☐

ANALYSES

BOD Anions Solids (TSS) (TDS) (SS)	
COD, TOC, Nutrients	
Phenolics	
Mercury	
Metals	
Cyanide	
Oil and Grease	
Organics GC/MS	
Priority Pollutants	
Volatile Organics	
Pesticides	
Mutagenicity	
Bacteriology	

Remarks:

Tag No.	Lab Sample No.
3 60966	

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL

Date

Signature

NUS CORPORATION

NUS CORPORATION

CUSTODY SEAL

Date

Signature

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1.0 PURPOSE

This procedure provides instruction for sample packaging and shipping in accordance with U.S. Department of Transportation (DOT) regulations.

2.0 SCOPE

Samples collected at hazardous waste sites usually have to be transported elsewhere for analysis. This requires that the samples be appropriately preserved to prevent or minimize chemical alteration prior to analysis, and be transported to protect their integrity, as well as to protect against any detrimental effects from leakage or breakage. Regulations for packaging, marking, labeling, and shipping hazardous materials and wastes are promulgated by the U.S. Department of Transportation and described in the Code of Federal Regulations (49 CFR 171 through 177, in particular 172.402h, Packages Containing Samples). In general, these regulations were not intended to cover shipment of samples collected at controlled or uncontrolled hazardous waste sites or samples collected during emergency responses. However, the EPA has agreed through a memorandum of agreement to package, mark, label, and ship samples observing DOT procedures. The information presented here is for general guidance.

This procedure is applicable to all samples taken from uncontrolled hazardous substance sites for analysis at laboratories away from the site.

3.0 GLOSSARY

Carrier - A person or firm engaged in the transportation of passengers or property.

Hazardous Material - A substance or material in a quantity and form which may pose an unreasonable risk to health and safety or property when transported in commerce ("commerce" here to include any traffic or transportation). Defined and regulated by DOT (49 CFR 173.2) and listed in Attachment A of this guideline.

Hazardous Waste - Any substance listed in 40 CFR Subpart D (¥261.20 et seq) or otherwise characterized as ignitable, corrosive, reactive, or EP toxic as specified under 40 CFR Subpart C (¥261.20 et seq) that would be subject to manifest requirements specified in 40 CFR 262. Defined and regulated by EPA.

Marking - Applying the descriptive name, instruction, cautions, weight, or specification marks or combination thereof required to be placed outside containers of hazardous materials.

n.o.i. - Not otherwise indicated.

n.o.s. - Not otherwise specified.

ORM - Other regulated material

Packaging - The assembly of one or more containers and any other components necessary to assure compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, multiunit tank car tanks.

Placard - Color-coded, pictorial sign depicting the hazard class symbol and name to be placed on all four sides of a vehicle transporting certain hazardous materials.

Reportable Quantity (RQ) - A parenthetical note of the form "(RQ-1000/454)" following an entry in the DOT Hazardous Materials table (49 CFR 172.101) indicates the reportable quantity of the substance in pounds and kilograms. If a spill of that amount or more of the substance occurs during transit or storage, a report must be filed with DOT according to ¥171.15-15 concerning hazardous materials incidents reports. If the material spilled is a hazardous waste, a report must always be filed, regardless of the amount, and must include a copy of the manifest. If the RQ notation appears, it must be shown either immediately before or after the proper shipping name on the shipping paper (or manifest). Most shipping papers and manifests will have a column designated "HM" which may be used for this purpose.

4.0 RESPONSIBILITIES

Field Operations Leader or Team Sampling Leader - responsible for determining that samples are properly packaged and shipped.

Sampling Personnel - responsible for implementing the packaging and shipping requirements.

5.0 PROCEDURES

5.1 INTRODUCTION

Samples collected for shipment from a site shall be classified as either environmental or hazardous material (or waste) samples. In general, environmental samples are collected off-site (for example from streams, ponds, or wells) and are not expected to be grossly contaminated with high levels of hazardous materials. On-site samples (for example, soil, water, and materials from drums or bulk storage tanks, obviously contaminated ponds, lagoons, pools, and leachates from hazardous waste sites) are considered hazardous. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples. If there is any doubt, a sample shall be considered hazardous and shipped accordingly.
- Protect the health and safety of laboratory personnel receiving the samples. Special precautions are used at laboratories when samples other than environmental samples are received.

5.2 ENVIRONMENTAL SAMPLES

5.2.1 Packaging

Environmental samples may be packaged following the procedures outlined in Section 5.4 for samples classified as "flammable liquids" or "flammable solids." Requirements for marking, labeling, and shipping papers do not apply.

Environmental samples may also be packed without being placed inside metal cans as required for flammable liquids or solids.

- Place sample container, properly identified and with a sealed lid, in a polyethylene bag, and seal the bag.
- Place sample in a fiberboard container or metal picnic cooler which has been lined with a large polyethylene bag.
- Pack with enough noncombustible, absorbent, cushioning materials to minimize the possibility of the container breaking.
- Seal large bag.
- Seal or close outside container.

5.2.2 Marking Labeling

Sample containers must have a completed sample identification tag and the outside container must be marked "Environmental Sample." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling are required.

5.2.3 Shipping Papers

No DOT shipping papers are required. However, the appropriate chain-of-custody forms must be included with the shipment.

5.2.4 Transportation

There are no DOT restrictions on mode of transportation.

5.3 DETERMINATION OF SHIPPING CLASSIFICATION FOR HAZARDOUS MATERIAL SAMPLES

Samples not determined to be environmental samples, or samples known or expected to contain hazardous materials, must be considered hazardous material samples and transported according to the requirements listed below.

5.3.1 Known Substances

If the substance in the sample is known or can be identified, package, mark, label and ship according to the specific instructions for that material (if it is listed) in the DOT Hazardous Materials Table, 49 CFR 172.101.

Unz and Company have published the following steps to help in locating a proper shipping name from the Hazardous Materials Table, 49 CFR 172.101.

1. Look first for the chemical or technical name of the material, for example, ethyl alcohol. Note that many chemicals have more than one technical name, for example, perchloroethylene (not listed in 172.101) is also called tetrachloroethylene (listed 172.101). It may be useful to consult a chemist for all possible technical names a material can have. If your material is not listed by its technical name then. . . . . .

2. Look for the chemical family name. For example, pentyl alcohol is not listed but the chemical family name is: alcohol, n.o.s. (not otherwise specified). If the chemical family name is not listed then. . . . . .

3. Look for a generic name based on end use. For example, Paint, n.o.s or Fireworks, n.o.s. If a generic name based on end use is not listed then. . . . . .

4. Look for a generic family name based on end use, for example, drugs, n.o.s. or cosmetics, n.o.s. Finally, if your material is not listed by a generic family name but you suspect or know the material is hazardous because it meets the definition of one or more hazardous classes, then. . . . . .

5. You will have to go the the general hazard class for a proper shipping name. For example, Flammable Liquid, n.o.s, or Oxidizer, n.o.s.

5.3.2 Unknown Substances

For samples of hazardous substances of unknown content, select the appropriate transportation category according to the DOT Hazardous Materials Classification (Attachment A), a priority system of transportation categories.

The correct shipping classification for an unknown sample is selected through a process of elimination, utilizing Attachment A. Unless known or demonstrated otherwise (through the use of radiation survey instruments), the sample is considered radioactive and appropriate shipping regulations for "radioactive material" followed.

If a radioactive material is eliminated, the sample is considered to contain "Poison A" materials (Attachment B), the next classification on the list. DOT defines "Poison A" as extremely dangerous poisonous gases or liquids of such a nature that a very small amount of gas, or vapor of the liquids, mixed with air is dangerous to life. Most Poison A materials are gases or compressed gases and would not be found in drum-type containers. Liquid Poison A would be found only in closed containers; however,all samples taken from closed drums do not have to be shipped as Poison A, which provides for a "worst case" situation. Based upon information available, a judgment must be made whether a sample from a closed container is a Poison A.

If Poison A is eliminated as a shipment category, the next two classifications are "flammable" or "nonflammable" gases. Since few gas samples are collected, "flammable liquid" would be the next applicable category. With the elimination of radioactive material, Poison A, flammable gas, and nonflammable gas, the sample can be classified as flammable liquid (or solid) and shipped accordingly. These procedures would also suffice for shipping any other samples classified below flammable liquids in the DOT classification table (Attachment A). For samples containing unknown materials, categories listed below flammable liquids/solids on Attachment A are generally not used because showing that these materials are not flammable liquids (or solids) requires flashpoint testing, which may be impractical and possibly dangerous at a site. Thus, unless the sample is known to consist of materials listed as less hazardous than flammable liquid (or solid) on Attachment A, it is considered a flammable liquid (or solid) and shipped as such.

For any hazardous material shipment, utilize the shipping checklist (Attachment C) as a guideline to ensure that all sample-handling requirements are satisfied.

5.4 PACKAGING AND SHIPPING OF SAMPLES CLASSIFIED AS FLAMMABLE LIQUID (OR SOLID)

5.4.1 Packaging

Applying the word "flammable" to a sample does not imply that it is in fact flammable. The word prescribes the class of packaging according to DOT regulations.

1. Collect sample in the prescribed container with a nonmetallic, Teflon-lined screw cap. To prevent leakage, fill container no more than 90 percent full.

2. Complete sample label and sample identification tag and attach securely to sample container.

3. Seal container and place in 2-mil thick (or thicker) polyethylene bag, one sample per bag. Position sample identification tag so that it can be read through bag. Seal bag.

4. Place sealed bag inside metal can and cushion it with enough noncombustible, absorbent material (for example, vermiculite or diatomaceous earth) between the bottom and sides of the can and bag to prevent breakage and absorb leakage. Pack one bag per can. Use clips, tape, or other positive means to hold can lid securely, tightly and permanently. Mark can as indicated in Paragraph 1 of Section 5.4.2, below.

5. Place one or more metal cans (or single 1-gallon bottle) into a strong outside container, such as a metal picnic cooler or a DOT-approved fiberboard box. Surround cans with noncombustible, absorbent cushioning materials for stability during transport. Mark container as indicated in Paragraph 2 of Section 5.4.2.

5.4.2 Marking/Labeling

1. Use abbreviations only where specified. Place the following information, either hand-printed or in label form, on the metal can (or 1-gallon bottle):

   - Laboratory name and address.

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."

Not otherwise specified (n.o.s) is not used if the flammable liquid (or solid) is identified. Then the name of the specific material is listed before the category (for example, Acetone, Flammable Liquid), followed by its appropriate UN number found in the DOT Hazardous Materials table (49 CFR 172.101).

2. Place all information on outside shipping container as on can (or bottle), specifically:

   - Proper shipping name.
   - UN or NA number.
   - Proper label(s).
   - Addressee and sender.

   Place the following labels on the outside shipping container: "Cargo Aircraft Only" and "Flammable Liquid" (or "Flammable Solid"). "Dangerous When Wet" label shall be used if the solid has not been exposed to a wet environment. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" shall also be marked on the top of the outside container, and upward-pointing arrows shall be placed on all four sides of the container.

5.4.3 Shipping Papers

1. Use abbreviations only where specified. Complete the carrier-provided bill of lading and sign certification statement (if carrier does not provide, use standard industry form, see Attachment D). Provide the following information in the order listed (one form may be used for more than one exterior container).

   - "Flammable Liquid, n.o.s. UN1993" or "Flammable Solid, n.o.s. UN1325."
   - "Limited Quantity" (or "Ltd. Qty.").
   - "Cargo Aircraft Only."
   - Net weight (wt) or net volume (vol), just before or just after "Flammable Liquid, n.o.s." or "Flammable Solid, n.o.s.," by item, if more than one metal can is inside an exterior container.
   - "Laboratory Samples" (if applicable).

2. Include Chain-of-Custody Record, properly executed in outside container.

3. "Limited Quantity" of "Flammable Liquid, n.o.s." is limited to one pint per inner container. For "Flammable Solid, n.o.s.," net weight of inner container plus sample shall not exceed one pound; total package weight shall not exceed 25 pounds.

5.4.4 Transportation

1. Transport unknown hazardous substance samples classified as flammable liquids by rented or common carrier truck, railroad, or express overnight package services. Do not transport by any passenger-carrying air transport system, even if they have cargo-only aircraft. DOT regulations permit regular airline cargo-only aircraft, but difficulties with most suggest avoiding them. Instead, ship by airline carriers that only carry cargo.

2. For transport by government-owned vehicle, including aircraft, DOT regulations do not apply. However, procedures described above, with the exception of execution of the bill of lading with certification, shall still be used.

6.0 REFERENCES

U.S. Department of Transportation, 1983. Hazardous Materials Regulations, 49 CRF 171-177.

NUS Standard Operating Procedure SA-6.1 - Sample Identification and Chain-of-Custody

NUS Standard Operating Procedure SA-1.2 - Sample Preservation

NUS Standard Operating Procedure SF-1.5 - Compatibility Testing

7.0 ATTACHMENTS

Attachment A - DOT Hazardous Material Classification (49 CFR 173.2)
Attachment B - DOT List of Class "A" Poisons (49 CFR 172.101)
Attachment C - Hazardous Materials Shipping Checklist
Attachment D - Standard Industry Certification Form

ATTACHMENT A

DOT HAZARDOUS MATERIAL CLASSIFICATION (49 CFR 173.2)

1. Radioactive material (except a limited quantity)
2. Poison A
3. Flammable gas
4. Nonflammable gas
5. Flammable liquid
6. Oxidizer
7. Flammable Solid
8. Corrosive material (liquid)
9. Poison B
10. Corrosive material (solid)
11. Irritating material
12. Combustible liquid (in containers having capacities exceeding 110 gallons [416 liters])
13. ORM-B
14. ORM-A
15. Combustible liquid (in containers having capacities of 110 gallons [416 liters] or less)
16. ORM-E

ATTACHMENT B

DOT LIST OF CLASS "A" POISON (49 CFR 172.101)

Material	Physical State at Standard Temperature
Arsine	Gas
Bromoacetone	Liquid
Chloropicrin and methyl chloride mixture	Gas
Chloropicrin and nonflammable,nonliquefied compressed gas mixture	Gas
Cyanogen chloride	Gas (>13.1°C)
Cyanogen gas	Gas
Gas identification set	Gas
Gelatin dynamite (H. E. Germaine)	----
Grenade (with Poison "A" gas charge)	----
Hexaethyl tetraphosphate/compressed gas mixture	Gas
Hydrocyanic (prussic) acid solution	Liquid
Hydrocyanic acid, liquefied	Gas
Insecticide (liquefied) gas containing Poison "A" or Poison "B" material	Gas
Methyldichloroarsine	Liquid
Nitric oxide	Gas
Nitrogen peroxide	Gas
Nitrogen tetroxide	Gas
Nitrogen dioxide, liquid	Gas
Parathion/compressed gas mixture	Gas
Phosgene (diphosgene)	Liquid

ATTACHMENT C
HAZARDOUS MATERIALS SHIPPING CHECKLIST

PACKAGING

1. Check DOT 172.500 table for appropriate type of package for hazardous substance.
2. Check for container integrity, especially the closure.
3. Check for sufficient absorbent material in package.
4. Check for sample tags and log sheets for each sample, and chain-of-custody record.

SHIPPING PAPERS

1. Check that entries contain only approved DOT abbreviations.
2. Check that entries are in English.
3. Check that hazardous material entries are specially marked to differentiate them from any nonhazardous materials being sent using same shipping paper.
4. Be careful all hazardous classes are shown for multiclass materials.
5. Check total amounts by weight, quantity, or other measures used.
6. Check that any limited-quantity exemptions are so designated on the shipping paper.
7. Offer driver proper placards for transporting vehicle.
8. Check that certification is signed by shipper.
9. Make certain driver signs for shipment.

RCRA MANIFEST

1. Check that approved state/federal manifests are prepared.
2. Check that transporter has the following: valid EPA identification number, valid driver's license, valid vehicle registration, insurance protection, and proper DOT labels for materials being shipped.
3. Check that destination address is correct.
4. Check that driver knows where shipment is going.
5. Check that the driver is aware of emergency procedures for spills and accidents.
6. Make certain driver signs for shipment
7. Make certain one copy of executed manifest and shipping document is retained by shipper.

ATTACHMENT D

STANDARD INDUSTRY CERTIFICATION FORM

NO PCS	SIZE	GROSS WEIGHT	H M	DOT PROPER SHIPPING NAME	HAZARD CLASS	CODE	I II	CONTAINER NUMBERS	PLC	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-[illegible]	C	1	✓	
1	55 gal	450 lbs	x	Flammable liquid, n.o.s.	Flammable liquid	55-[illegible]	—	2		✓
1	55 gal	250 lbs	x	Flammable liquid, n.o.s.	Flammable liquid	55-[illegible]	B	3	✓	
1	16-A	12 lbs.	x	Bromine	Corrosive Material	55-[illegible]	C	4	✓	

SHIPPER'S CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Shipper's Signature

Placards Req'd _____

Shipment Date _____ Manifest No _____

Shipper Work Order _____

Service Order No _____

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1.0 PURPOSE

This procedure describes the process for keeping a site logbook.

2.0 SCOPE

The site logbook is a controlled document which records all major on-site activities during a Remedial Investigation/Feasibility Study. At a minimum, the following activities/events shall be recorded in the site logbook:

- Arrival/departure of site visitors
- Arrival/departure of equipment
- Sample pickup (chain-of-custody form numbers, carrier, time)
- Sampling activities/sample logsheet numbers
- Start or completion of borehole/trench/monitoring well installation or sampling activities
- Health and Safety issues

The site logbook is initiated at the start of the first on-site activity (e.g., initial reconnaissance survey). Entries are made for every day that on-site activities take place which involve RI/FS contractor personnel. One current site logbook is maintained per site.

The site logbook becomes part of the permanent site file maintained in the RI contractor's office. Because information contained in the site logbook may be admitted as evidence in cost recovery or other legal proceedings, it is critical that this document be properly maintained.

3.0 GLOSSARY

Site Logbook - The logbook is a bound notebook with consecutively numbered pages that cannot be removed. Upon entry of data, the logbook requires signature by the responsible site leader (see Section 5.1).

4.0 RESPONSIBILITIES

The site logbook is issued by the Regional Manager (or his designee) to the Site Manager for the duration of the project. The Site Manager releases the site logbook to the Field Operations Leader or other person responsible for the direction of on-site activities (e.g., Reconnaissance Survey Team Leader, Sampling Team Leader). It is the responsibility of this person (or his designee) to keep the site logbook current while in his possession, and return it to the Site Manager or turn it over to another field team. Following the completion of all fieldwork, the site logbook is returned to the Site Manager for inclusion in the permanent site files.

5.0 PROCEDURES

5.1 GENERAL

The cover of each site logbook contains the following information:

- Project Name
- NUS Project Number
- RI/FS Contractor and Site Manager's Name
- Sequential Book Number

- Start Date
- End Date

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded:

- Date
- Start time
- Weather
- All field personnel present
- Any visitors present

During the day, a summary of all site activities and level of personal protection shall be recorded in the logbook. The information need not duplicate that recorded in other field notebooks (e.g., sample logbook, Site Geologist's notebook, Health and Safety Officer's notebook, etc.), but shall summarize the contents of these other notebooks and refer to the page locations in these notebooks for detailed information. An example of a site logbook page is shown in Attachment A.

The sample logsheet for each sample collected (see Procedure SA-6.6) must be referenced. If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the notebook and page number(s) on which they are recorded (see Attachment A).

All entries shall be made in black pen. No erasures are permitted. If an incorrect entry is made, the data shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the Field Operations Leader or responsible site leader at the end of each day.

5.2 PHOTOGRAPHS

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

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A - Typical Site Logbook Entry

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

NUS	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 offsite, gate locked.

_____
Field Operations Leader

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6.0 REFERENCES

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1.0 PURPOSE

This procedure 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

2.0 SCOPE

This procedure is applicable for use in an on-site groundwater quality monitoring program to be conducted during a remedial investigation or site investigation program at a hazardous or non-hazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc. and are not, in general, subject to solution interferences from color, turbidity and colloidal material, or suspended matter.

This procedure provides generic 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.

3.0 GLOSSARY

3.1 pH MEASUREMENT

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

pH Paper - Paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution pH.

3.2 SPECIFIC CONDUCTANCE MEASUREMENT

Ohm - Standard unit of electrical resistance (R). A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's law, $E = IR$, where E is the potential difference, I is the current, and R is the resistance.

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. Conductivity and specific conductance are used synonymously.

3.3 TEMPERATURE MEASUREMENT

None.

3.4 DISSOLVED OXYGEN MEASUREMENT

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

Reduction - The gaining of electrons by an atom or group of atoms and subsequent increase in negative charge.

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

3.6 SPECIFIC ION ELECTRODES MEASUREMENT

Specific Ion Electrode - An electrode which develops a potential difference across a membrane in response to the concentration differences for selected ions on either side of that membrane.

4.0 RESPONSIBILITIES

Site Manager - in consultation with the Project Geochemist, is responsible for determining which on-site water quality measurements can contribute to the RI, when these measurements shall be made, and the data quality objectives (DQOs) for these measurements. The Project Operations Plan (POP) shall contain details of type, frequency and locations of the desired measurements.

Project Geochemist - primarily responsible for determining the type, frequency and locations for on-site water quality measurements as presented in the POP and for interpreting the results, including determination of which measurements are unrepresentative.

Field Operations Leader - responsible for implementing the POP, and also for deciding under what field conditions a particular on-site measurement will be unrepresentative or unobtainable.

Field Samplers/Analysts - responsible for the actual analyses that take place, including calibration, quality control and recording of results, as well as for the care and maintenance of the equipment in the field.

5.0 GUIDELINES

5.1 MEASUREMENT OF pH

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.

Measurements of pH can also be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis, and specific techniques are not described.

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

5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to hydrogen ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.4 Measurement Techniques for Field Determination of pH

1. pH Meter

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

a. The instrument and batteries shall be checked and calibrated prior to initiation of the field effort.

b. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.

c. 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.

d. 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).

e. Immerse the electrode(s) in a pH-7 buffer solution.

f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

g. Adjust the pH meter to read 7.0.

h. Remove the electrode(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.

i. 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 chemical 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.

j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.

k. Rinse the electrode(s) with deionized water.

l. Keep the electrode(s) immersed in deionized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

2. 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.

5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

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

5.2.2 Principles of Equipment Operation

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

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

5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirement of the sampling program.

5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturers instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

5.3 MEASUREMENT OF TEMPERATURE

5.3.1 General

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

5.3.2 Equipment

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

5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

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

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.2 Principles of Equipment Operation

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

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

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not

easily depolarized from the indicating electrode. If the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor or equivalent.
- Dissolved oxygen/temperature probe for above monitor.
- Sufficient cable to allow the probe to contact the sample.

5.4.4 Measurement Techniques for Dissolved Oxygen Determination

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

- The equipment shall be calibrated and have its batteries checked in the laboratory before going to the field.

- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

- The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) 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 B).

- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. 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.

- 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 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendence of organic or inorganic compounds to exist in an oxidized state. The technique 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.

5.5.2 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 will be dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.3 Equipment

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

- Accumet 150 portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.

5.5.4 Measurement Techniques for Oxidation-Reduction Potential

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

- The equipment shall be calibrated and have its batteries checked before going to the field.

- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.

- Thoroughly rinse the electrode with demineralized water.

- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added, the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of water from a wash bottle. Place the sample in a clean glass beaker or sample cup and insert the electrodes. Set temperature

compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes commonly used in groundwater quality monitoring programs and describes the essential elements of a field investigation program. Analytical methods using some specific ion electrodes have not been approved by the USEPA. In addition, calibration procedures and solutions, interferences and conditions and requirements for use for various electrodes vary greatly. Consequently, review of manufacturer's literature is mandatory prior to use.

5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a solution of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus allowing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range for various membranes and electrodes will vary.

5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.

- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.

- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

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.

7.0 ATTACHMENTS

Attachment A - Specific Conductance of KC1 Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.

ATTACHMENT A

SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES[1]

Temperature (°C)	Specific Conductance (µmhos/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 B

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

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

ATTACHMENT B
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	
25	8.4	8.0	7.6	7.2	6.7	0.008
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 concenration (and therefore used to correct measured D.O. concentration) using Attachment A.

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		Prepared Earth Sciences	
Subject SAMPLE PRESERVATION		Approved D. Senovich	

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1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/ freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

3.0 GLOSSARY

HCl - Hydrochloric Acid
H_2SO_4- Sulfuric Acid
HNO_3 - Nitric Acid
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of H_2SO_4 containing two gram-atoms of H, is "two-normal."

4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

5.0 PROCEDURES

5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the

dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with HNO_3, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

5.2.1 Addition of Acid (H_2SO_4, HCl, or HNO_3) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

Acid Base	Concentration	Normality	Amount for Acidification*
HCl	1:1 dilution of concentrated HCl	6N	5-10 ml
H_2SO_4	1:1 dilution of concentrated H_2SO_4	18N	2-5 ml
HNO_3	Undiluted concentrated HNO_3	16N	2-5 ml
NaOH	400 grams solid NaOH in 870 ml water	10N	2 ml**

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. U.S. EPA-EMSL, Cincinnati, Ohio.

7.0 ATTACHMENTS

Attachment A - General Sample Container and Preservation Requirements CERCLA/RCRA Samples

Attachment B - Required Containers, Preservation Techniques, and Holding Times (3 sheets)

ATTACHMENT A
GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

FT-7.06
REVISION 0

	SAMPLE TYPE & CONCENTRATION	CONTAINER[1]	SAMPLE SIZE	PRESERVATION[2]	HOLDING TIME[2]
WATER					
Organics (GC & GC/MS)	VOA	borosilicate glass	2 x 40 ml	Cool to 4°C	7 days
	Extractables				
	Low	amber glass	2 x 2 l or 4 x 1 l	Cool to 4°C	5 days to extraction 40 days after extraction
	Medium	wide-mouth glass	4 x 32 oz	None	Same as above
Inorganics	Metals				
	Low	high density (h.d.) polyethylene	1 l	HNO_3 to pH ≤ 2	6 months (Hg-30 days)
	Medium	wide-mouth glass	16 oz	None	6 months
	Cyanide				
	Low	h.d. polyethylene	1 l	NaOH to pH >12	14 days
	Medium	wide-mouth glass	16 oz	None	
Organic/Inorganic	High Hazard	8 oz wide-mouth glass	6 oz	None	14 days
COD	--	h.d. polyethylene	0.5 l	H_2SO_4 to pH <2	28 days
TOC	--	h.d. polyethylene	0.5 l	HCl to pH <2	28 days
Oil & Grease	--	glass	1.0 l	H_2SO_4 to pH <2	28 days
Phenols	--	h.d. polyethylene	1.0 l	H_2SO_4 to pH <2	28 days
General Chemistry	--	h.d. polyethylene	1.0 l	None	---
SOIL					
Organics (GC & GC/MS)	VOA	2 x 120 ml (4 oz) wide-mouth glass	240 ml	Cool to 4°C	10 days
	Extractables				
	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	10 days to extraction 40 days after extraction
Inorganics	Low/Medium	8 oz or 2 x 4 oz (120 ml) wide-mouth glass	6 oz	Cool to 4°C	NA
Organic/Inorganic	High Hazard	8 oz (120 ml) wide-mouth glass	6 oz	None	NA
Dioxin	All	4 oz (120 ml) wide-mouth glass	4 oz	None	NA
EP Toxicity	All	250 ml h.d. polyethylene	200 grams	None	NA
Air					
Volatile Organics	Low Medium	Charcoal Tube 7 cm long, 6 mm OD, 4 mm ID	100 l air	Cool to 4°C	NA

1. All glass containers should have Teflon cap liners or septa.
2. See Attachment B.

SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 1

Parameter No./Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Biochemical Oxygen Demand, Carbonaceous	P,G	Cool, 4°C	48 hours
Chemical Oxygen Demand	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Chloride	P,G	None required	28 days
Chlorine, Total Residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P,G	Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P,G	HNO_3 to pH 2, H_2SO_4 to pH 2	6 months
Hydrogen Ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and Organic Nitrogen	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and Grease	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Organic Carbon	P,G	Cool, 4°C, HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P,G	Filter immediately, Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle and top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle and top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, Total	P,G	Cool, 4°C, H_2SO_4 to pH 2	28 days
Residue, Total	P,G	Cool, 4°C	7 days
Residue, Filterable	P,G	Cool, 4°C	48 hours
Residue, Nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, Settleable	P,G	Cool, 4°C	48 hours
Residue, Volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P,G	HNO_3 to pH 2	6 months

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 2

Parameter No./Name	Container(1)	Preservation(2,3)	Maximum Holding Time(4)
ORGANIC TESTS:(8)			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$(5) HCl to pH 2(9)	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$(5) adjust pH to 4-5(10)	14 days
Phenols(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
Benzidines(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction(13)
Phthalate Esters(11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines(11,14)	G, Teflon-lined cap	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
PCBs(11) Acrylonitrile	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and Isophorone(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5), store in dark	7 days until extraction, 40 days after extraction
Polynuclear Aromatic Hydrocarbons(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5), store in dark	7 days until extraction, 40 days after extraction
Haloethers(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
Chlorinated Hydrocarbons(11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDD(11)	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$(5)	7 days until extraction, 40 days after extraction
PESTICIDES TESTS:			
Pesticides(11)	G, Teflon-lined cap	Cool, 4°C, pH 5-9(15)	7 days until extraction, 40 days after extraction
RADIOLOGICAL TESTS:			
1-5 Alpha, beta and radium	P, G	HNO_3 to pH 2	6 months

TABLE 1 Notes

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator.

(5) Should only be used in the presence of residual chlorine.

ATTACHMENT B
REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 3

(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).

(12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SF-2.3	Page 1 of 4
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject DECONTAMINATION OF CHEMICAL SAMPLING AND FIELD ANALYTICAL EQUIPMENT		Approved D. Senovich	

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1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

5.0 PROCEDURES

In order to assure that chemical analysis results are reflective of the actual concentrations present at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample points) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

5.1 ACCESS FOR SAMPLING

5.1.1 Bailers and Bailing Line

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

Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point if heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse**
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

5.1.2 Sampling Pumps

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

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

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 into the water being sampled (especially the phthalate esters) or adsorb organics from the sampled water. For all other sampling, the hose should be Viton, polyethylene, or polyvinyl chloride (in order of preference). Whenever possible, dedicated hoses should be used.

---

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

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

5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. 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.

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 FIELD ANALYTICAL EQUIPMENT

5.2.1 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
- Acetone or methanol rinse
- 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.

5.2.2 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; in those cases, the methods of decontamination must be clearly described in the FSAP. 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 will be wiped with clean paper-towels or cloth wetted with alcohol.

6.0 REFERENCES

None.

7.0 RECORDS

None.

APPENDIX C

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

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1.0 PROJECT DESCRIPTION

As requested by the U.S. Navy, HALLIBURTON NUS has prepared this Quality Assurance/Quality Control (QA/QC) Plan for a Work Plan at NAVSURFWARCEN IHDIV, Indian Head, Maryland. The sites under investigation are the Strauss Avenue Thermal Treatment Point and the Caffee Road Thermal Treatment Point.

HALLIBURTON NUS has established quality assurance/quality control (QA/QC) measures and a program to ensure that these measures are applied to the collection and interpretation of all environmental quality data at the facility. The QA/QC Plan is designed to assure that the precision, accuracy, representativeness, comparability, and completeness (the PARCC parameters) of the data are known, documented, and adequate to satisfy the data quality objectives of the study.

This plan represents the policies, organization, objectives, data-collection activities, and QA/QC activities that will be utilized to ensure that all data collected during, and reported by, this study are representative of existing conditions. Chemical analyses will be conducted by a laboratory subcontractor. The laboratory will have prior OESO (Ordinance Environmental Support Office, formally NEESA) approval. QA/QC procedures for the chemical analyses will satisfy OESO requirements for Level C QC. The Site and Data Management Plan outlines the procedures that will be followed for the inventory, control, storage, and retrieval of data collected during the investigation.

2.0 INVESTIGATION SCOPE OF WORK

The inspection will be performed to obtain representative hydrogeologic and environmental quality data capable of clearly defining conditions at the two Thermal Treatment Points of the NAVSURFWARCEN IHDIV facility. These data will be used to evaluate the nature and extent of potential contamination and will be used to define background groundwater conditions at the TTP sites. In addition, these data will be used as a portion of a RCRA Part B, Subpart X Permit application. Details of the investigation, such as the approach, selection of drilling locations, and sample collection activities, are found in Sections 3.0 and 4.0 of the Work Plan. Descriptions of physical features and site history can be found in Section 2.0 of the Work Plan.

3.0 SAMPLE MATRICES, PARAMETERS, AND FREQUENCY COLLECTION

As part of the investigation, environmental quality samples will be collected from the following matrices: soil, surface water, sediment, and groundwater. A listing of the sample matrices, parameters, and frequency of collection is found in Tables 4-1, 4-2, 4-4, and 4-5 of the Work Plan. Sampling protocols to be used in this study are provided in Section 6.0 of this QA/QC Plan. As required by OESO, a sampling rationale is included in Section 3.0 and Section 4.0 of the Work Plan. All samples submitted for laboratory analysis will be analyzed for nitroaromatics, propellants, metals, and Appendix IX volatiles, semivolatiles, and pesticides/PCBs, as listed in Tables 4-1, 4-2, 4-4, and 4-5. In addition, Table 4-3 of the Work Plan presents the sample containers, preservatives, and allowable holding times for the analyses requested for the Thermal Treatment Points at NAVSURFWARCEN IHDIV.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The contractor retained to perform the fieldwork will be responsible for the overall management of the project, including the field inspection and conduct of all drilling and sampling activities. Personnel from Navy will be actively involved in the investigation and will coordinate with personnel from the contractor in a number of areas.

4.1 Project Organization

The key firms and personnel involved in the investigation, as well as the chain-of-communication and responsibility of the project personnel, are as follows:

Chesapeake Division
Naval Facilities Engineering Command
Washington Navy Yard, Building 212
Washington, D.C. 20374-2121
(202) 433-3760

Javier Garcia
Remedial Project Manager

NAVSURFWARCEN IHDIV
101 Strauss Avenue
Indian Head, MD 20640-5035
(301) 743-6745

Sherry McCahill
Facility - Point of Contact

HALLIBURTON NUS Environmental Corporation
Foster Plaza VII
661 Andersen Drive
Pittsburgh, Pennsylvania 15220
(412) 921-7090

Deborah Wroblewski
Program Manager

Ralph Basinski
Project Manager

Tom Dickson
Health and Safety

The Project Manager has the primary responsibility for project and technical management of this project. He is responsible for the coordination of all onsite personnel, and for providing technical assistance for all activities that are directly related to the determination of the hydrogeologic conditions and the environmental quality of the site. The review of all environmental and hydrogeologic data will also be conducted by the project manager. If quality assurance problems or deficiencies requiring special action are identified, the project manager and project QA/QC advisor will identify the appropriate corrective action. Figure C-1 illustrates Project Organization.

4.2 Field Organization

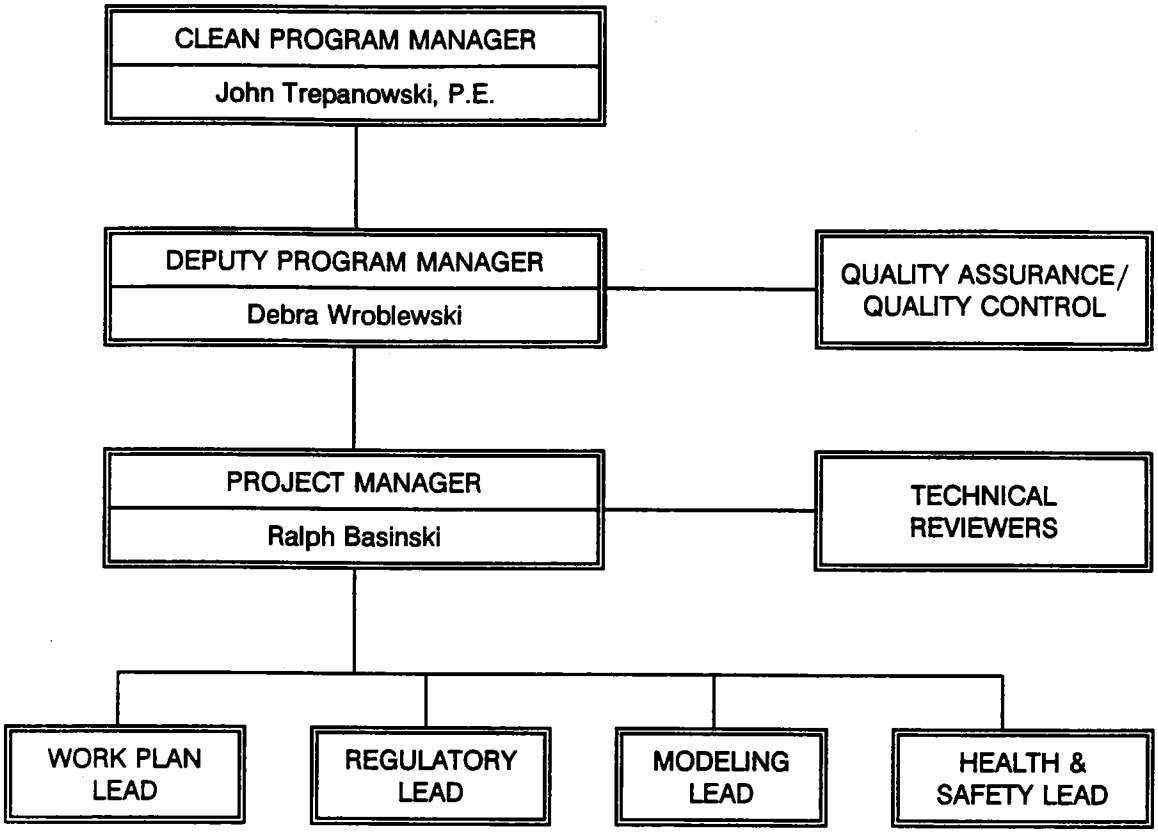
The contractor's field investigation team will be organized according to the activity planned. For onsite sampling, the sampling team members will be selected based upon the type and extent of effort required. The team will consist of a combination of the following personnel:

- Field Operations Leader (FOL)
- Field hydrogeologist/geologist

The FOL will be responsible for the coordination of all onsite personnel and for providing technical assistance when required. The FOL, or his or her designee will coordinate and be present during all sampling activities and will assure the availability and maintenance of all sampling materials/equipment. The FOL will be responsible for the completion of all sampling, well construction, and chain-of-custody

FIGURE C-1

PROJECT ORGANIZATION



documentation, and will assume custody of all samples and ensure the proper handling and shipping of samples.

The FOL will also be responsible for providing technical supervision of the drilling subcontractor and for maintaining a geologic log of all borings drilled. Copies of the forms to be used in this investigation are provided as Appendix A.

The site health and safety specialist will be responsible for assuring that all team members adhere to the designated health and safety requirements. It is not anticipated that the health and safety specialist will be required on site.

5.0 QUALITY ASSURANCE OBJECTIVES

The overall QA objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide environmental monitoring data of known and acceptable quality. Specific procedures to be used for sampling, chain-of-custody, calibration of field instruments, laboratory analysis, reporting, internal quality control, audits, preventative maintenance, and corrective actions are described in later sections of this QA/QC Plan. The purpose of this section is to address the data quality objectives in terms of the (PARCC) parameters, quantitation and detection limits, trip blanks, field blanks, rinsate blanks, duplicates, and bottleware cleanliness.

5.1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the investigation activities. The sampling rationale provided in the Work Plan explains the choice of sample locations and media which will supply information needed for the investigation.

5.2 PARCC Parameters

The quality of data set is measured by certain characteristics of the data, namely the PARCC parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The objectives of the investigation and the intended use of the data define the PARCC goals.

5.2.1 Precision

Precision characterizes the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for a sample under the same or similar conditions. Precision is expressed as a range (the difference between two measurements of the same parameter) or as a relative percent difference (the range relative to the mean, expressed as a percent). Range and Relative Percent Difference (RPD) values are calculated as follows:

$$\text{Range} = OR - DR$$

$$RPD = \frac{[OR - DR]}{1/2\,(OR + DR)} \times 100\%$$

where: OR = original sample result

DR = duplicate sample result

The internal laboratory control limits for precision are three times the standard deviation of a series of RPD or range values. RPD values may be calculated for both laboratory and field duplicates, and can be compared to the control limits as a QA check. Laboratory duplicates will be analyzed at the rate required by OESO. Field duplicates will be collected for 10 percent of all samples collected.

5.2.2 Accuracy

Accuracy is the comparison between experimental and known or calculated values expressed as a percent recovery (%R). Percent recoveries are derived from analysis of standards spiked into deionized water (standard recovery) or into actual samples (matrix spike or surrogate spike recovery). Recovery is calculated as follows:

$$\%R = \frac{E}{T} x\ 100\%$$

where: E = experimental result

T = true value (theoretical result)

$$with\ \frac{(Sample\ Aliq.)\ (Sample\ Conc.)\ +\ (Spike\ Aliq.)\ (Spike\ Conc.)}{Sample\ Aliq.\ +\ Spike\ Aliq.}$$

Control limits for accuracy are set at the mean plus or minus three times the standard deviation of a series or %R values.

Accuracy for aqueous and solid samples will be evaluated by use of surrogate and matrix spikes. Out-of-criteria results will be reviewed for data applicability as a part of data validation.

5.2.3 Representativeness

All data obtained should be representative of actual conditions at the sampling location. The Work Plan is designed so that the samples taken will present an accurate representation of actual site conditions. The rationales discussed in the Work Plan and QA/QC Plan are designed to ensure this. All sampling activities will conform to the protocols given in Section 6.0 of this QA/QC Plan. The use of OESO approved analytical protocols and data deliverables will ensure that analytical results and deliverables are representative, and both consistently performed and reported.

5.2.4 Comparability

Comparability will be achieved by utilizing standardized sampling and analysis methods and data reporting format. Both analytical procedures and sample collection techniques will maximize the comparability of this new data to previous data. Additionally, consideration will be given to seasonal conditions and other environmental conditions that could influence analytical results.

5.2.5 Completeness

Completeness is a measure of the amount of valid data obtained from the measurement program, compared to the total amount collected. For relatively clean, homogeneous matrices, 100-percent completeness is expected. However, as matrix complexity and heterogenicity increase, completeness may decrease. Where analysis is precluded or where DQOs are compromised, effects on the overall investigation must be considered. Whether any particular sample is critical to the investigation will be evaluated in terms of the sample location, the parameter in question, the intended data use, and the risk associated with the error.

Critical data points may not be evaluated until all the analytical results are evaluated. If in the evaluation of results it becomes apparent that the data for a specific medium are of insufficient quality (95 percent), either with respect to the number of samples or an individual analysis, resampling of the deficient data points may be necessary.

5.3 Field Blanks

Field blanks are obtained by sampling the water(s) used in decontamination during the field investigation. Samples consist of the source water used in (1) steam cleaning of large equipment and (2) analyte-free water used for decontamination of sampling equipment. Field blanks will be used to confirm the effectiveness of decontamination procedures, and to determine if the analyte-free water or the potable water

(used for steam cleaning) may be contributing to sample contamination. Field blanks will be collected for each type of water used for decontamination and will be submitted at a frequency of one per sampling event.

5.4 Rinsate Blanks

Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (bailer, split spoon, corer, etc.) after decontamination and placing it in the appropriate sample containers for analysis. Equipment blanks will be used to assess the effectiveness of decontamination procedures. Equipment blanks will be collected for each type of non-dedicated sampling equipment used and will be submitted at a frequency of one per day per media. Equipment blanks however will only be analyzed every other day unless positive detections are recorded in the prior sample blank. It will be the responsibility of the FOL to communicate to the laboratory whether an equipment blank is, or is not, to be analyzed as stated above.

5.5 Field Duplicates

Field duplicates are two samples collected; (1) independently at a sampling location in the case of groundwater or surface water, or (2) a single sample split into two portions in the case of soil or sediment. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Ten percent of all samples for each media shall be field duplicates. Duplicates shall be analyzed for the same parameters in the laboratory.

5.6 Trip Blanks

Trip blanks are used to determine whether contamination of sample or bottleware has occurred in the field. Trip blanks consist of analyte-free water taken from the laboratory to the site, and returned. Trip blanks are taken at the rate of one per cooler of organics and will be analyzed for TCL VOCs only.

5.7 Bottle Ware

OESO requires specific bottleware cleaning procedures. Precleaned bottles will be used at the NAVSURFWARCEN IHDIV site; the required certification will be provided.

6.0 SAMPLING PROCEDURES

6.1 Site Background

The site background information is provided in Section 2.0 of the Work Plan.

6.2 Sampling Objectives

The overall objective of the field activities will be to characterize the nature and extent of any contamination which may be present at the Strauss Avenue and Caffee Road Thermal Treatment Points, to further define the site hydrogeology/geology, and to assess the background water quality for these areas. In addition, the monitoring wells installed at these sites will allow for detection of any future groundwater contamination which may occur. The environmental and background data collected will also serve as a portion of a RCRA Subpart X Permit application.

6.3 Sample Location and Frequency

Soils, sediments, surface water, and groundwater samples will be collected during the field activities. These samples will be analyzed in accordance with OESO methodology. A list of the analytes, analytical method, containers, preservatives, and holding times are provided in Tables 4-1, 4-2, 4-3, 4-4, and 4-5 of the Work Plan.

The sampling program consists of five activities. These activities are as follows and are described in detail in Section 3.0 and 4.0 of the Work Plan.

- Monitoring Well/Piezometer Installation
- Subsurface/Surface Soil Sampling
- Staff Gauge installation
- Monitoring Well Sampling
- Surface Water/Sediment Sampling
- Slug Tests/Water Levels

6.4 Sample Designation

Each sample collected will be assigned a unique sample tracking number. The sample tracking number will consist of a three-segment, alpha-numeric code that identifies the sample medium and location, sample

depth (in the case of soil samples), and QA designation, if required. Any other pertinent information regarding sample identification will be recorded in the field log books.

The alpha-numeric coding to be used in the sample system is explained in the diagram and the subsequent definitions:

(AA)	-	(AANN)	-	(NNNN)	-	(A)
(Site Location)		(Medium & Location)		(Sample depth)		(QA designation)

Character Type:

A = Alpha

N = Numeric

Site:

SA = Strauss Avenue

CR = Caffee Road

Medium:

GW = Groundwater from monitoring well

SB = Soil sample from soil borings

SW = Surface water

SD = Sediment

SS = Surface soil

Sample Location:

Surface soil / subsurface soil = well number

Surface water / sediment = Surface water / sediment sample location number.

Groundwater sample = well number.

Sample Depth:

For soil samples = Start depth of sample (in feet).

Not used for groundwater or surface water/sediment samples.

QA Sample Designation:

D = Duplicate

B = Equipment Rinsate Blank

F = Field Blank

6.5 Sample Equipment and Protocols

The sampling equipment and protocols to be used are presented in Appendix B of the Work Plan and are HALLIBURTON NUS Standard Operating Procedures GH-1.3 through GH-1.7.

6.6 Sample Handling and Analysis

Sample handling and analysis are presented in Sections 5.0, 6.0, and 7.0 of this QA/QC Plan.

6.7 Equipment Decontamination

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

Major Equipment

All downhole drilling equipment and sampling tools shall be steam cleaned prior to beginning work, between well borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program. In addition, well casing and screens shall be steam cleaned prior to being installed into the borings.

These decontamination operations will consist of washing the equipment using a high-pressure steam wash. All decontamination activities will take place at a location determined during mobilization. Additional requirements for drilling equipment decontamination can be found in HALLIBURTON NUS SOP GH-1.6: Section 5.

Sampling Equipment

All sampling equipment used for collecting samples will be decontaminated both prior to beginning field sampling and between samples. The following decontamination steps will be taken:

- Potable water rinse
- Alconox or liquinox detergent wash
- Potable water rinse
- Distilled/deionized water rinse
- Methanol double rinse
- Nitric acid rinse
- Distilled/deionized water rinse
- Air dry

Field analytical equipment such as pH, conductivity and temperature instrument probes will be rinsed first with analyte-free water, then with the sample liquid.

7.0 SAMPLE CUSTODY

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. An example of the chain-of-custody form, which will be used during this investigation, is included in Appendix A of the Work Plan.

Samples collected during the site investigation will be the responsibility of identified persons from the time they are collected until they, or their derived data, are incorporated into the final report. Stringent chain-of-custody procedures will be followed to document sample possession.

7.1 Field Custody

- The FOL, or his or her designee, is responsible for the care and custody of the samples collected until they are delivered to the analyzing laboratory or entrusted to a carrier.

- Sample logs or other records will always be signed and dated.

- Chain-of-custody sample forms will be completed to the fullest extent possible prior to sample shipment. They will include the following information: project name, sample number, time collected, source of sample and location, description of sample location, matrix, type of sample, grab or composite designation, preservative, and name of sampler (see Appendix A for sampling forms).

These forms will be filled out in a legible manner, using waterproof ink, and will be signed by the sampler. Similar information will be provided on the sample label which will be securely attached to the sample bottle. The label will also include the general analyses to be conducted. In addition, sampling forms will be used to document collection, filtration, and preparation procedures. Copies of all logs used are provided in Appendix A.

7.2 Transfer of Custody and Shipment

The following procedures will be used when transferring custody of samples:

- Samples will always be accompanied by a chain-of-custody record. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time of the chain-of-custody record. This record documents the sample custody transfer from

the sampler to the laboratory, often through another person or agency (common carrier). Upon arrival at the laboratory, internal sample custody procedures will be followed.

- Prior to shipment to the laboratory for analysis, samples will be properly packaged. Individual custody records will accompany each shipment. Shipping containers will then be sealed for shipment to the laboratory. The methods of shipment, courier name, and other pertinent information, will be entered in the remarks section of the custody record.

- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment; and a copy will be retained by the field sampler.

- Proper documentation will be maintained for shipments by common carrier.

7.3 Sample Shipment Procedures

The following procedures will be followed when shipping samples for laboratory analysis:

- Samples requiring refrigeration will be promptly chilled with ice or Blue Ice to a temperature of 4°C and will be packaged in an insulated cooler for transport to the laboratory. Ice will be sealed in containers to prevent leakage of water. Samples will not be frozen.

- Only shipping containers that meet all applicable state and Federal standards for safe shipment will be used.

- Shipping containers will be sealed with nylon strapping tape, custody seals will be signed, dated, and affixed, in a manner that will allow the receiver to quickly identify any tampering that may have occurred during transport to the laboratory.

- The field chain-of-custody document will be placed inside the shipping container in a sealed plastic envelope after the courier has signed the document.

- Shipment will be made by a public courier. After samples have been taken, they will be sent to the laboratory within 48 hours.

7.4 Field Documentation Responsibilities

It will be the responsibility of the FOL to secure all documents produced in the field (geologist's daily logs, lithologic and sampling logs, communications) at the end of each work day.

The possession of all records will be documented; however, only the project FOL or designee may remove field data from the site for reduction and evaluation.

8.0 CALIBRATION PROCEDURES

Field equipment such as the photoionization equipment (HNu), the pH and specific conductance meters, and any other equipment used during this project will be calibrated and operated in accordance with the manufacturer's instructions and manuals. A log will be kept documenting the calibration results for each field instrument. The log will include the date, standards, personnel, and results of the calibration.

9.0 ANALYTICAL PROCEDURES

Environmental samples collected during the field investigation for chemical analyses will be analyzed using the appropriate analytical procedures as outlined in Sections 3.0 of this QA/QC Plan and Tables 4-1, 4-2, 4-4, and 4-5 of the Work Plan.

10.0 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction, validation, and reporting are basic steps in the control and processing of field and laboratory project-generated data. Data validation procedures are described below.

Data validation consists of a stringent review of an analytical chemical data package with respect to sample receipt and handling, analytical methods, data reporting and deliverables, and document control. The quality of data generated by a laboratory is extremely important; it is an integral part of the investigation and should be clearly tied to the project goals. Data used to develop qualitative trends, for example, will not have the same data validation requirements as data used for litigation purposes.

A qualified chemist chosen by the contractor will review the analytical data packages using EPA procedures. Approximately 10% of the total number of environmental samples will be validated. After the data is validated, a listing of non-conformities will be generated and used to determine whether the data can be utilized for its intended purpose. Non-conformities require data qualifiers, which are used to alert the data user to inaccurate or imprecise data. For example, if holding times are exceeded, the data reviewer must qualify all positive results as estimated and all sample quantitation limits as estimated. For situations in which there are several quality control criteria out of specification (with regard to the limits specified in the Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program), the data validator may make professional judgments and/or comments on the validity of the overall data package. In situations where the validity of an entire data package is in question, it may be necessary for the sample(s) to be re-analyzed. The reviewer will then prepare a technical memorandum presenting changes in the data, if necessary, and the rationale for making such changes.

The net result is a data package that has been carefully reviewed for its adherence to prescribed requirements and is suitable for its intended use. Data validation thus plays a major role in determining the confidence with which key technical evaluations may be made.

The final report will include a data summary. The summary of analytical data will exclude non-detected compounds. No subtraction of blanks will be allowed. Data will be flagged if blank contamination occurs. All data flags will follow the result in the summary.

The laboratory data for each sample will be reported in an appendix. These data will be presented in a spreadsheet format with all field, and laboratory blanks marked. The format recommended by OESO will be used. Field logs and forms will be included in another appendix.

11.0 INTERNAL QUALITY CONTROL CHECKS

Quality control samples generated by the contractor will include the collection of field duplicates, the preparation of field blanks, and the preparation of equipment/rinsate blanks. An approximate 10 percent duplication (one per 10 samples or one per sample matrix if less than 10 samples will be collected (see Work Plan Tables 4-1, 4-2, 4-4, and 4-5).

Trip blanks will accompany samples to determine if VOC contamination has effected samples. Rinsates, prepared by running distilled water through the sampling equipment, will be analyzed to determine whether the sampling procedures may be biasing the data. Field blanks will be prepared at a rate of one per source per event. Procedures for collecting these samples are contained in the Section 6.0 of this QA/QC Plan.

There are two types of quality assurance mechanisms used to ensure the production of analytical data of known and documented quality. The internal quality control procedures for the analytical services are specified under OESO guidelines and Tables 4-1, 4-2, 4-4, and 4-5. These specifications include the types of control samples required (sample spikes, surrogate spikes, controls, and blanks), the frequency of each control, the compounds to be used for sample spikes and surrogate spikes, and the quality control acceptance criteria. It will be the laboratory's responsibility to document, in each package, that both initial and on-going instrument and analytical QC criteria are met. This documentation will be included in the data packages generated by contract laboratory.

Analytical results of field-collected quality control samples will also be compared to acceptance criteria, and documentation will be performed showing that criteria have been met. Any samples in nonconformance with the QC criteria will be identified and reanalyzed by the laboratory, if possible. The following procedures will be employed for the NAVSURFWARCEN IHDIV samples:

- Proper storage of samples.
- Use of qualified and/or certified technicians.
- Use of calibrated equipment.
- Formal independent confirmation of all computation and reduction of laboratory data and results.

- Use of standardized test procedures.

- Inclusion of replicate samples at a frequency of one replicate per 10 samples or one per sample matrix if less than 10 samples are collected.

12.0 PERFORMANCE AND SYSTEM AUDITS

System audits will be performed on a semicontinuous basis, as appropriate, to assure that the work is being implemented in accordance with the approved project SOPs and in an overall satisfactory manner.

- The FOL will supervise and check on a daily basis that the monitoring wells are installed and developed correctly, field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.

- The data validator will review (on a timely basis) the data packages submitted by the laboratory. The data validator will check that the data was obtained through the approved methodology, that the appropriate level of QC effort and reporting was conducted, that holding times were met, and that the results are in conformance with the QC criteria. On the basis of these factors, the data validator will evaluate the data quality and limitations.

- The project manager will oversee the FOL and data validator, and check that management of the acquired data proceeds in an organized and expeditious manner.

- System audits for the laboratory are performed on a regular basis and are integral to OESO approval.

- A formal audit of the field sampling procedures may be conducted in addition to the auditing that is an inherent part of the daily project activities.

- The auditors will check that sample collection, sample handling, decontamination protocols, and instrument calibration and use are in accordance with the approved project SOPs. The auditors will also check that the field documentation logs and chain-of-custody forms are being filled out properly.

The subcontracted analytical laboratory must be approved by OESO, be eligible to perform the required analysis under OESO protocols, and must have site-specific approval prior to commencement of work.

13.0 PREVENTATIVE MAINTENANCE

HALLIBURTON NUS has established a program for the maintenance of field equipment to ensure the availability of equipment in good working order when and where it is needed. This program consists of the following elements:

- The equipment manager keeps an inventory of the equipment in terms of items (model and serial number) quantity and condition. Each item of equipment is signed out when in use, and its operating condition and cleanliness checked upon return.

- The equipment manager conducts routine checks on the status of equipment and is responsible for the stocking of spare parts and equipment readiness.

- The equipment manager maintains the equipment manual library and trains field personnel in the proper use and care of equipment.

- The FOL is responsible for working with the equipment manager to make sure that the equipment is tested, cleaned, charged, and calibrated in accordance with the manufacturer's instructions before being taken to the job site.

The laboratory follows a well-defined program to prevent the failure of laboratory equipment and instrumentation. This preventative program, includes the periodic inspection, lubrication, cleaning, and replacement of parts of the equipment.

14.0 DATA ASSESSMENT PROCEDURES

14.1 Representativeness, Accuracy, and Precision

All data generated in the investigation will be assessed for its representativeness, accuracy, and precision. The completeness of the data will also be assessed by comparing the valid acquired data to the project objectives to see that these objectives are being addressed and met. The specific procedures used to determine data precision, accuracy, and completeness will be provided in the analytical reports. Accuracy will be determined using laboratory spiked samples and laboratory field blanks.

The representativeness of the data will be assessed by determining if the data are consistent with known or anticipated hydrogeologic or chemical conditions and accepted principles. Field measurements will be checked for completeness of procedures and documentation of procedures and results.

Precision and accuracy will be determined using replicate samples and blank and spiked samples, respectively. The specific procedures for determining PARCC parameters are outlined in Section 5.0.

14.2 Validation

Ten percent of the analytical data packages for each media will be validated. If problems are found during this partial validation, then additional or all the data packages may be validated.

14.3 Data Evaluation

The evaluation of the data collected during the field investigation will be a comparison of: chemical concentrations in the hydraulically upgradient groundwater wells versus the chemical concentration in the downgradient groundwater wells; chemical concentrations in groundwater versus ARARs (such as the Safe Drinking Water Act MCLs) and risk-based concentrations; and chemical concentrations in soils versus background and risk-based concentrations.

The concentrations any contaminants which may be found during chemical analysis will be compared to the values in the hydraulically upgradient groundwater versus downgradient groundwater. Typically, a statistical approach (such as the t-test) can be used to determine is there is a significant increase in contaminant concentrations across a site. This increase would indicate that the site is a source of the contamination. The conclusions of the data collected are expected to either conclusively indicate that the site is, or is not, causing groundwater contamination; or the data may be inconclusive and indicate that

additional data collection is required. Relatively conclusive data that the site is causing groundwater contamination would occur if there is a significant (one or more orders of magnitude) increase in contaminant concentrations from the upgradient wells to the downgradient wells. If the contaminant concentrations are nearly identical (+/- 25%) in the upgradient and downgradient wells, then this would indicate that the site is not causing the groundwater contamination. Otherwise, the data is inclusive and additional rounds of groundwater sampling would be required to allow a statistical evaluation.

The approach for evaluating contaminant concentrations in soils is similar to that for groundwater. The evaluation of the data collected during the field investigation will be a statistical comparison of: chemical concentrations in the background (natural) values versus the chemical concentration in the onsite samples; and chemical concentrations in site soils versus MCLs and risk-based concentrations.

15.0 CORRECTIVE ACTION

The QA program will enable problems to be identified, controlled, and corrected. Potential problems may involve nonconformance with the SOPs and/or analytical procedures established for the project or other unforeseen difficulties. Any person identifying an unacceptable condition will notify the project manager. The project manager, with the assistance of the project QA/QC officer, will be responsible for developing and initiating appropriate corrective action and verifying that the correction action has been effective. Corrective actions may include the following: resampling and/or reanalysis of sample, amending or adjusting project procedures. If warranted by the severity of the problem (for example, if a change in the approved work plan is required), the Navy will be notified in writing and their approval will be obtained prior to implementing any change. Additional work that is dependent on a nonconforming activity will not be performed until the problem has been eliminated.

The laboratory maintains an internal closed-loop corrective action system that operates under the direction of the laboratory QA coordinator.

16.0 QUALITY ASSURANCE REPORTS

The QA/QC advisor will review all aspects of the implementation of the QA/QC Plan on a regular basis and prepare a summary report. Reviews will be performed at the completion of each field activity and reports will be completed at this time. These reports will include an assessment of data quality and the results of system and/or performance audits. Any significant QA deficiencies will be reported and identified, and corrective action possibilities discussed. The laboratory will issue monthly progress reports.

17.0 REFERENCES

American Society of Agronomy, 1986. Methods of Soil Analysis. Madison, Wisconsin.

Naval Energy and Environmental Support Activity (NEESA). June 1988. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. NEESA, Port Hueneme, CA. NEESA 20.2-047B.

U.S. EPA, 1986. Test Methods for Evaluating Solid Waste - SW846.

APPENDIX D

SITE-SPECIFIC HEALTH AND SAFETY PLAN

NAVAL ORDNANCE STATION
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD DIVISION
INDIAN HEAD, MARYLAND

SUBMITTED TO:
CHESAPEAKE DIVISION
ENVIRONMENTAL ENGINEERING BRANCH, CODE 18
NAVAL FACILITIES ENGINEERING COMMAND
BUILDING 212, WASHINGTON NAVY YARD
WASHINGTON, DC 20374-2121
AND
AIR AND HAZARDOUS WASTE BRANCH
NAVAL ORDINANCE STATION
INDIAN HEAD, MARYLAND

SUBMITTED BY:
HALLIBURTON NUS ENVIRONMENTAL CORPORATION
661 ANDERSEN DRIVE
PITTSBURGH, PA 15220

CONTRACT NUMBER: _____
CONTRACT TASK ORDER: _____

AUGUST 1992

SUBMITTED BY:	APPROVED BY:
_____	_____
Ralph R. Basinski	Matthew M. Soltis, CSP
Project Manager	Health & Safety Manager

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1.0 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: Naval Ordnance Station Client Contact: Sherry McCahill

Address: Indian Head, Maryland Phone Number: (301) 743-6745

Effective Date: TBA

Purpose of Site Visit: Multi-Media Sampling at the two Thermal Treatment Points(TTP) Strauss Avenue and Caffee Road. This activity will be conducted to determine the vertical and horizontal extent of contamination as a result of the Open burning(OB) activities at these points.

Proposed Dates of Work: TBA

Project Team:

HALLIBURTON NUS Personnel:	Discipline/Tasks Assigned:
Ralph Basinski	Project Manager
Pete Nimmer	Field Operations Leader (FOL)/Geologist
Thomas M. Dickson	Health and Safety Officer (HSO)
TBA	Geologist/Sampler

Non-HALLIBURTON NUS Personnel:

Plan Preparation:

Prepared by: Thomas M. Dickson

Reviewed and Approved by:

HALLIBURTON NUS
Navy CLEAN
Health and Safety Manager: Matthew M. Soltis, CSP

Reviewed:

HALLIBURTON NUS

Project Manager: Ralph Basinski

Follow Up Report:

Responsible Person: Pete Nimmer (Must fill out Follow-Up Report)

1.1 INTRODUCTION

This Health and Safety Plan (HASP) has been developed to provide the minimum safety procedures for HALLIBURTON NUS and subcontractor personnel engaged in Multi-media sampling and surveying activities at the Thermal Treatment Points, Strauss Avenue and Caffee Road at NAVSURFWARCEN IHDIV. This plan was developed using available information regarding known/suspected chemical contaminants and physical hazards that may be encountered during the planned activities. If additional information becomes available prior to or throughout the course of field activities, this document will be modified accordingly. Modifications will be determined by the HALLIBURTON NUS Health and Safety Officer (HSO) and will be immediately communicated to appropriate personnel. This HASP is intended to be in compliance with 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response; Final Rule."

This HASP is structured, and may be presented, as a stand-alone document. Although the information herein is designed to function independently, it may be used in conjunction with previously generated HASPs. If this document is used in this manner, and conflicting information becomes evident, this plan will take precedence.

2.0 DESCRIPTION AND BACKGROUND

2.1 BACKGROUND INFORMATION

NAVSURFWARCEN IHDIV covers 3423 acres and is bounded by the Potomac River, Mattawoman Creek, Chicamuxen Creek, the town of Indian Head, and private property. It is situated in the northwestern section of Charles County, Maryland, 25 miles southwest of Washington, D.C. Figure 2-1 shows the location of the Naval Ordnance Station in relationship to the surrounding communities.

The mission of NAVSURFWARCEN IHDIV is to provide material and technical support for assigned weapons systems, weapons, or components and to perform additional tasks as directed by the Naval Sea Systems Command. These tasks may include research, development, engineering, production, and quality surveillance for weapons systems, propulsion, unconventional explosives, cartridge-actuated and propellant-actuated devices, and chemicals. Disciplines represented at NAVSURFWARCEN IHDIV include expertise in weapons systems, propulsion, explosives development, and propellant and explosives chemistry.

NAVSURFWARCEN IHDIV hosts two major tenants: the Naval Explosive Ordnance Disposal Technology Center (NEODTC) and the Naval School, Explosive Ordnance Disposal (NSEOD). NEODTC was established to develop procedures for rendering safe conventional and special weapons, guided missiles, biological and chemical munitions, tools, and equipment. The mission of NSEOD is to train officers and enlisted personnel in methods and procedures for recovery, evaluation, rendering safe, and disposal of surface, underwater, conventional, and nuclear explosive ordnance.

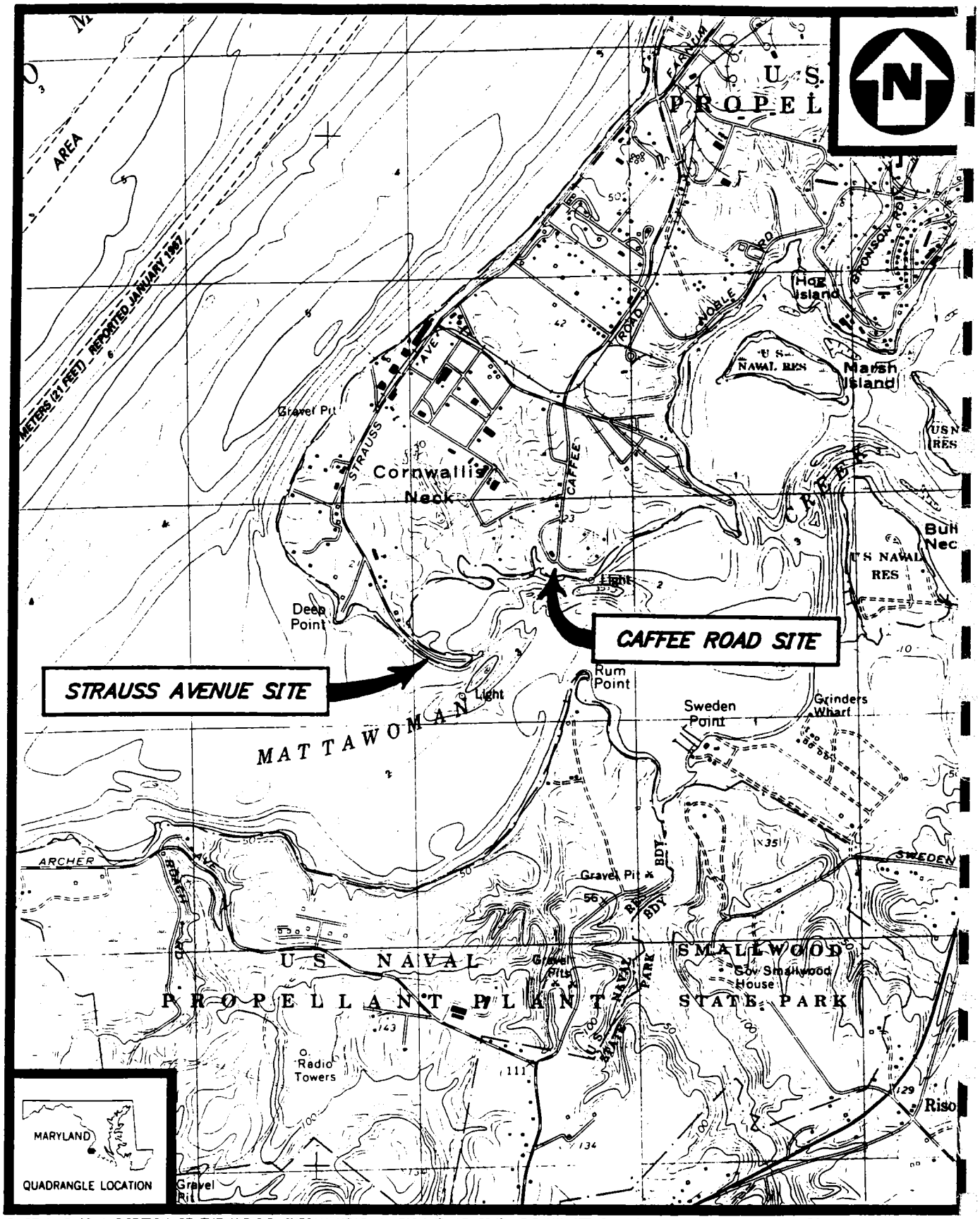
The Thermal Treatment Points (TTP's) addressed in this proposed scope of work are located at the southwest portion of the base. The Strauss Avenue activity is on a narrow , 1,100 foot long peninsula which extends off Indian Head into Mattawoman Creek, a tidal tributary of the Potomac River. The nearby Caffee Road activity occupies 1.25 acres, and is located along the bank of Mattawoman Creek approximately 2500 feet to the northeast of the Strauss Avenue site. Both of the TTP's sites are located in the flood plain of the Potomac River.

2.2 SITE ACTIVITIES

Thermal treatment of RCRA reactive wastes occur by open burning(OB) at two locations. These materials range from pure propellant to energetic contaminated equipment, chemicals, and other items.

2.2.1 Strauss Avenue

Materials which are thermally treated at the Strauss Avenue TTP include rocket grains (motors), explosive scrap, and other materials contaminated with explosives and propellants. Treatment activity occurs at two locations at the Strauss Avenue TTP. The Main Point, located at the end of the Strauss Avenue peninsula, is used for the majority of materials which require thermal treatment. There are seven (7) burn pans spaced along the perimeter of the Main Point. The Auxiliary Point is a smaller peninsula which branches off from the Strauss Avenue peninsula. This area contains six (6) burn pans, one (1) solvent treatment vessel one (1) jato block and one (1) igniter vessel. A map of the Strauss Avenue site is shown in Figure 2-2.



BASE MAP IS A PORTION OF THE U.S.G.S. INDIAN HEAD, MARYLAND—VIRGINIA 7.5 MINUTE QUADRANGLE, PHOTOREVISED 1978.

LOCATION MAP OF INDIAN HEAD PENINSULA

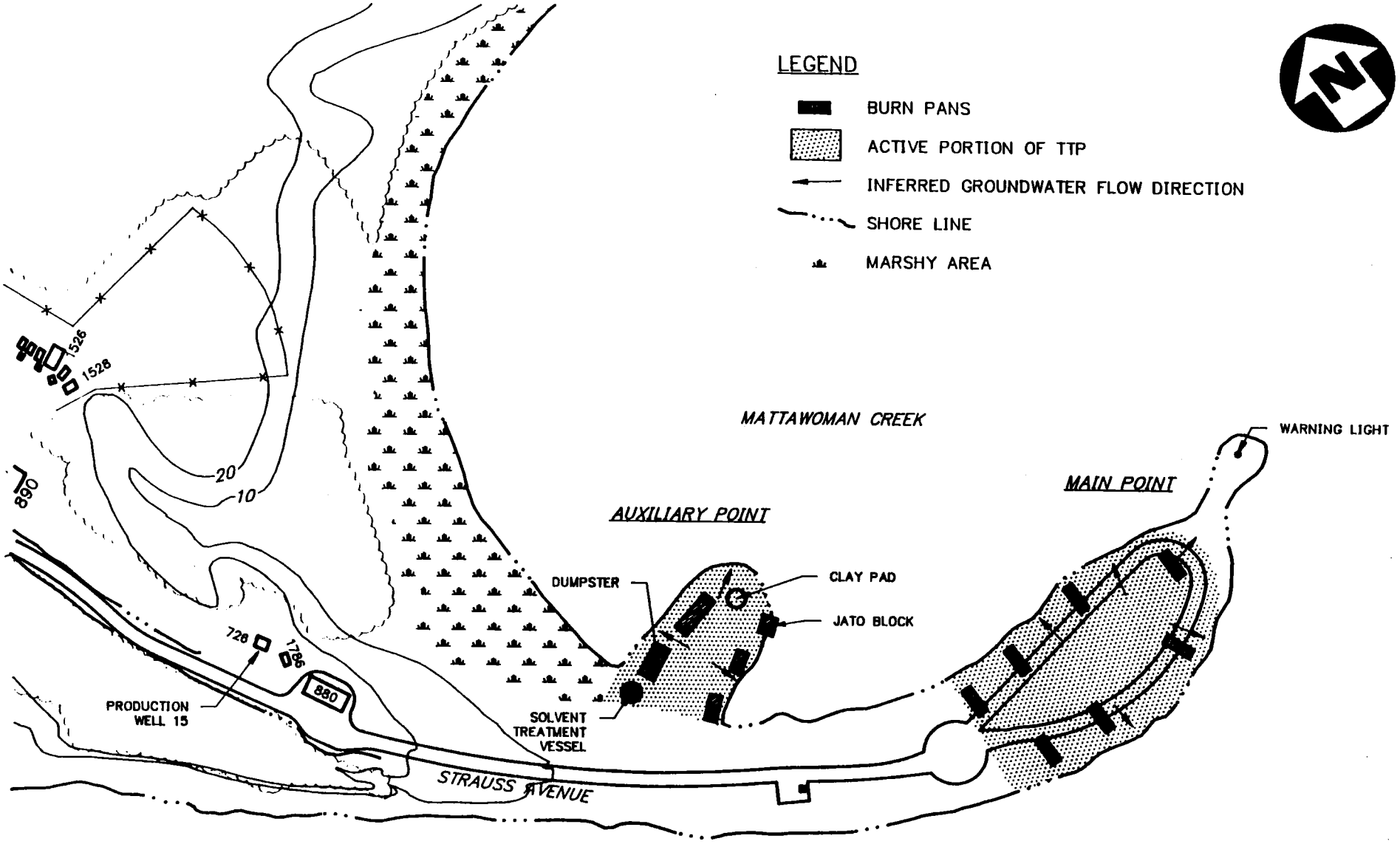
FIGURE 2-1

INDIAN HEAD, MARYLAND

0 2000 4000

SCALE IN FEET

HALLIBURTON NUS
Environmental Corporation



0 200 400
SCALE IN FEET

SITE MAP
STRAUSS AVENUE TTP
INDIAN HEAD, MARYLAND

FIGURE 2-2

HALLIBURTON NUS
Environmental Corporation

Thermal treatment occurs daily at the Main Point, while the Auxiliary Point is used less frequently. The majority of thermal treatment of materials occurs in clay-lined burn pans on the Main and Auxiliary Points. These burn pans are lined with a minimum of 6 inches of clay, which serves as a support medium for the wastes treated, and also serves to protect the pans from the heat generated during treatment. In many cases it is necessary to add supplementary fuel, such as wooden items or fuel oil to assist in initiating and sustaining effective thermal treatment of the waste. Burn pans are covered when not in use to prevent and accumulation of precipitation inside the pans and to prevent wind dispersal of ash.

At the Auxiliary Point, in addition to the use of burn pans, rocket grains are treated by attaching them to a large concrete (jato) block to prevent unrestrained motion of the items during treatment. Liquid wastes and solvents contaminated with explosives are treated at the Auxiliary Point in a solvent treatment and igniter vessels. These containers, which has a secondary containment pan beneath the vessel, has legs to support it above the ground and is regularly inspected for structural integrity. Occasionally, treatment of grains larger than the burn pans may occur on clay pads, directly on the ground. Base personnel report that large grains are treated outside of burn pans quite infrequently, generally less than once a year.

2.2.2 Caffee Road

The Caffee Road site is used to treat explosive/propellent contaminated bulk metal items, which range in size from small scrap pieces to contaminated storage tanks, pipes, and other large metal objects. In addition, explosive/propellant contaminated scrap of a nonmetallic nature, such as packing material and containers are treated at this site. The amount of combustible materials, or actual energetics which are contained in the waste is small in comparison to the size of the item. Therefore, ignition aids such as fuel oil and wooden items may be used to achieve complete decontamination of the items. Figure 2-3 shows a map of the Caffee Road activity.

Thermal treatment activities occur at Caffee Road approximately once every two weeks. After the scrap material has been rendered nonreactive, it is stored on the site until it can be sold for recycling.

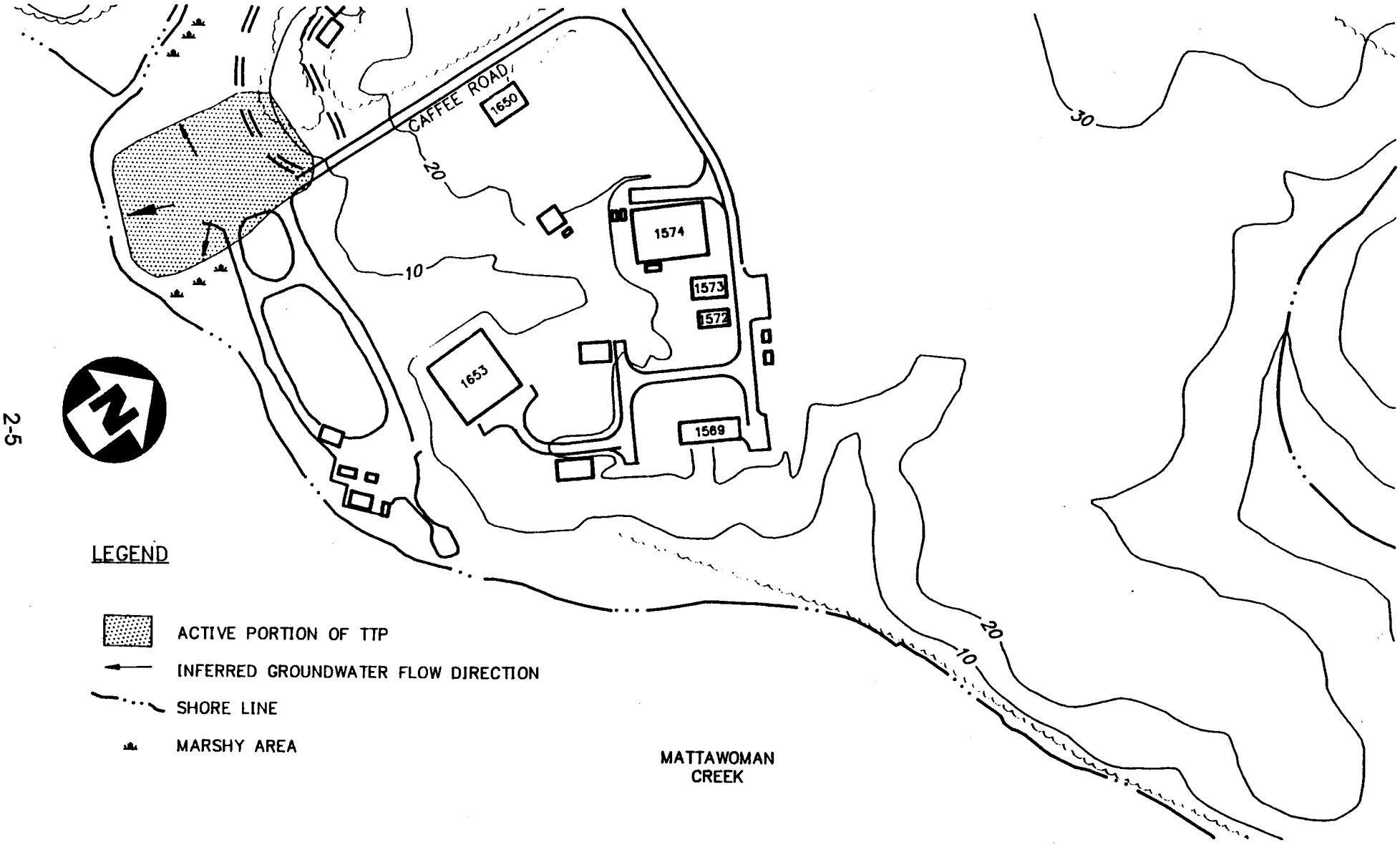


FIGURE 2-3

SITE MAP
CAFFEE ROAD TTP
INDIAN HEAD, MARYLAND

HALLIBURTON NUS
Environmental Corporation

ACAD: 0040\BASE.DWG VIEW = 2 08/11/92 MJJ

3.0 FIELD OPERATIONS

3.1 FIELD OPERATIONS SUMMARY

The field investigation to be performed at NAVSURFWARCEN IHDIV will consist of multi-media environmental sampling at the Strauss Avenue and Caffee Road Thermal Treatment Points. Activities to be conducted at Strauss Avenue TTP include drilling and sampling of 16 soil borings, including instalation of fourteen monitoring wells and two piezometers. Seven surface water and sediment samples will be taken at Strauss Avenue TTP, and one staff gauge will be installed. At the Caffee Road TTP, eight soil borings will be completed and six monitoring wells will be installed. Three surface water and sediment samples will be taken at Caffee Road, and one staff gauge will be installed.

Once the monitoring wells, piezometers, and staff gauges have been installed a survey team will plot the locations.

4.0 HAZARD ASSESSMENT

4.1 CHEMICAL HAZARDS

The primary hazard associated with this investigation will be the potential for dermal contact and inhalation exposure with the waste/contamination in general. The contaminants of concern during this field operation will be broken into two categories representing primary and secondary chemical contaminants. Monitoring instrument action levels, and safety measures will be directed as a function of the primary chemical contaminant list as these chemicals present the representative priority compounds of known concentrations thermally treated at the TTP's. For this reason these substances on the primary list will be used as indicator compounds to activate safety measures. Information concerning toxicity, chemical and physical properties may be obtained in Table 4-1.

Personal protective equipment (PPE), proper decontamination, site control, and standard work practices, Sections 6.0, 7.0, 12.0, and 10.0 of this plan, respectively, will be used when necessary to help reduce or eliminate exposures and therefore reduce the potential for adverse health effects.

4.2 PHYSICAL HAZARDS ON SITE

During the execution of the proposed scope of work (see Section 3.0) certain physical hazards may be encountered by field personnel while engaged in on site activities. Based on the hazard analysis, it is anticipated the physical hazards could involve but not limited to the following items:

- Contact with Energized Sources
- Exposure to moving machinery, particulary during drilling activities
- Uneven or unstable terrain (slip, trip hazards)
- Strain sprains or muscle pulls
- Noise in excess of 85 dBA
- Heat stress
- Cold stress
- Water hazards
- Natural hazards (Ticks, Snakes, and other indigenous creatures)
- Inclement weather
- Contact with energetic material

Control efforts for these potential hazards shall employ a variety of safety measures to mitigate these hazards. These measures shall be discussed individually with each area of concern mentioned above.

4.2.1 Contact with Energized Sources

To avoid hazards of this type, no drilling mast or any other such projecting items shall be permitted within a 20-foot radius of any energized source. Also, any areas targeted for subsurface activities shall first be investigated to determine the presence of underground utilities.

4.2.2 Exposure to Moving Machinery

Personnel shall also be advised of the hazards presented due to working in a close proximity of moving machinery(i.e. drill rig). Safety measures employed to overt hazards of this nature will include proper fitting personal protective equipment to avoid possible entanglement in moving parts, employing

TABLE 4-1
PRIMARY CHEMICAL CONTAMINANTS

Names & Synonyms	Chemical Abstract Service Number (CAS No.)	Safe Exposure Limit, OSHA; ACGIH; NIOSH	Method of Detection	Warning Properties	Signs & Symptoms of Overexposure	Physical Properties
Aluminum	7429-90-5	15 mg/m^3 Total dust 5 mg/m^3 Respirable dust 10 mg/m^3 10 mg/m^3 Total dust 5 mg/m^3 Respirable dust	PID: Not detected IP: Not detected FID: Not detected RR: Not detected	None - This material will be in the form of a particulate under ambient temperatures and conditions. As their is no suitable way to determine its presence through warning properties or monitoring instruments, a general approach will be to control all particulate emissions and hence control potential exposures to this compound.	<u>Routes of Exposure:</u> Inhalation, Eyes, Skin <u>Acute Toxicity:</u> Typically inhalation resulted in difficulty in breathing, coughing, mechanical irritation, variable sputum production which would be likely in any airborne particulate atmosphere. <u>Chronic toxicity:</u> Inhalation of finely divided powders has been reported to cause bronchopneumonia and in repeated or prolonged exposure interstitial pulmonary fibrosis <u>CNS Effects:</u> In rare cases encephalopathy has been reported	Boiling Pt: 2450°C Melting Pt: 660°C Freezing Pt: Not available Solubility: Insoluble Specific Gravity: 2.7 Vapor Pressure: Not available Flash Pt: Not available LEL: Not available UEL: Not available <u>Incompatibles:</u> Acids, alkalies, strong oxidizers, halogens, and halogenated hydrocarbons
Ammonium Nitrate TNT	No information found under this title	No information found under this title	PID:No information found under this title IP: FID: RR:	No information found under this title	<u>Routes of Exposure:</u> No information found under this title	Boiling Pt: Melting Pt: Freezing Pt: Solubility: Specific Gravity: Vapor Pressure: Flash Pt: LEL: UEL: <u>Incompatibles:</u> No information found under this title

TABLE 4-1
PRIMARY CHEMICAL CONTAMINANTS
PAGE 2

Names & Synonyms	Chemical Abstract Service Number (CAS No.)	Safe Exposure Limit, OSHA; ACGIH; NIOSH	Method of Detection	Warning Properties	Signs & Symptoms of Overexposure	Physical Properties
Barium Chromate	10294-40-3	0.5 mg(Ba)/m^3 for soluble barium compounds	PID: Not detected IP: Not detected FID: Not detected RR: Not detected	No information found- This material will be in the form of a particulate under ambient temperatures and conditions. As their is no suitable way to determine its presence through warning properties or monitoring instruments, a general approach will be to control all particulate emissions and hence control potential exposures to this compound	Routes of Exposure: Inhalation, ingestion Acute toxicity: poisonous! gastroenteritis, muscular paralysis, decreased pulse rate, altered heartbeat (v.fibrillation) Chronic toxicity: This substance has been reported as a human carcinogen	Boiling Pt: Not available Melting Pt: Not available Freezing Pt: Not available Solubility: Insoluble Specific Gravity: (density 4.50)@ 15°C Vapor Pressure: Not available Flash Pt: Not available LEL: Not available UEL: Not available Incompatibles: Reducing materials Heavy yellow, crystalline powder
Dinitrocellulose	50935-18-7	None established	PID: Unknown IP: Unknown FID: Unknown RR: Unknown No information found under this title	No information found under this title	Routes of Exposure: No information found under this title	Boiling Pt: Melting Pt: Freezing Pt: Solubility: Specific Gravity: Vapor Pressure: Flash Pt: LEL: UEL: Incompatibles: No information found under this title

TABLE 4-1
PRIMARY CHEMICAL CONTAMINANTS
PAGE 3

Names & Synonyms	Chemical Abstract Service Number (CAS No.)	Safe Exposure Limit, OSHA; ACGIH; NIOSH	Method of Detection	Warning Properties	Signs & Symptoms of Overexposure	Physical Properties
Dinitrotoluene See also 2,4-DNT	121-14-2	1.5 mg/m^3 (skin)	PID: Unknown IP: Unknown FID: Unknown RR: Unknown No information found under this title	This material will be in the form of a particulate under ambient temperatures and conditions. As their is no suitable way to determine its presence through warning properties or monitoring instruments, a general approach will be to control all particulate emissions and hence control potential exposures to this compound	Routes of Exposure: Inhalation, ingestion, and skin and eye contact Acute toxicity: Toxic effects characterized by exposure include headaches, fatigue, vertigo, anemia, and methemoglobinemia and possibly cyanosis. In more severe cases difficulty in breathing, dizziness, sleepiness, and pain in the joints. An irritant and allergen. Chronic toxicity: liver damage	Boiling Pt: 300°C Melting Pt: 69.5°C Freezing Pt: Not available Solubility: Slight Specific Gravity: 1.32 @ 71°C Vapor Density: 6.27 Vapor Pressure: 1 torr @ 20°C Flash Pt: 404°F LEL: Not available UEL: Not available Incompatibles: Nitric Acid, alkalies, and strong oxidizers
Chlorinated Solvents	General information	None established for general categories	PID: Not applicable IP: FID: RR:	Varies between compounds	Routes of Exposure: Inhalation, ingestion, and contact Acute Toxicity: Several of the halogenated derivatives are potent lacrimators, vesicants, and lung irritants Chronic toxicity: These compounds are best typified as liver and kidney toxins, and central nervous system depressants	Boiling Pt: Melting Pt: Freezing Pt: Solubility: Specific Gravity: — The properties vary between constituents Vapor Density: Vapor Pressure: Flash Pt: LEL: UEL: Incompatibles:

TABLE 4-1
PRIMARY CHEMICAL CONTAMINANTS
PAGE 4

Names & Synonyms	Chemical Abstract Service Number (CAS No.)	Safe Exposure Limit, OSHA; ACGIH; NIOSH	Method of Detection	Warning Properties	Signs & Symptoms of Overexposure	Physical Properties
HMX See also Cyclotetramethylene Tetranitramine	2691-41-0	None established	PID: Not detected IP: Not detected FID: Not detected RR: Not detected	This material will be in the form of a particulate under ambient temperatures and conditions. As their is no suitable way to determine its presence through warning properties or monitoring instruments, a general approach will be to control all particulate emissions and hence control potential exposures to this compound	Routes of Exposure: Inhalation, ingestion, and contact Acute Toxicity: This substance may be irritating to the skin, eyes, and mucous membranes, however no statistical data exists. Chronic toxicity: No information found concerning chronic toxicity under this title	Boiling Pt: Melting Pt: Not available Freezing Pt: Solubility: Not available Specific Gravity: Not available Vapor Density: Vapor Pressure: Flash Pt: Explodes LEL: Unknown UEL: Unknown Incompatibles: Heat, flame, friction, shock, mercury fulminate, and metal azides
Lead	7439-92-1	0.050 mg/m^3 See 29CFR 1910.1025 0.15 mg/m^3 < 0.1 mg/m^3 * * - < 0.060 mg/100g Whl.Bld	PID: Not detected IP: Not detected FID: Not detected RR: Not detected	This material will be in the form of a particulate under ambient temperatures and conditions. As their is no suitable way to determine its presence through warning properties or monitoring instruments, a general approach will be to control all particulate emissions and hence control potential exposures to this compound	Routes of Exposure: Inhalation, ingestion, and contact (organic lead compounds) Acute toxicity: Metallic taste, loss of appetite, dry throat, thirst, abdominal pain, nausea, vomiting, sometimes diarrhea, less often constipation with bloody or black stools, anemia, general malaise, insomnia, headache, irritability, muscle and joint pains, possibly tremors, hallucinations, and distorted perceptions. Low levels of lead have been shown to affect neurotransmission and immune system function. Major organ systems affected through exposure are the nervous system, blood, and kidneys. Chronic toxicity: Lead is a cumulative poison. Chronic exposure can lead to irreversible kidney and vascular damage. Severe toxicity can cause sterility, abortion, and neonatal mortality and morbidity.	Boiling Pt: 3164°F Melting Pt: 621°F Freezing Pt: Not available Solubility: Insoluble (as metal) Specific Gravity: 11.34 (as metal) Vapor Density: Not available Vapor Pressure: 0 mmHg Flash Pt: Noncombustible in bulk form LEL: Not applicable UEL: Not applicable Incompatibles: Strong oxidizers, hydrogen peroxide, and acids Appearance: Bluish-white silvery gray metal. Lustrous when fresh cut however tarnishes quickly in air. Very soft and malleable

TABLE 4-1
PRIMARY CHEMICAL CONTAMINANTS
PAGE 5

Names & Synonyms	Chemical Abstract Service Number (CAS No.)	Safe Exposure Limit, OSHA; ACGIH; NIOSH	Method of Detection	Warning Properties	Signs & Symptoms of Overexposure	Physical Properties
Nitroglycerine See also Glyceral trinitrate; 1,2,3-Propanetriol trinitrate; Trinitroglycerine	55-63-0	0.1 mg/m^3 (ceiling) (skin) 0.46 mg/m^3 (skin) 0.1 mg/m^3 (ceiling);(skin)	PID: Not detected IP: Not detected FID: Not detected RR: Not detected	No information found. This material will exist as a viscous liquid above 56°F.	Routes of Exposure: Inhalation, ingestion, absorption, and contact Acute toxicity: Severe headaches, nausea, vomiting, abdominal cramps, confusion, delerium altered heart rhythm, dyspnea (potentially respiratory paralysis), methemoglobinemia and cyanosis. This material will also cause skin irritation and possibly a rash. Chronic toxicity: Severe headaches, hallucinations, and skin rashes. Note: Alcohol may aggravate and intensify the symptoms.	Boiling Pt: decomposes 122°F-140°F Melting Pt: Not available Freezing Pt: 56°F Solubility: 0.1% Specific Gravity: 1.60 Vapor Density: 7.84 Vapor Pressure: 0.0003 mm Flash Pt: Explodes LEL: Unknown UEL: Unknown Incompatibles: Heat, ozone, shock uv radiation and acids Appearance: Colorless to pale yellow liquid with a sweet taste.
Nitroguanidine See also Picrite(The Explosive)	556-88-7	None Established	PID: Not detected IP: Not detected FID: Not detected RR: Not detected	This material will be in the form of a particulate under ambient temperatures and conditions. As their is no suitable way to determine its presence through warning properties or monitoring instruments, a general approach will be to control all particulate emissions and hence control potential exposures to this compound	No specific information found on this chemical however, information based on the chemical family would suggest this chemical may express carcinogenic potential of the nasal, throat, stomach, and liver.	Boiling Pt: decomposes 225°F-250°F Melting Pt: 246°F Freezing Pt: Not available Solubility: Soluble Specific Gravity: Not available Vapor Density: Not available Vapor Pressure: Not available Flash Pt: Explodes LEL: Unknown UEL: Unknown Incompatibles: Heat, flame, shock oxidizing materials Appearance: Yellow solid, usually stable needles.

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lockout/tagout procedures prior to performing maintenance functions on equipment, and lastly all equipment, prior to use, then periodically afterwards will be inspected by the on site health and safety representative to ensure all guards, protective cages, and and emergency shut-off devices are in place and function properly.

4.2.3 Uneven or Unstable Terrain

During the monitoring well installation, surface water/sediment sampling, or staff gauge installation there is potential for slip, trip, and falls associated with wet, steep or unstable banks and sediment surfaces along the creeks, ditches, and tidal pond and other areas associated with the sampling task. To minimize the hazards of this nature, personnel required to work in and along areas prone to these types of hazards will be required to employ life lines and/or safety harnesses, ring buoys and other means of personnel extraction suitable for the task at hand. All sampling conducted will be performed utilizing the Buddy system with one member of the team in position for extraction.

4.2.4 Strain, Sprains and/or Muscle Pulls

During execution of this scope of work there is potential for strains, sprains and/or muscle pulls due to the physical demands and nature of this task. To avoid injury, during lifting tasks personnel are to lift with the force of the load carried by their legs and not their backs. When lifting or handling heavy material or equipment, use an appropriate number of personnel. Due to the type of environment/topography (soft muck, swampy type environment), locomotion and operation will be extremely difficult. These conditions increase hazard potential and make even small jobs more difficult. Therefore extreme caution and best professional judgement should be exercised to mitigate these hazards as they are encountered.

4.2.5 Noise in Excess of 85 dBA

As this sampling will be accomplished through a variety of means the potential exists that noise in excess of 85 dBA will be encountered. The HSO will determine the need to conduct a noise survey of operations. However as a precautionary measure hearing protection will be available on site should it be required.

4.2.6 Heat Stress

As this scope of work will require personnel to employ personal protective equipment (PPE) as a means of protection from both chemical and physical hazards, the potential for heat related disorders during the proposed field dates is significant. To combat this problem the Project Manager and the Health and Safety Officer shall initiate Heat stress monitoring, and effect the appropriate control efforts, in accordance with HALLIBURTON NUS Standard Operating Procedures HS-09 "Heat Stress Control", (a copy of which is included as Attachment D-I), and the ACGIH recommended control measures, included in the same attachment.

4.2.7 Cold Stress

Cold stress information is presented in Attachment D-I is intended to protect field personnel from injury due working in cold climates or from immersion in low temperature water. This information is presented by the ACGIH encompassing definitions, signs and symptoms of overexposure, evaluation and control for working in cold climates. Due to the location, and proposed time schedule for field activities cold stress may become a possibility.

4.2.8 Water Hazards

There are sampling points proposed within the sampling plan only accessible by boat or along waters edge. To avoid potential hazards associated with working on waters edge or over water (drowning) the field team shall employ life lines, safety harnesses, and U.S Coast Guard approved flotation devices when working on or within four feet of the water. As stated earlier some of these devices or a combination of, may be used for other reasons within this scope of work, however the objective, when on or near water, is quick effective personnel extraction. All activities on water or at waters edge will be terminated should inclement weather conditions arise. This will be at the discretion and direction of the field operations leader and the on site health and safety representative.

4.2.9 Natural Hazards (ticks, snakes, mosquitos, and other indigenous creatures)

Natural hazards such as poisonous plants, bites from poisonous or disease carrying animals or insects (i.e., snakes, ticks, mosquitos) cannot be avoided within this type of environment. However in an effort to offset the impact of this hazard field personnel will have access to commercially available snake bite kits,and insect repellants. Nesting areas in and about sampling points shall be avoided and another point selected within the vicinity. Lastly, within recent years a marked increase in Lyme Disease has been reported. For this operation this is a significant point as ticks are the primary vector. In an effort to control this hazard close attention must be given during operations and personal hygiene to detect and remove ticks once they have adhered to the body. Instruction will be given as to the hazard presented, control methods, and proper tick removal procedures (See Attachment D-II).

4.2.10 Inclement Weather

As all work will be conducted outdoors, inclement weather may be encountered. As conditions may vary, it will be at the discretion of the field operations leader and acting health and safety representative on the team to terminate work or continue work if these conditions present themselves. All activities shall be terminated in the event of electrical storms.

NOTE : Contact with Energetic Material

This HASP was written under the pretense that no energetic material existed in sufficient concentrations in the areas identified for subsurface investigation to pose this type of hazard. With regards to this type of hazard, areas previously cited for investigation were eliminated on this basis. However where subsurface investigation points and potential pockets of energetic material may co-exist which are essential to this investigation HALLIBURTON NUS will rely on the Navy to prepare that area or point subsurface investigation through the "shocking" process or what other means they have at their disposal for the detection and elimination of this material. As previously stated handling materials of this nature in sufficient quantities to present this type of hazard is not within the scope of HALLIBURTON NUS's expertise and unless crucial to this investigation and prepared by the Navy will be eliminated as a point of investigation.

5.0 AIR MONITORING AND ACTION LEVELS

5.1 AIR MONITORING REQUIREMENTS

This section presents the requirements for the use of real time monitoring instruments during site activities. It establishes the types of instruments to be used, techniques for their use, and action levels for employing the results obtained through their use. Additionally methods for instrument maintenance, and calibration are described.

5.2 AIR MONITORING ACTION LEVELS

The air monitoring action levels presented are as follows:

LEL/O2 Meter <10% LEL	Continue Monitoring
LEL/O2 Meter 10-20% LEL	Continue Monitoring Remove All Ignition Sources Use Spark Proof Tools Level B Protection
LEL/O2 Meter >20% LEL	Stop Work until situation can be brought under safe parameters
LEL/O2 Meter <19.5%, >25% O2	Level B Protection
HNU or OVA ≤ Background	Continue Monitoring
HNU or OVA > Background @ Source	Monitor breathing zones
HNU or OVA > Background @ Breathing Zone	Level C Protection
HNU or OVA > 10 Units @ Breathing Zone	Level B Protection
Particulate Monitor	Eliminate emissions source or Level C Protection
Odors/irritation detected	Level C Protection
Odors/irritation detected with respirator	Level B Protection
Signs/Symptoms of overexposure	Stop Work

Background readings shall be determined at a location upwind from potential sources of emissions. Sources, such as within the borehole, excavated materials (sediment, and water), contaminated materials loading area/ operation, and decontamination fluids and sediments shall be monitored continuously for off gas emissions. Worker breathing zones shall be monitored anytime potential sources of emissions are identified. Level C protection will include full-face or half-face air purifying respirators equipped with organic vapor acid gas cartridges and HEPA filters. Level B protection will include pressure-demand, supplied-air (airline or SCBA) respirators.

5.3 INSTRUMENT CALIBRATION AND MAINTENANCE

Air monitoring instruments are pre-field calibrated and maintained at the HALLIBURTON NUS equipment warehouse. Field calibrations will be performed prior to each daily use in accordance with the manufacturers recommendations and HALLIBURTON NUS Standard Operating Procedures. Field maintenance will consist of daily cleaning of the outer surfaces of the instruments with a damp

cloth, replenishment of hydrogen (OVA), cleaning of the lamp with a dry lint-free cloth (HNU), and overnight charging of batteries.

All monitoring instrumentation used onsite will be calibrated and maintained in accordance with HALLIBURTON NUS Health and Safety SOPs and/or the manufacturer's recommendations. On a daily basis, before site work begins, background readings from a clean area will be obtained for instruments that will be used for field work. From this background level, the appropriate action level as described in this section will be observed.

5.4 INSTRUMENT USE

The HNu, OVA, Particulate monitor, and the LEL/O2 meters will be used primarily as screening tools during drilling, sampling or any other intrusive activity which might release emissions of toxic contaminants. There selection is based on chemicals readily released into the environment.

5.5 VISUAL OBSERVATION

Based on the hazard assessment a large portion of the contaminants present will be in the form of a particulate. It is therefore assessed by controlling particulate generation and dispersal through work hygiene practices such as wetting down areas of potential generation this will act as a contolling factor of the contaminants.

6.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personal Protective Equipment (PPE) anticipated for use has been summarized in Table 6-1.

6.1 PPE SELECTION CRITERIA/LIMITATIONS:

- Safety glasses and steel toe, hard sole work boots, and hardhats were selected as minimum requirements to protect personnel from the physical hazards which may exist onsite. Neoprene outer and butyl inner gloves were selected as a precaution against direct skin contact with site contaminants. Tyvek coveralls were selected for tasks that involve a potential for contamination only by dust, dirt, or tick infestation. Saranex coveralls were selected for all other tasks including those to be conducted on or near water. Rubber boots or chemical-resistant boot covers were selected to prevent contamination and saturation of work boots.

- Respiratory protection, as described in Section 5.0, will be worn in accordance with the action levels set forth in that section.

- Sampling activities performed out of boating vessels or within four feet of the waters edge shall carry an additional requirement for the use of U.S. Coastal Guard-approved personal flotation devices.

- Hip waders may be required if sampling in especially muddy areas or minimum depth water is necessary.

- TLD badges are required for all HALLIBURTON NUS personnel.

6.2 ACCEPTABLE MODIFICATIONS TO PERSONAL PROTECTION REQUIREMENTS

- Chemical resistant gloves will be worn whenever there is a potential for direct contact with site contaminants. Tyvek coveralls will be worn whenever contamination of street clothes by contaminant-laden dust or dirt is possible. Saranex coveralls will be worn when working on or near water and anytime free phase product in encountered. Joints between protective garments (i.e., at wrists and ankles) will be taped as necessary.

TABLE 6-1
PPE ANTICIPATED FOR EACH SITE TASK/OPERATION
INDIAN HEAD, MD

TASK/OPERATION	PPE ANTICIPATED
Mobilization/Demobilization	Safety glasses, steel toe/hard sole work boots,hardhat, and work gloves as needed.
Soil Sampling	Safety glasses, steel-toe, hard sole work boots, Tyvek* coveralls, neoprene outer gloves, butyl inner gloves, rubber boots or chemical protective clothing boot covers, taped ankle/wrist seams. Respirators as per Section 5.0, Air Monitoring and Action Levels.
Surface Water and Sediment Sampling	Same as above only Saranex coveralls will be worn in place of Tyvek coveralls. This will be done when there is potential for direct contact with the contaminant in liquid phase, or contaminated media.
Surveying	Safety glasses, steel-toe boots, surgical-style gloves, rubber boot covers, Tyvek coveralls as necessary to prevent contamination of street clothes and protection from tick infestation.
Monitoring Well Installation	See Surface Water and Sediment Sampling
Staff Gauge Installation	Same as surveying with possibly the addition of hip waders tagline and an U.S.C.G approved flotation device

* If free phase product in encountered or the potential exists for the Tyvek to become saturated, Saranex coveralls will be worn in place of Tyvek.

7.0 DECONTAMINATION

7.1 PERSONNEL DECONTAMINATION REQUIREMENTS

The decontamination of personnel and their protective clothing shall be performed in three stages. Stage 1 includes removing contamination from reusable protective clothing with a detergent/water solution and soft bristle scrub brushes. Stage 2 shall include removal of protective clothing (disposable items shall be discarded into a container conspicuously marked "Potentially Contaminated Clothing"). Stage 3 shall consist of workers washing hands and face with potable water and soap whenever they remove PPE and leave the exclusion zone.

All decontamination waste fluids and potentially contaminated PPE shall be contained and handled in accordance with the requirements stipulated by the client contact.

7.2 DECONTAMINATION OF SAMPLING TOOLS

All sampling equipment that will be leaving the site will require a thorough decontamination. This can be accomplished either by steam cleaning or by a detergent wash and potable water rinse until tools are visibly clean. Decontamination of sampling tools to prevent cross contamination of samples shall be performed in accordance with client specifications. All equipment, prior to leaving the site, will be inspected by the FOL to verify it has been properly decontaminated.

7.3 PPE REQUIREMENTS FOR DECONTAMINATION OPERATIONS

All decontamination efforts will require the use of chemical protective clothing as described below:

- Saranex coveralls
- Neoprene outer gloves
- Butyl inner gloves
- Rubber boots (or rubber boot covers)
- Splash shield (if respirator not worn)
- Respiratory protection (if needed*)

* The same level of respiratory protection worn for the work assignment, will be worn when decontaminating the equipment used for that assignment.

8.0 TRAINING REQUIREMENTS

This section describes the minimum requirements for initial, refresher, and site-specific training.

8.1 INTRODUCTORY AND REFRESHER TRAINING

8.1.1 Requirements for HALLIBURTON NUS Personnel

All HALLIBURTON NUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at Indian Head NAVSURFWARCEN. Additionally, HALLIBURTON NUS personnel who have had introductory training more than 12 months prior to site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work.

Documentation of HALLIBURTON NUS introductory and refresher training will be maintained at the project. Copies of certificates or other official documentation will be used to fulfill this requirement.

8.1.2 Requirements for Subcontractors

All HALLIBURTON NUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) prior to performing field work Indian Head. HALLIBURTON NUS subcontractors must certify that each employee has had such training by sending HALLIBURTON NUS a letter, on company letterhead, containing the information in the example letter provided as Figure 8-1. Figures 8-1 and 9-2 can be combined into one letter.

8.2 SITE-SPECIFIC TRAINING

HALLIBURTON NUS will provide site-specific training to all HALLIBURTON NUS employees and subcontractor personnel who will perform work at this project. Site-specific training will include:

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan and addendum
- Emergency response procedures (evacuation and assembly points)
- Review the contents of relevant Material Safety Data Sheets

8.2.1 Site-Specific Training Documentation

HALLIBURTON NUS and subcontractor personnel will be required to sign a statement indicating receipt of site-specific training and understanding of site hazards and control measures. Figure 8-2 will be used to document site-specific training.

FIGURE 8-1

OSHA TRAINING CERTIFICATION

The following statements must be typed on company letterhead and signed by an officer of the company:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Ralph Basinski
Project Manager
HALLIBURTON NUS Environmental Corp.
661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: Hazardous Waste Site Training - NAVSURFWARCEN Indian Head Division

Dear Mr. Basinski:

The employees listed below have had introductory hazardous waste site training or equivalent work experience as required by 29 CFR 1910.120(e). In addition, those employees listed below who have received their introductory training more than 12 months ago have also received 8 hours of refresher training in accordance with 29 CFR 1910.120 (e)(8) within the past 12 months.

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name of Company Officer)

FIGURE 8-2

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing investigation activities at NAVSURFWARCEN IH DIV Indian Head and that I have received site-specific training which included the elements presented below:

- Names of personnel and alternates responsible for site safety and health
- Safety, health and other hazards present on site
- Use of personal protective equipment
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- The contents of the health and safety plan
- Emergency response procedures (evacuation and assembly points)
- Review contents of relevant Material Safety Data Sheets

I further state that I have been given the opportunity to ask questions and that all of my questions have been answered to my satisfaction.

Name	Signature	Date

9.0 MEDICAL SURVEILLANCE

9.1 REQUIREMENTS FOR HALLIBURTON NUS PERSONNEL

All HALLIBURTON NUS personnel participating in project field activities will have had a physical examination meeting the requirements of HALLIBURTON NUS' medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained in the HALLIBURTON NUS

Pittsburgh office and made available as necessary.

9.2 REQUIREMENTS FOR SUBCONTRACTORS

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" (Figure 9-1) can be used to satisfy this requirement providing it is properly completed and signed by a licensed physician.

Subcontractors who have a company medical surveillance program meeting the requirements of paragraph (f) of OSHA 29 CFR 1910.120 can substitute Figure 9-1 with a letter, on company letterhead, containing all of the information in the example letter presented as Figure 9-2. Figures 8-1 and 9-2 can be combined into one letter.

9.3 REQUIREMENTS FOR ALL FIELD PERSONNEL

Each field team member (including subcontractors) shall be required to complete and submit a copy of Attachment D-III (Medical Data Sheet). This shall be provided to the HSO prior to participating in site activities.

FIGURE 9-1

SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of _____
Company Name

Participant Name: _____ Date of Exam: _____

Part A

The above-named individual has:

1. Undergone a physical examination in accordance with OSHA Standard 29 CFR 1910.120, paragraph (f) and found to be medically -

   ( ) qualified to perform work at the NAVSURFWARCEN IH DIV Indian Head work site
   ( ) not qualified to perform work at the NAVSURFWARCEN Indian Head work site

and,

2. Undergone a physical examination as per OSHA 29 CFR 1910.134(b)(10) and found to be medically -

   ( ) qualified to wear respiratory protection
   ( ) not qualified to wear respiratory protection

My evaluation has been based on the following information, as provided to me by the employer.

( ) A copy of OSHA Standard 29 CFR 1910.120 and appendices.
( ) A description of the employee's duties as they relate to the employee's exposures.
( ) A list of known/suspected contaminants and their concentrations (if known).
( ) A description of any personal protective equipment used or to be used.
( ) Information from previous medical examinations of the employee which is not readily available to the examining physician.

Part B

I, _____, have examined _____
Physician's Name (print) Participant's Name (print)
and have determined the following information:

FIGURE 9-1
SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

1. Results of the medical examination and tests (excluding finding or diagnoses unrelated to occupational exposure):

_____

_____

_____

2. Any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health:

_____

_____

---

3. Recommended limitations upon the employee's assigned work:

_____

_____

_____

_____

I have informed this participant of the results of this medical examination and any medical conditions which require further examination of treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at the _____ work site, this participant

( ) may
( ) may not

perform his/her assigned task.

Physician's Signature _____

Address _____

Phone Number _____

NOTE: Copies of test results are maintained and available at:

_____
Address

FIGURE 9-2

MEDICAL SURVEILLANCE LETTER

The following statements must be typed on company letterhead and signed by an officer of he company:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Ralph Basinski
Project Manager
HALLIBURTON NUS Environmental Corp.
661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: Medical Surveillance - NAVSURFWARCEN Indian Head

Dear Mr. Basinski:

As an officer of XYZ Corporation, I hereby state that the persons listed below participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120 entitled "Hazardous Waste Operations and Emergency Response: Final Rule." I further state that the persons listed below have had physical examinations under this program within the past 12 months and that they have been cleared, by a licensed physician, to perform hazardous waste site work and to wear positive and negative pressure respiratory protection. I also state that, to my knowledge, no person listed below has any medical restriction that would preclude him/her from working at NAVSURFWARCEN Indian Head.

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE

Should you have any questions, please contact me at (555) 555-5555.

Sincerely,

(Name of Company Officer)

10.0 STANDARD WORK PRACTICES

The following Standard Work Practices are to be applied in addition to the Health and Safety Standard Operating procedures:

* Eating, drinking, chewing gum or tobacco, taking medication, and smoking are prohibited in the exclusion or decontamination zones, or any location where there is a possibility for contact with site contaminants exists.

* Upon leaving the exclusion zone, hands and face must be thoroughly washed with soap and potable water. Any protective outer clothing is to be decontaminated and removed as specified in this HASP, and left at a designated area prior to entering the clean area.

* Contact with potentially-contaminated substances must be avoided. Contact with the ground or with contaminated equipment must also be avoided.

* No facial hair, which interferes with a satisfactory fit of the mask-to-face seal, is permitted on personnel required to wear respiratory protective equipment.

* All personnel must satisfy all training requirements (40-hr, 8-hr refresher, site specific training, emergency response training) prior to commencing site activities.

* All personnel must have a working knowledge of this HASP. Including being aware of the action levels for upgrading/downgrading levels of protective equipment, and emergency procedures.

* All personnel must satisfy medical monitoring procedures.

* All personnel must complete a medical data sheet, to be maintained on site (see Attachment C).

* All personnel working in sight restriction areas of heavy vegetation or where the topography does not permit line of sight contact must utilize the buddy system.

* When lifting or moving equipment or material, use proper lifting techniques.

* All work areas must be kept free of ground clutter.

* No flames or open fires will be permitted on site.

* Site personnel must immediately notify HALLIBURTON NUS Health Sciences of all incidents for OSHA recordkeeping purposes.

* If personnel note any warning properties of chemicals (irritation, odors, symptoms, etc.) or even remotely suspect the occurrence of exposure, they must immediately notify the CHSO for further direction.

* Site personnel are not to undertake any activity which would be considered a confined-space entry without first being trained in the proper procedures by the CHSO, and obtaining a Confined Space/Limited Egress Permit.

* A full-sized copy of the OSHA poster included as Attachment B of this HASP shall be conspicuously posted on site.

* Any new information must be promptly conveyed to the Project HSO and the Field Operations Leader.

* All compressed gas cylinders used (empty or full) must be stored, secured, and used properly to protect from damage.

DRILLING OPERATIONS

* No drilling or any other operation which will bring a drill mast or any other projecting device within 20 feet in any direction of overhead power lines will be permitted. Prior to any subsurface investigations, the locations of all underground utilities will be identified and marked prior to initiating any subsurface activity.

* Hand signals with the driller will be established prior to the commencement of drilling activities.

* All drill rigs and other machinery with exposed moving parts must be equipped with an operational emergency stop device. All personnel working in a close proximity must be aware of the location of this emergency stop device and its operation. This device will be tested initially then periodically to insure its operational status. The driller and the helper shall not simultaneously handle moving augers or flights unless there is a standby person to activate the emergency stop device.

* The driller must never leave the controls while tools are rotating unless all personnel are clear of the rotating equipment.

* A long handled shovel or the equivalent shall be used to clear away drill cuttings from the hole and rotating equipment. Hands or feet shall not be used for this purpose.

* A remote sampling device must be used to sample drill cuttings near rotating tools. The driller shall shutdown operations if the sampler must near the tools to obtain samples.

* All personnel working in the vicinity of the drill rig while its operating shall secure all loose clothing.

* Only manufacturer approved equipment may be used in conjunction with site equipment (i.e. pins for auger flights etc.). Pins or other protruding items from rotating equipment shall not be permitted.

* No person shall climb a drill mast while equipment is rotating.

* No person shall climb a drill mast without use of ANSI approved fall protection (i.e. belts, lanyards and a fall protection slide rail) or portable ladders which meet OSHA's requirements.

* Work areas will be kept clear of clutter.

11.0 SPILL CONTROL

11.1 SPILL CONTROL

Bulk liquids of containers larger than 55-gallons will not be handled during this work and major spills of hazardous materials are, therefore, not anticipated and a spill discharge and control plan is not necessary.

12.0 SITE CONTROL MEASURES

12.1 EXISTING PERIMETER AND/OR ZONE CONTROLS

Perimeter, zone, and site control will be accomplished through implementation of the following control factors:

* Base Security
* Perimeter/Zone Identification (Map)
* Traffic Control/Number of Personnel
* Sampling Area Security

12.1.1 Base Security

Restriction of general traffic will be accomplished through Base security. Restriction of unauthorized base personnel will be coordinated through the Base contact and Safety and Environmental Management Section.

12.1.2 Perimeter/Zone Identification

Perimeter/Zone identification will be accomplished in a dual step approach. The first step will be the overall identification of the sampling areas utilizing maps in section 1.0, and the maps available illustrating the proposed sampling points. This will be used to educate field personnel the potential areas of contamination and therefore areas of restriction. As it would be impossible to secure the entire area to be sampled, a three zone delineation shall be utilized in step two of the dual stage approach. Security of the work zones will be established in and about the drilling/sampling points to restrict unauthorized personnel during intrusive activities (drilling/sampling) when potential for incidental exposure would be the greatest.

12.1.3 Three Zone Delineation of the Sampling Points

A three zone approach will be used to secure sampling points, control potential migration of site contaminants, and to protect the health and welfare of the site workers, base personnel, and general public.

This approach will designate the drilling/sampling point and a ten foot circumference as the Exclusion Zone, this area may be expanded based on observation of the field team and monitoring instrument data this will be considered the area of known contamination. A ten foot circumference outside the exclusion zone shall act as the Contamination Reduction Zone, where all decontamination activities will take place. All operations conducted within these two zones shall employ extra measures of protection stipulated in this plan to be utilized in the presence of contamination. The third, and final zone is the support zone. This is a designated clean zone where no contamination is present. All materials and support for these operations will be routed from this zone. Movement between the zones will be done through control points. All movement from the exclusion zone outward toward the support zone will require complete decontamination and approval from the field operations leader or the on site health and safety representative for all equipment and personnel.

12.2 BUDDY SYSTEM

Personnel while engaged in on site activities will practices the "buddy system" to insure the safety of all personnel involved in this operation.

12.3 COMMUNICATIONS

As personnel will be working within close proximity to one another during field activities no supported means of communications will be necessary. Communications between the field operations leader and the base contact will be maintained via telephone as needed during all on base operations. This means of communications will serve as the primary link with the base for emergency services should the need arise.

12.4 MATERIAL SAFETY DATA SHEETS (MSDS) REQUIREMENTS

HALLIBURTON NUS personnel will provide MSDS's for all chemicals brought on site. The MSDS's will be maintained in a central location (i.e.temporary office)and will be available for anyone to review upon request.

13.0 EMERGENCY RESPONSE PLAN

In the event of any on-site emergencies (i.e. fires, significant spills or releases, etc.), site personnel shall be immediately evacuated to a safe place of refuse and notify appropriate off-site response agencies (Figure 13-1), the HALLIBURTON NUS Project Manager (Ralph Basinski), and the CLEAN Health and Safety Manager (Matthew M. Soltis). In view of this approach, this section of the Health and Safety Plan is provided to be in compliance with OSHA Standard 29 CFR 1910.38(a) [as permitted by OSHA 29 CFR 1910.120(l)(1)(ii)].

13.1 EMERGENCY ESCAPE

If site evacuation becomes necessary, personnel shall immediately take the most direct route to the main gate where they will await further instruction from the HALLIBURTON NUS Field Operations Leader.

13.2 MAINTENANCE OF CRITICAL OPERATIONS

It is not anticipated that any personnel will need to remain at their worksite to maintain any critical operations. If this condition should change, the site Health and Safety Officer shall identify the personnel an their responsibilities in this regard and amend this Plan accordingly. Any such modifications must be communicated to the Health and Safety Manager for concurrence.

13.3 PERSONNEL ACCOUNTING

In the event of an emergency evacuation, personnel shall immediately report to the designated refuge location, and remain there. The Site Safety Officer, assisted by the Field Operations Leader, shall conduct a roll call (using the site log book) to account for all personnel to ensure that a total worksite evacuation has taken place. If the roll call identifies that any personnel are not accounted for, this information shall be immediately communicated to the off-site emergency response agency upon their arrival. This information is to be supplemented with any additional information available which could be of assistance in conducting rescue operations (i.e., last known location of the missing personnel, etc.). Site personnel are not authorized to participate in emergency response/rescue operations.

13.4 RESCUE AND MEDICAL DUTIES

Site personnel are not authorized to participate rescue in activities. However, any personnel present who are trained and to perform emergency first aid activities may perform these functions, if needed, after rescue or evacuation operations have been completed.

13.5 EMERGENCY REPORTING

Emergency reporting functions shall be the responsibility of the Field Operations Leader. Figure 13-1 identifies the agencies to be contacted. The Field Operations Leader will become thoroughly familiar with this Plan prior to the initiation of any site work activities.

In the event that an emergency incident occurs and off-site response assistance is necessary, the Field Operations Leader shall contact the appropriate agency (or agencies) and communicate the following information:

- Nature of the incident (fire, spill, chemical exposure, physical injury, etc.)
- Number of injuries and type(s) of injury (injuries)
- Possible contaminants which may be encountered in response efforts

13.6 SITE EMERGENCY ALARM SYSTEM

All workers will be in close proximity to each other, therefore, an emergency alarm system is not needed.

FIGURE 13-1

EMERGENCY NOTIFICATION AND DIRECTIONS TO HOSPITAL

EMERGENCY PHONE NUMBERS

FIRE DEPARTMENT	(NAVSURFWARCEN)	(301) 743-4281
POLICE DEPARTMENT	(NAVSURFWARCEN)	(301) 743-4333
RESCUE/AMBULANCE	(NAVSURFWARCEN)	(301) 743-4449
PRIMARY HOSPITAL	(Physicians Memorial)	(301) 645-0100
ALTERNATE HOSPITAL	(Southern Maryland)	(301) 868-8000
OFF-SITE EMERGENCY SERVICE	(Sheriff)	(301) 870-3232
POISON CONTROL CENTER		(800) 962-1253
NATIONAL RESPONSE CENTER		(800) 424-8802
PROJECT MANAGER	Ralph Basinski	(412) 921-8308
OFFICE HSO	Matthew Soltis, CSP	(412) 921-8912

DIRECTIONS TO HOSPITAL:

PHYSICIANS MEMORIAL HOSPITAL, LA PLATA, MARYLAND (PRIMARY)

Take Indian Head Highway (MD. Route 210) North to MD. Route 225. Turn right on 225 and follow until junction with MD. Route 301. Turn right on 301. Turn left at first traffic light. The hospital is on the right, about a 1/2 block past the railroad tracks.

SOUTHERN MARYLAND HOSPITAL, CLINTON, MARYLAND (ALTERNATE)

Take Indian Head Highway (MD. Route 210) North to MD. Route 373. Follow until intersection with Branch Ave. (MD. Route 5). Turn left on Branch Ave., right on Surratts Road. The hospital is just past the Colony South Hotel.

14.0 CONFINED SPACE ENTRY PROCEDURES

No confined space activity is planned as part of this proposed field activity, therefore this section will not apply.

15.0 MATERIALS AND DOCUMENTS

The HALLIBURTON NUS Field Operations Leader shall ensure the following materials/documents are taken to the project site and utilized as required.

- Incident Reports (blank)
- Medical Data Sheets (Attachment D-III)
- Follow-Up Reports (to be completed by the Field Operations Leader - see Attachment D-IV)
- OSHA Job Safety and Health Poster (Posted in site trailer - see Attachment D-V)
- Training Documentation Form (Blank)

ATTACHMENT D-I

HEAT/COLD STRESS

HEAT/COLD STRESS

Heat Stress

The HSO shall visually monitor personnel to note for signs of heat stress. Field personnel will also be instructed to observe for symptoms of heat stress and methods on how to control it. One or more of the following control measures can be used to help control heat stress:

- Provide adequate liquids to replace lost body fluids. Personnel must replace water and salt lost from sweating. Personnel must be encouraged to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement.
- Replacement fluids can be commercial mixes such as Gatorade®.
- Establish a work regime that will provide adequate rest periods for cooling down. This may require additional shifts of workers.
- Cooling devices such as vortex tubes or cooling vests can be worn beneath protective garments.
- Breaks are to be taken in a cool rest area (77°F is best).
- Personnel shall remove impermeable protective garments during rest periods.
- Personnel shall not be assigned other tasks during rest periods.
- Personnel shall be informed of the importance of adequate rest, acclimation, and proper diet in the prevention of heat stress.

The heat stress of personnel on-site may be monitored utilizing biological monitoring or the Wet Bulb Globe Temperature Index (WBGT) technique when workers are not wearing protective coveralls (i.e. Tyvek®). This method will require the use of a heat stress monitoring device.

One of the following biological monitoring procedures shall be followed when the workplace temperature is 70°F or above.

- Heart rate (HR) shall be measured by the pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, the next work period should be shortened by 10 minutes (or 33 percent), while the length of rest period stays the same. If the pulse rate is 100 beats/minute at the beginning of the next rest period, the following work cycle should be shortened by 33 percent. The length of the initial work period will be determined by using the table below.

PERMISSIBLE HEAT EXPOSURE THRESHOLD LIMIT VALUES

	Work Load		
Work-Rest Regimen	Light	Moderate	Heavy
Continuous	80.0°F	80.0°F	77.0°F
75% Work - 25% Rest, Each Hour	87.0°F	82.4°F	78.6°F
50% Work - 50% Rest, Each Hour	88.5°F	85.0°F	82.2°F
25% Work - 75% Rest, Each Hour	90.0°F	88.0°F	86.0°F

- Body temperature shall be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature at the beginning of the rest period should not exceed 99°F. If it does, the next work period should be shortened by 10 minutes (or 33 percent), while the length of the rest period stays the same. However, if the oral temperature exceeds 99.7°F at the beginning of the next rest period, the following work cycle shall be further shortened by 33

percent. OT should be measured at the end of the rest period to make sure that it has dropped below 99°F. At no time shall work begin with the oral temperature above 99°F.

NOTE: External temperatures in excess of those stated above shall be regarded as inclement weather. Work continuation, termination, or alteration of the work schedule will be at the discretion of the FTL and on site health and safety representative. The heat and cold stress related sections of this are applicable to the season when work will be completed.

Cold Stress

The cold stress TLVs are intended to protect workers from the severest effects of cold stress (hypothermia) and cold injury and to describe exposures to cold working conditions under which it is believed that nearly all workers can be repeatedly exposed without adverse health effects. The TLV objective is to prevent the deep body temperature from falling below 36°C (96.8°F) and to prevent cold injury to body extremities (deep body temperature is the core temperature of the body determined by conventional methods for rectal temperature measurements). For a single, occasional exposure to a cold environment, a drop in core temperature to no lower that 35°C (95°F) should be permitted. In addition to provisions for total body protection, the TLV objective is to protect all parts of the body with emphasis on hands, feet, and head from cold injury.

Introduction

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or from immersion in low temperature water. The single most important aspect of life-threatening hypothermia is the fall in the deep core temperature of the body. The clinical presentations of victims of hypothermia are shown in Table 1. Workers should be protected from exposure to cold so that the deep core temperature does not fall below 36°C (96.8°F); lower body temperatures will very likely result in reduced mental alertness, reduction in rational decision making, or loss of consciousness with the threat of fatal consequences.

Pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering depends when the body temperature has fallen to 35°C (95°F). This must be taken as a sign of danger to the workers and exposure to cold should be immediately terminated for any workers when severe shivering becomes evident. Useful physical or mental work is limited when severe shivering occurs.

Since prolonged exposure to cold air, or to immersion in cold water, at temperatures well above freezing can lead to dangerous hypothermia, whole body protection must be provided.

1. Adequate insulating dry clothing to maintain core temperatures above 36°C (96.8°F) must be provided to workers if work is performed in air temperatures below 4°C (40°F). Wind chill cooling rate and the cooling power of air are critical factors. [Wind chill cooling rate is defined as heat loss from a body expressed in watts per meter squared which is a function of the air temperature and wind velocity upon the exposed body.] The higher the wind speed and the lower the temperature in the work area, the greater the insulation value of the protective clothing required. An equivalent chill temperature chart relating the actual dry bulb air temperature and the wind velocity is presented in Table 2. The equivalent chill temperature should be used when estimating the combined cooling effect of wind and low air temperatures on exposed skin or when determining clothing insulation requirements to maintain the deep body core temperature.

2. Unless there are unusual or extenuating circumstances, cold injury to other than hands, feet, and head is not likely to occur without the development of the initial signs of hypothermia. Older workers or workers with circulatory problems require special precautionary protection against cold injury. The use of extra insulating clothing and/or a reduction in the duration of the exposure period are among the special precautions which should be considered. The precautionary actions to be taken will depend upon the physical condition of the worker and should be determined with the advice of a physician with knowledge of the cold stress factors and the medical condition of the worker.

TABLE 1
PROGRESSIVE CLINICAL PRESENTATIONS OF HYPOTHERMIA*

Core Temperature		Clinical Signs
°C	°F	
37.6	99.6	"Normal" rectal temperature
37	98.6	"Normal" oral temperature
36	96.8	Metabolic rate increases in an attempt to compensate for heat loss
35	95.0	Maximum shivering
34	93.2	Victim conscious and responsive, with normal blood pressure
33	91.4	Severe hypothermia below this temperature
32	86.0	Consciousness clouded; blood pressure becomes difficult to obtain; pupils dilated but react to light; shivering ceases
31	87.8	
30	86.0	Progressive loss of consciousness; muscular rigidity increases; pulse and blood pressure difficult to obtain; respiratory rate decreases
29	84.2	
28	82.4	Ventricular fibrillation possible with myocardial irritability
27	80.6	Voluntary motion ceases; pupils nonreactive to light; deep tendon and superficial reflexes absent
26	78.8	Victim seldom conscious
25	77.0	Ventricular fibrillation may occur spontaneously
24	75.2	Pulmonary edema
22	71.6	Maximum risk of ventricular fibrilation
21	69.8	
20	68.0	Cardiac standstill
18	64.4	Lowest accidental hypothermia victim to recover
17	62.6	Isoelectric electroencephalogram
9	48.2	Lowest artificially cooled hypothermia patient to recover

* Presentations approximately related to core temperature. Reprinted from the January 1982 issue of American Family Physician, published by the American Academy of Family Physician.

Evaluation and Control

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C(-25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C (30.2°F) regardless of wind speed.

At air temperatures of 2°C (35.6°F) or less, it is imperative that workers who become immersed in water or whose clothing becomes wet be immediately provided a change of clothing and be treated for hypothermia.

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 3.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

1. If fine work is to be performed with bare hands for more than 10-20 minutes in an environment below 16°C (60.8°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be utilized. Metal handles of tools and control bars should be covered by thermal insulating material at temperatures below -1°C (30.2°F).

2. If the air temperature falls below 16°C (60.8°F) for sedentary, 4°C (39.2°F) for light, -7°C (19.4°F) for moderate work and fine manual dexterity is not required, then gloves should be used by the workers.

To prevent contact frostbite, the workers should wear anti-contact gloves.

1. When cold surfaces below -7°C (19.4°F) are within reach, a warning should be given to each worker by the supervisor to prevent inadvertent contact by bare skin.

2. If the air temperature is -17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers should wear cold protective clothing appropriate for the level of cold and physical activity:

1. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment.

TABLE 2
COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS EQUIVALENT TEMPERATURE
(under calm conditions)*

Estimated Wind Speed (in mph)	Actual Temperature Reading (°F)											
	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
	Equivalent Temperature (°F)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148

(Wind speeds greater than 40 mph have little additional effect)	**LITTLE DANGER** In < hr with dry skin. Maximum danger of false sense of security	**INCREASING DANGER** Danger from freezing of exposed flesh within one minute.	**GREAT DANGER** Flesh may freeze within 30 seconds.
	Trenchfoot and immersion foot may occur at any point on this chart.		

* Developed by U.S. Army Research Institute of Environmental Medicine, Natick MA.

TABLE 3
THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT*

Air Temperature - Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx)	°F (approx)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15° to -19°	(Norm Breaks)	1	(Norm Breaks)	1	75 min	2	55 min	3	40 min	4
-29° to -31°	-20° to -24°	(Norm Breaks	1	75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	-25° to -29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35° to -37°	-30° to -34°	55 min	3	40 min	2	30 min	5	Non-emergency work should cease		Non-emergency work should cease	
-38° to -39°	-35° to -39°	40 min	4	30 min	1	Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	
-40° to -42°	-40° to -44°	30 min	5	Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	
-43° & below	-45° & below	Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease		Non-emergency work should cease	

NOTES:

1. Schedule applies to moderate to heavy work activity with warm-up breaks of ten (10) minutes in a warm location. For Light-to-Moderate Work (limited phyical movement): apply the schedule one step lower. For example, at -35°C (-30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5).

2. The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.

3. If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be intiated at a wind chill cooling rate of about 1750 W/M^2; 2) all non-emergency work should have ceased at or before a wind chill of 2250 W/m^2. In general, the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.

4. TLVs apply only for workers in dry clothing.

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* Adapted from Occupational Health & Safety Division, Saskatchewan Department of Labor.

2. If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use may be of a type impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outerwear should be changed as it becomes wetted. The outer garments should include provisions for easy ventilation in order to prevent wetting of inner layers of sweat. If work is done at normal temperatures or in a hot environment before entering the cold area, the employee should make sure that clothing is not wet as a consequence of sweating. If clothing is wet, the employee should change into dry clothes before entering the cold area. The workers should change socks and any removable felt insoles at regular daily intervals or use vapor barrier boots. The optimal frequency of change should be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.

3. If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items should be supplied in auxiliary heated versions.

4. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work should be modified or suspended until adequate clothing is made available or until weather conditions improve.

5. Workers handling evaporative liquid (gasoline, alcohol, or cleaning fluids) at air temperatures below 4°C (39.2°F) should take special precautions to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling. Special note should be taken of the particularly acute effects of splashes of "cryogenic fluids" or those liquids with a boiling point that is just above ambient temperature.

Work - Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) or below -7°C (19.4°F), heated warming shelters (tents, cabins, rest rooms, etc.) should be made available nearby. The workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation or a change of dry work clothing provided. A change of dry work clothing should be provided as necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10.4°F) ECT, the following should apply:

1. The worker should be under constant protective observation (buddy system or supervision).

2. The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods should be taken in heated shelters and opportunity for changing into dry clothing should be provided.

3. New employees should not be required to work fulltime in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.

4. The weight and bulkiness of clothing should be included in estimating the required work performance and weights to be lifted by the worker.

5. The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats should not be used. The worker should be protected from drafts to the greatest extent possible.

6. The workers should be instructed in safety and health procedures. The training program should include as a minimum instruction in:

   a. Proper rewarming procedures and appropriate first aid treatment.
   b. Proper clothing practices.
   c. Proper eating and drinking habits.
   d. Recognition of impending frostbite.
   e. Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.
   f. Safe work practices.

Special Workplace Recommendations

Special design requirements for refrigerator rooms include:

1. In refrigerator rooms, the air velocity should be minimized as much as possible and should not exceed 1 meter/sec (200 fpm) at the job site. This can be achieved by properly designed air distribution systems.

2. Special wind protective clothing should be provided based upon existing air velocities to which workers are exposed.

Special caution should be exercised when working with toxic substances and when workers are exposed to vibration. Cold exposure may require reduced exposure limits.

Eye protection for workers employed out-of-doors in a snow and/or ice-covered terrain should be supplied. Special safety goggles to protect against ultraviolet light and glare (which can produce temporary conjunctivitis and/or temporary loss of vision) and blowing ice crystals should be required when there is an expanse of snow coverage causing a potential eye exposure hazard.

Workplace monitoring is required as follows:

1. Suitable thermometry should be arranged at any workplace where the environmental temperature is below 16°C (60.8°F) so that overall compliance with the requirements of the TLV can be maintained.

2. Whenever the air temperature at a workplace falls below -1°C (30.2°F), the dry bulb temperature should be measured and recorded at least every 4 hours.

3. In indoor workplaces, the wind speed should also be recorded at least every 4 hours whenever the rate of air movement exceeds 2 meters per second (5 mph).

4. In outdoor work situations, the wind speed should be measured and recorded together with the air temperature whenever the air temperature is below -1°C (30.2°F)

5. The equivalent chill temperature should be obtained from Table 2 in all cases where air movement measurements are required; it should be recorded with the other data whenever the equivalent chill temperature is below -7°C (19.4°F).

Employees should be excluded from work in cold at -1°C (30.2°F) or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments. Workers who are routinely exposed to temperatures below -24°C (-11.2°F) with wind speeds less than five miles per hour, or air temperatures below -18°C (0°F) with wind speeds above five miles per hour, should be medically certified as suitable for such exposures.

Trauma sustained in freezing or subzero conditions requires special attention because an injured worker is predisposed to cold injury. Special provisions should be made to prevent hypothermia and freezing of damaged tissues in addition to providing for first aid treatment.

ATTACHMENT D-II

Lyme Disease

Lyme disease - A newly recognized infectious disease characterized by fever, joint pain, and a distinctive red annular rash. Transmission of this disease is accomplished via a vector in this case ticks. Once the infected tick attaches to the host(field personnel) it passes the bacteria (spirochete) via the bloodstream. From introduction of the bacteria to the onset of the signs and symptoms of the disease may vary from individual to individual however generally ranges from 1 to 4 weeks for initial symptoms. Initial treatment would indicate those individuals infected have responded well to treatment with penicillin. In addition to the aforemention disease ticks affectively vector many other maladies such as Rocky Mountain Spotted Fever, Tularaemia, and Tick paralysis.

Identification and Control

Several species of hard-backed ticks exist in a variety of climates, however, reward flourish during the early spring and summer. Typically, ticks exist in warm moist climates, heavily vegetative, and attach to their host through contact as the host passes by through grasses and underbrush. Tick identification may be accomplished through their markings and structure. To aid in this identification examples of different types of ticks which may be encountered have been included in Figure 1-D.

Tick Control. Climatic factors are probably the most important in natural control of ticks. As the timing of the field activities is not coordinated with the climatic and natural control of this hazard additional control measures must be implemented.

Control Measures. Every effort should be made to discover the presence of ticks on the body and clothing by careful examination, especially of the head, promptly after exposure to tick infested areas. Tyvek uniforms will be worn for all movement through the brush(potential tick infested areas). These uniforms will be discarded between excursions into the infested areas. These uniforms will be stored away from other garments to avoid potential infestation. Commercially produced repellants have been found to be fairly effective when applied to the outer garments prior to engaging in field activities. For this reason these compounds will be employed. Additional precautions such as securing outer garments at the pants legs, wrists, and neck to avoid the opportunity of attachment. Field personnel shall assist one another in the detection of ticks inspection of one another on exposed portions of the body.

Tick Removal. Should ticks sucessfully attach, they can be encouraged to release their mouthparts (means of attachment) by applying chloroform, turpentine, alcohol, or a heated needle to their body. Once removed a topical medication such as Tincture of iodine should be forced into the hole evacuated by the mouthparts. Care should be taken not to get the blood of crushed ticks into the eyes or into scratches or breaks in the skin. Prompt removal of discovered ticks will reduce the chance of serious consequences.

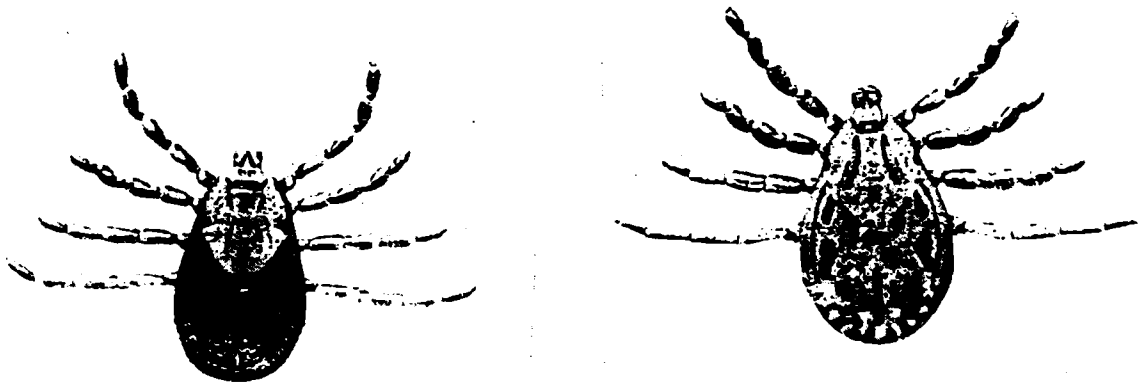

FIGURE 1-D

Above are examples of hard-back ticks which may be encountered during field activities.

ATTACHMENT D-III

MEDICAL DATA SHEET

Medical Data Sheet and Field Team Review

This brief Medical Data Sheet will be completed by all onsite personnel and will be kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project _____

Name _____ Home Telephone _____

Address _____

Age _____ Height _____ Weight _____

Name of Next Kin _____

Drug or other Allergies _____

Particular Sensitivities _____

Do You Wear Contacts? _____

Provide a Checklist of Previous Illnesses or Exposure to Hazardous Chemicals _____

_____

_____

What medications are you presently using? _____

_____

_____

Do you have any medical restrictions? _____

_____

_____

Name, Address, and Phone Number of personal physician: _____

_____

_____

_____

_____

==========

I am the individual described above. I have read and understand this HASP.

_____ _____

Signature Date

ATTACHMENT D-IV

SITE HEALTH AND SAFETY FOLLOW-UP REPORT

SITE HEALTH AND SAFETY FOLLOW-UP REPORT

Appendix A must be filled out and returned to the Site Health and Safety Officer after the conclusion of each site visit.

Person responsible for follow-up report: _____

Actual date(s) of work: _____

1. **Actual Project Team:**

HALLIBURTON NUS Personnel:	Discipline/Tasks:

Non-HALLIBURTON NUS Personnel/Affiliation:	Discipline/Tasks

2. **Personal Protective Equipment Used:**

• Level of Respiratory Protection Used	Activity

• Field Dress	Activity

3. General Safety

Were any health or safety problems encountered while on site?

Explain: _____

4. Incident Report Information

Did any team member report:	Yes	No
• Chemical exposure		
• Illness, discomfort, or unusual symptoms		
• Environmental problems (heat, cold, etc.)		
• Injury		

Explain: _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Was an Employee Incident Report Completed? ___ Yes ___ No

5. Evaluation of Site Health and Safety Plan

Was the Health and Safety Plan adequate? _____ Yes _____ No

What changes would you recommend?

_____

_____

_____

_____

_____

FIRST AID SUPPLIES USAGE FORM

Project No.	Date	Item(s) Used	Kit No.

Please submit this information as soon as possible to to the HALLIBURTON NUS/EMG Equipment Manager for first-aid supply replenishment. Telephone number (412) 262-4583

SCBA LOG

Site: _____

Location: _____

Dates of Investigation: _____

User	Date of Use	SCBA #	Satisfactory Check-Out (Yes/No - Initials)	Date Cleaned

SCBA Performance Comments:

_____ Site Manager

_____ Date

Return to HSO at Completion of Activity

AIR PURIFYING
RESPIRATOR LOG

Type of Respirator: _____

Site: _____

Location: _____

Dates of Investigation: _____

User	Date of Use	Cleaned and Inspected Prior To Use (Initials)	Cartridges Changed Prior to Use (Yes/No)	Total Hours On Cartridge

_____ Site Manager

_____ Date

Return to HSO at Completion of Activity

INCIDENT REPORT

Report No. _____

Site: _____ Project No. _____

Location: _____

Date of Report: _____ Preparer's Name: _____

Name and Address of Injured: _____ SSN: _____ Age: _____

_____ Sex: _____

Years of Service: _____ Time of Present Job: _____ Title/Classification: _____

Division/Department: _____ Date of Incident: _____ Time: _____

Incident Category: _____ Motor Vehicle _____ Property Damage _____ Fire

_____ Chemical Exposure _____ Near-Miss _____ Other

Severity of Injury or Illness: _____ Nondisabling _____ Disabling

_____ Medical Treatment _____ Fatality

Amount of Damage: $_____ Property Damage: _____

Estimated Number of Days Away from Job: _____

Nature of Injury or Illness: _____

1. <u>Classification of Injury</u>:

_____	Fractures	_____	Heat Burns	_____	Cold Exposure
_____	Dislocations	_____	Chemical Burns	_____	Frostbite
_____	Sprains	_____	Radiation Burns	_____	Heat Stroke
_____	Abrasions	_____	Bruises	_____	Heat Exhaustion
_____	Lacerations	_____	Blisters	_____	Concussion
_____	Punctures	_____	Toxic Respiratory	_____	Faint/Dizziness
_____	Bites		Exposure	_____	Toxic Respiratory
_____	Respiratory Allergy	_____	Toxic Ingestion	_____	Dermal Allergy

Part of Body Affected: _____

Degree of Disability: _____

Date Medical Care Was Received: _____

Where Medical Care Was Received: _____

Address (if off site): _____

2. **Incident Location**

Causative agent most directly related to accident (object, substance, material, machinery, equipment, conditions): _____

_____

_____

_____

Was weather a factor? _____

Unsafe mechanical/physical/environmental condition at time of accident (Be specific):

_____

_____

_____

Unsafe act by injured and/or others contributing to the accident (Be specific, must be answered):

_____

_____

_____

Personal factors (improper attitude, lack of knowledge or skill, slow reaction, fatigue):

_____

_____

_____

Level of personal protection equipment required in Site Safety Plan:

_____

_____

_____

Modifications: _____

_____

_____

_____

Was injured using required equipment? _____

_____

_____

If not, how did actual equipment use differ from plan? _____

_____

_____

_____

What can be done to prevent a recurrence of this type of accident (modification of machine; mechanical guards; correct environment; training)?

_____

_____

_____

Detailed narrative description (how did accident occur, why; objects, equipment tools used, circumstances, assigned duties). Be specific:

_____

_____

_____

(Use back of sheet, as required)

Witnesses to accident: _____

_____

_____

Signature of Preparer _____

Signature of Site Manager _____

3. <u>Department Appraisal and Recommendation</u>

In your opinion, what actions or equipment contributed to this accident?

_____

_____

_____

Your recommendation:

_____

_____

_____

Date: _____ Signature of Department Manager _____

4. **Costs of the Incident (to be completed by Health Sciences Department)**

Temporary total	_____	Permanent partial	_____
Death or permanent total	_____		
Started losing time	_____	Part of body	_____
Returned to work	_____	Percent loss or	
Time charge	_____	loss of use	_____
		Time charge	_____
Compensation	$_____	Medical	$_____
Other	$_____	Total	$_____

Name and Address of Hospital _____

_____

Name and Address of Physician _____

_____

cc: Office Health and Safety Supervisor
Administrative Manager
Manager of Health Sciences
Medical Consultant

INCIDENT FOLLOW-UP REPORT

(To be Completed by Health Sciences Department)

Date of Incident: _____

Name: _____ Employee No. _____

Site: _____

Brief description of incident: _____

_____

_____

_____

_____

_____

_____

Outcome of incident: _____

_____

_____

_____

_____

_____

_____

Physician's recommendations: _____

_____

_____

_____

_____

_____

_____

Date returned to work: _____

ATTACH ANY ADDITIONAL INFORMATION TO THIS FORM

cc: Office Health and Safety Supervisor
Administrative Manager
Manager of Health Sciences
Medical Consultant

ATTACHMENT D-V

OSHA POSTER

ATTACHMENT D-V

OSHA POSTER

JOB SAFETY & HEALTH PROTECTION

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers by promoting safe and healthful working conditions throughout the Nation. Requirements of the Act include the following:

Employers

All employers must furnish to employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to employees. Employers must comply with occupational safety and health standards issued under the Act.

Employees

Employees must comply with all occupational safety and health standards, rules, regulations and orders issued under the Act that apply to their own actions and conduct on the job.

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to help ensure compliance with the Act.

Inspection

The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint

Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or for otherwise exercising their rights under the Act.

Employees who believe they have been discriminated against may file a complaint with their nearest OSHA office within 30 days of the alleged discrimination.

Citation

If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty

The Act provides for mandatory penalties against employers of up to $1,000 for each serious violation and for optional penalties of up to $1,000 for each nonserious violation. Penalties of up to $1,000 per day may be proposed for failure to correct violations within the proposed time period. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $10,000 for each such violation.

Criminal penalties are also provided for in the Act. Any willful violation resulting in death of an employee, upon conviction, is punishable by a fine of not more than $10,000, or by imprisonment for not more than six months, or by both. Conviction of an employer after a first conviction doubles these maximum penalties.

Voluntary Activity

While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries. OSHA's Voluntary Protection Programs recognize outstanding efforts of this nature.

Such voluntary action should initially focus on the identification and elimination of hazards that could cause death, injury, or illness to employees and supervisors. There are many public and private organizations that can provide information and assistance in this effort, if requested. Also, your local OSHA office can provide considerable help and advice on solving safety and health problems or can refer you to other sources for help such as training.

Consultation

Free consultative assistance, without citation or penalty, is available to employers, on request, through OSHA supported programs in most State departments of labor or health.

More Information

Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:

Atlanta, Georgia
Boston, Massachusetts
Chicago, Illinois
Dallas, Texas
Denver, Colorado
Kansas City, Missouri
New York, New York
Philadelphia, Pennsylvania
San Francisco, California
Seattle, Washington

Telephone numbers for these offices, and additional area office locations, are listed in the telephone directory under the United States Department of Labor in the United States Government listing.

Washington, D.C.
1988 (Revised)
OSHA 2203

Ann McLaughlin, Secretary of Labor

U.S. Department of Labor

Occupational Safety and Health Administration

Under provisions of Title 29, Code of Federal Regulations, Part 1903.2(a)(1) employers must post this notice (or a facsimile) in a conspicuous place where notices to employees are customarily posted.

GPO : 1988 O - 219-667