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NSWC WHITE OAK
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Section : 06.02
Site 20903-5640 (White Oak)
Doc. #: 0001
00152

Design Verification Sampling and Analysis Plan

for

Remedial Actions at Sites 2, 3, 4, 8, 9, and 11 Naval Surface Warfare Center White Oak

Silver Spring, Maryland

Engineering Field Activity Chesapeake
Naval Facilities Engineering Command

Northern Division Contract Number N62472-90-D-1298

Contract Task Order 0180

January 1995

Halliburton NUS
CORPORATION

Section: 06.02
Site 20903-5640 (White Oak)
Doc. #: W/0001

Halliburton NUS CORPORATION

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C-49-1-5-271

January 26, 1995

Project Number 2295

Mr. David Mills
Engineering Field Activity, Chesapeake
901 M Street, SE
Washington Navy Yard, Building 212
Washington, DC 20374-5018

Reference: CLEAN Contract No. N62472-90-D-1298
Contract Task Order No. 0180

Subject: Naval Surface Warfare Center - White Oak
Silver Spring, Maryland
Remedial Actions at Six Sites
Design Verification Sampling and Analysis Plan

Dear Mr. Mills:

Attached for your review and comment are two (2) copies of the Design Verification Sampling and Analysis Plan (DVSAP). Comments received to date, with Halliburton NUS responses, are included separately and are also addressed within the DVSAP as noted.

In consideration of the expanded scope discussed in the draft DVSAP issued on December 20, 1994, (additional analytes and sampling locations) and the budget restrictions that you have indicated apply to this project, we have implemented the changes discussed with you last week. Specifically, the well points and groundwater samples have been eliminated, except for the gathering of limited groundwater elevation data, which will be helpful in source confirmation and in the groundwater remediation phase of the project; each leaching well location will be sampled, but investigation will be limited to two locations in each of Area 100 and Area 300. The increase in number of analytes and reduction in number of sampling locations make the use of an onsite mobile laboratory less attractive, and the DVSAP has been revised to reflect the use of a quick turnaround fixed laboratory. This approach allows us to work within the budget negotiated, assuming that field conditions do not deviate widely from those expected.

The approach also introduces an element of uncertainty regarding the total quantities of soil to be remediated, but we do not feel that this compromises the design. However, there will be a change in the nature of the design deliverables, with respect to the type of information that we can present on the drawings.

In regard to the issue of management of investigation derived waste (IDW) raised by NSWCWODET, we have addressed their request for elaboration on how this material will be handled during the investigation, but the disposal of such materials is outside of the Halliburton NUS scope. Since the quantity of the IDW will not be known until the investigation has been completed, Halliburton NUS suggests that we defer the IDW issues until we have the materials in hand and can accurately identify and estimate disposal requirements. However, at that time, we will request a scope change memorandum.

Should you have any questions or comments, please do not hesitate to call me at 412-921-8616.

Very truly yours,

Don Olmstead

Donald G. Olmstead, P.E.
Project Manager

DGO/

Attachments

cc: Mr. Roger Boucher, NORTHDIV (w/o attachments)
Mr. Dorn Carlson, NSWC (1 set)
Mr. Bill Spicer, NSWC (3 sets)
Mr. Heath Wells, EFACHES (1 set)
Mr. John Trepanowski, Halliburton NUS (1 set)
Ms. Debra Wroblewski, Halliburton NUS (w/o attachments)
Project File 2295

Section: 06.02
Site 20903-5640 (White Oak)
Doc. #: 0001

R-12-94-10

DESIGN VERIFICATION SAMPLING AND ANALYSIS PLAN FOR REMEDIAL ACTIONS AT SITES 2, 3, 4, 8, 9, and 11 NAVAL SURFACE WARFARE CENTER WHITE OAK SILVER SPRING, MARYLAND

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Chesapeake
Design Branch Code 04
Naval Facilities Engineering Command
Washington Navy Yard, Building 212
Washington, D.C. 20374-2121

Submitted by:
Halliburton NUS Corporation
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0180

JANUARY 1995

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DRAWING

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EXECUTIVE SUMMARY

This Design Verification Sampling and Analysis Plan (DVSAP) for sites at the Naval Surface Warfare Center, Dahlgren Division, White Oak Detachment (NSWCWODET), located in Silver Spring Maryland has been prepared for the Engineering Field Activity Chesapeake (EFACHES) as authorized under Contract Task Order No. 0180 under Contract N62472-90-D-1298. This work is part of the Navy's Installation Restoration Program (IRP), which is designed to identify contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as needed.

NSWCWODET has been engaged in the development and testing of weaponry for the United States Navy since 1944. During this time, wastes generated in facility operations were disposed at various locations on site. A facility assessment and RFI identified seven of these sites as requiring further action. EFACHES has directed Halliburton NUS to develop design documents for six of the seven sites. The primary contaminants of concern at these sites are volatile organic compounds, nitroaromatic compounds, and metals. Remedial alternatives discussed to date include capping two sites, and source removal at four other sites. Based on a review of available documents, Halliburton NUS identified the need for additional data to support the design effort. The collection of the additional design data will be accomplished through the implementation of the DVSAP.

The DVSAP delineates the scope and methods for sampling and analytical work which is necessary to more accurately define and characterize the contamination at the six sites. The information obtained through the DVSAP will be used to support the final design for the proposed remedial action. The DVSAP outlines the sampling and analytical approach necessary to further characterize the sites requiring remedial action and quantify the extent of contamination.

The DVSAP describes the methods and procedures required to accomplish the following:

- Determination of the limits of sediment excavation for Site 2.
- Determination of the limits of capping system installation for Sites 2 and 3.
- Determination of the limits of excavation for Sites 4, 8, 9 and 11.

The DVSAP provides detail on sampling methodologies to be used, sample collection equipment, and sample management.

1.0 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This document is provided to support the design for a Remedial Action addressing removal of groundwater contamination sources and associated soils at the Naval Surface Warfare Center Dahlgren Division Detachment, White Oak (NSWCWODET) located in Silver Spring, Maryland. The Design Verification Sampling and Analysis Plan is part of a design package which includes drawings and specifications which is to be prepared in accordance with the Work Plan for Contract Task Order (CTO) 180.

CTO 180 is part of the Comprehensive Long-Term Environmental Action Navy (CLEAN), Contract Number N62472-90-D-1298 which is part of the Navy's Installation Restoration Program (IRP). The IRP is designed to identify contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as needed. CTO 180 is being administered by the Naval Facilities Engineering Command, Northern Division (NAVFAC), through Engineering Field Activity - Chesapeake (EFACHES).

CTO 180 requests that the Halliburton NUS Team prepare design documents for a Remedial Action consisting of a system to extract and treat groundwater underlying areas of the Naval Surface Warfare Center located in Silver Spring, Maryland. The work is to include performing a supplemental subsurface contamination investigation providing drawings, specifications, cost estimate, design analysis, field survey, environmental compliance needs analysis, and preparation of environmental compliance documentation.

The objective of this sampling plan is to locate source material and quantify the extent of contaminated soil to be removed as part of a source removal action at NSWCWODET. Six sites are to be addressed:

- Site 2 - Apple Orchard Landfill
- Site 3 - Pistol Range Landfill
- Site 4 - Chemical Burial Site
- Site 8 - Abandoned Chemical Disposal Pit
- Site 9 - Industrial Wastewater Disposal from "300" Area
- Site 11 - Industrial Wastewater Disposal from "100" Area

The DVSAP will describe the methods and procedures required to accomplish the following:

- Determination of the limits of sediment excavation for Site 2.
- Determination of the limits of capping system installation for Sites 2 and 3.
- Determination of the limits of excavation for Sites 4, 8, 9 and 11.

1.2 SITE DESCRIPTION

NSWCWODET is a Navy owned and operated laboratory for Naval Surface Warfare research, located approximately 5 miles north of Washington, D.C., off New Hampshire Avenue in Silver Spring, Maryland (see Figure 1-1). The facility is located in both Prince George and Montgomery counties. NSWCWODET is bordered by the Adelphi Laboratory Center and the United States Naval Reserve (USNR) Training Center along with a mixture of residential, park and industrial, commercial properties. NSWCWODET covers approximately 732 acres.

1.2.1 Site Operations

In 1944, the Navy acquired 870 acres of land in White Oak, Maryland for the expansion of the Washington Navy Yard-based Naval Ordnance Laboratory (NOL). In November 1945, the NOL's first mission was assigned which involved the research and development of naval ordnance including explosives, projectiles, mines, and related munitions and control systems. In June 1948, the command and administration functions of NOL were officially transferred from the Washington Navy Yard to the facility.

In November 1969, 137 acres of land were transferred from the NOL to the United States Army. A fenced boundary was installed in this area, which is now the location the Harry Diamond Laboratories. In September 1974, the NOL was renamed the Naval Surface Weapons Center during the consolidation of NOL with the Naval Weapons Laboratory located in Dahlgren, Virginia. The facility has been recently reassigned as a division detachment to Dahlgren with Dahlgren as the division headquarters. The facility is currently titled the Naval Surface Warfare Center, Dahlgren Division Detachment, White Oak (NSWCWODET).

1.2.2 Investigative History

Site investigation activities related to areas of potential environmental concern have been undertaken at the facility since approximately 1983. The initial work included an Initial Assessment Study (IAS) conducted by the Naval Energy and Environmental Support Activity (report issued November 1984). Subsequent to the IAS, a Confirmation Study was conducted by Malcolm Pirnie commencing in 1985. This report, titled

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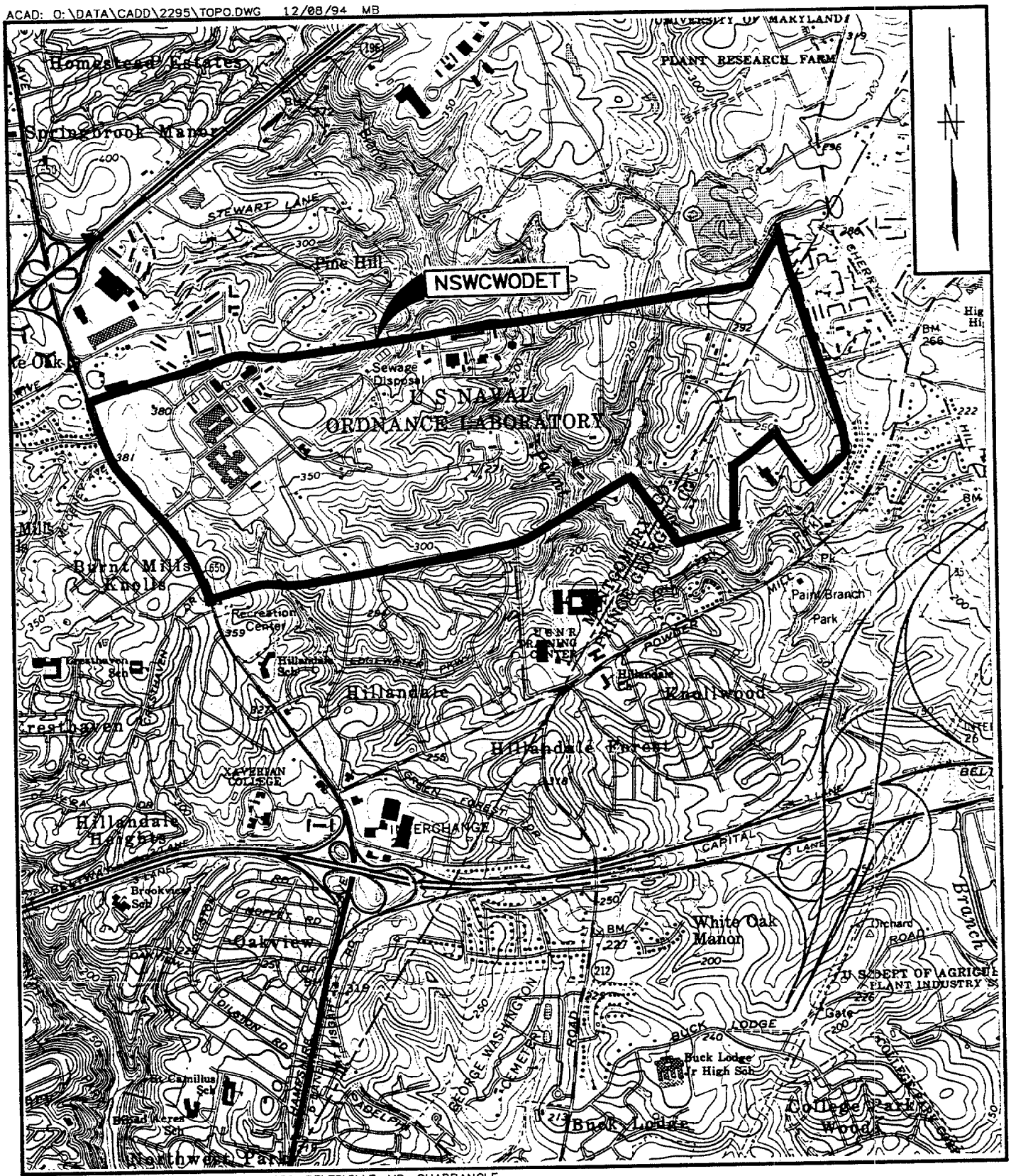


SOURCE: USGS 7.5' TOPOGRAPHIC SERIES, BELTSVILLE, MD. QUADRANGLE

FIGURE 1-1

FACILITY LOCATION MAP

NSWC WHITE OAK

0 2000 4000

SCALE IN FEET

Halliburton NUS CORPORATION

"Confirmation Study - Verification Phase, Naval Surface Warfare Center, White Oak" was completed in 1987. In addition, Malcolm Pirnie has also completed a Remedial Investigation (RI) Report (July 1992) and a *draft* Feasibility Study (FS) Report (March 1993) for the facility.

1.2.3 Physiography

NSWCWODET is located approximately 4 miles northeast of Washington, D.C. on the boundary between the Piedmont and Coastal Plain physiographic provinces. The facility lies in gently rolling terrain. The topographic expression of the area represents the result of deeply incised, dendritic stream channel pattern. Local drainage patters are dominated by Paint Branch Creek and its tributaries.

The highest elevation on the site is approximately 398 feet above mean sea level. The lowest elevation is roughly 145 feet above mean low water. The terrain of the western portion of the base slopes generally eastward toward Paint Branch Creek with about 3.5 percent grade. Similar grades are encountered in the eastern portion of the facility, but slopes are more generally southward or are locally influenced by proximity to Paint Branch Creek and its tributary drainages. Near stream channels, the ground slopes increase to as much as 65 percent.

1.2.4 Climate

NSWCWODET is located approximately 4 miles northeast of Washington, D.C. on the boundary between the Piedmont and Coastal Plain physiographic provinces. Summers at NSWCWODET are warm and humid, and winters are mild. Seasonal temperature variation is about 43°F. The warmest weather occurs in July, with daily temperatures ranging from 69°F to 88°F. The coldest weather occurs in late January and early February, with daily temperatures ranging from 28°F to 44°F.

The average annual precipitation is approximately 44 inches. Seasonal variation in precipitation is not pronounced, gradually fluctuating between a typical minimum of 3 inches in February to a typical maximum of 5 inches in August. Snowfall accumulations of more than 10 inches are rare, with the greatest snowfalls occurring in January and February.

The mean annual wind speed varies between 8 miles per hour in August and 11 miles per hour in March. The prevailing direction is from the south most of the year, except for northwesterly winds that occur during December, January and March.

1.2.5 Surface Drainage

NSWCWODET lies entirely within the drainage basin of Paint Branch, a 12 mile long tributary to the Northeast Branch of the Anacostia River. Like other streams in the region, Paint Branch is a gaining stream, as it is perennially supported by shallow ground water discharge from small springs and seeps along its length. One other unnamed perennial stream flows through the facility to the east of Paint Branch. It originates approximately one mile to the north and joins Paint Branch just south of the property line.

In addition to perennial streams, the facility is traversed by 8 intermittent streams, all of which discharge to Paint Branch either on the property or nearby. Several of these streams are very small and are not mapped by the U.S. Geological Survey (1964).

1.2.6 Soils

The facility soils, with the exception of stream-bed soils, tend to be moderately to excessively well drained and moderately to severely eroded. The soils generally fall within one of two major associations present in the vicinity; the Glenelg-Manor-Chester (GMC) association and the Chillum-Beltsville-Croom (CBC) association. The GMC association is developed in materials weathered from Piedmont metamorphic rocks while the CBC association is derived from Coastal Plain materials. Soils at the facility tend to be moderately acidic with a pH range ranging from 4 to 6 SUs (Soil Survey Report, U.S. Naval Ordnance Laboratory, White Oak, Maryland, 1920). This may be due to the presence of hydroxyl, humic and fulvic acids derived from the decay of organic matter.

1.2.7 Geology and Hydrogeology

NSWCWODET lies on the boundary between the Piedmont and Coastal Plain physiographic provinces. The boundary known as the Fall Line or Fall Zone, runs generally southwest to northeast and is roughly parallel to the Montgomery-Prince George's County line in the While Oak area. Physically the Fall Zone represents the contact where older Piedmont rocks, exposed to the northwest, dip beneath Coastal Plain sediments that increase in thickness to the southeast.

At the facility, Coastal Plain sediments are only a few tens of feet thick and in many places have been entirely eroded away. They are primarily unconsolidated sand and gravel deposits. The underlying or exposed Piedmont bedrock is the Wissahickon Formation metamorphic gneiss of late Precambrian age. The upper 50 to 70 feet of the Wissahickon gneiss has been highly weathered to a clayey saprolite material which retains the character of the parent material but is unconsolidated. This saprolite is considered a

separate lithologic unit. The Wissahickon gneiss and saprolite together account for at least 50 percent of the exposed formations at NSWCWODET. The gneiss bedrock tends only to crop out in or near the Paint Branch channel where overlying sediments have been removed by erosion.

1.3 PREVIOUS INVESTIGATIONS

Several investigations have been completed at NSWCWODET over the preceding 12 years. The work related with the previous studies and investigations is outlined below.

1.3.1 Initial Assessment Study

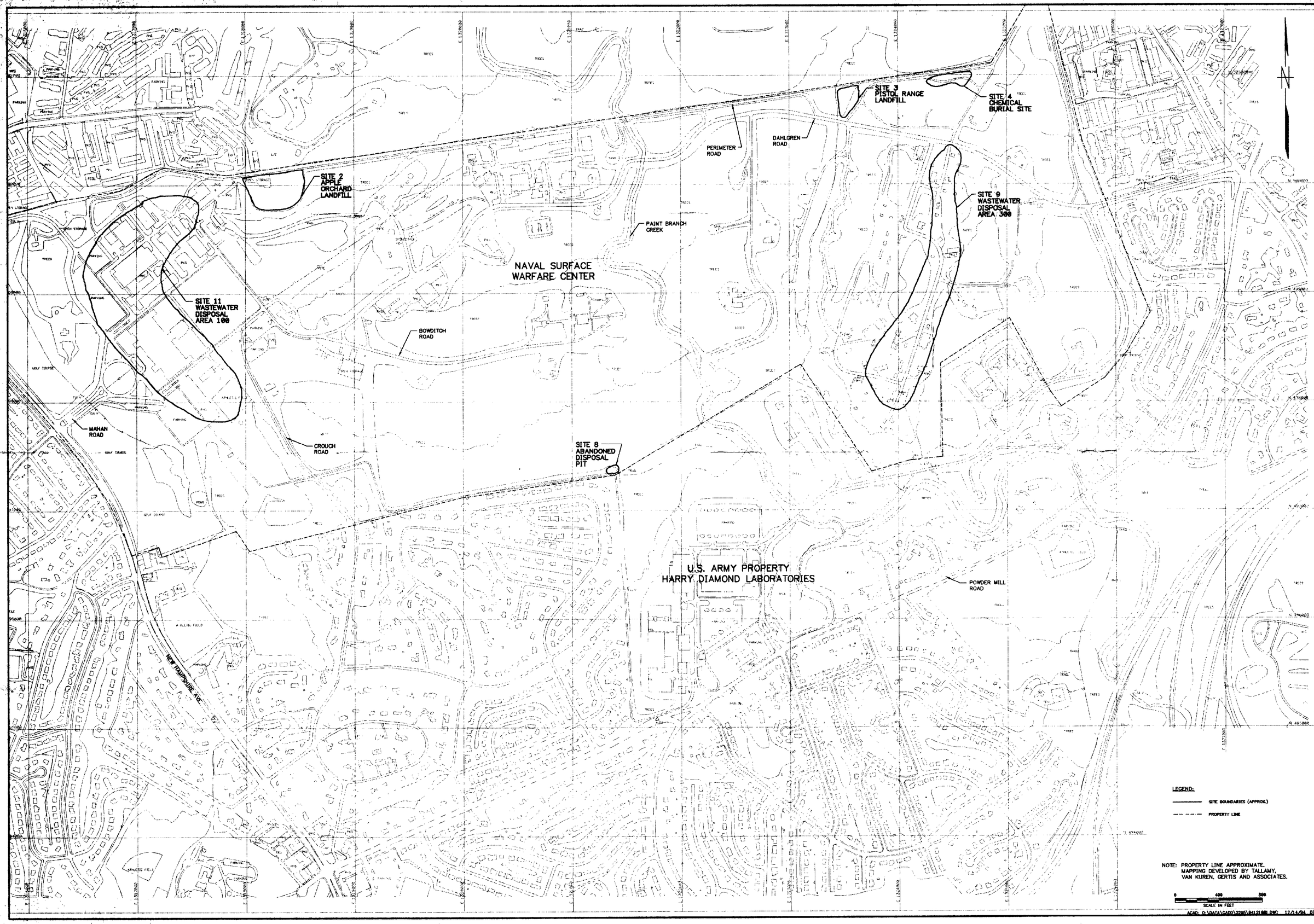
Site investigation activities related to areas of potential environmental concern have been undertaken at the facility since approximately 1983. Initial work included an Initial Assessment Study (IAS) conducted by the Naval Energy and Environmental Support Activity (NEESA, 1984). Through the investigation, fourteen sites where hazardous materials were reportedly disposed or spilled were investigated to determine if potential threat to human health and the environment was present and warranted any further examination. The study evaluated historic documentation and site operational data in the development of a score (quantifiable ranking of site hazards) for each site. From this study, seven of the sites were recommended for additional study. These sites included:

Site 2 - Apple Orchard Landfill
Site 3 - Pistol Range Landfill
Site 4 - Chemical Burial Site
Site 7 - Ordnance Burn Area
Site 8 - Abandoned Chemical Disposal Pit
Site 9 - Industrial Wastewater Disposal from "300" Area
Site 11 - Industrial Wastewater Disposal from "100" Area

This sampling plan addresses only Sites 2, 3, 4, 8, 9, 11 (identified on Drawing 1). Site 7 is to be addressed separately.

1.3.2 Confirmation Study, Verification Phase

In September 1985, Malcolm Pirnie was authorized to conduct the Confirmation Study, Verification Phase for the NSWC, White Oak. The study was conducted to confirm the findings of the IAS and to obtain additional information in characterizing site hazards. The study involved: the placement of 36 groundwater



LEGEND:

SITE BOUNDARIES (APPROX.)

PROPERTY LINE

NOTE: PROPERTY LINE APPROXIMATE.
MAPPING DEVELOPED BY TALLAMY,
VAN KUREN, GERTIS AND ASSOCIATES.

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SCALE IN FEET

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DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON NAVY YARD WASHINGTON, DC.

ENGINEERING FIELD ACTIVITY, CHESAPEAKE

SITE LOCATION MAP
NSWC WHITE OAK
SILVER SPRING, MARYLAND

NORTHDIV FOR COMMANDER, NAVFAC

ISSUED:

SEAL AREA

SAT TO	DATE
CODE I.D. NO.	80091
SCALE :	AS SHOWN
SPEC. NO. 84 -	NA
CONSTRN. CONTR. NO.	NA
NAVFAC DRAWING NO.	NA
SHEET 1 OF 1	
SIZE: D	DTS. SH. NO.

Halliburton NUS CORPORATION
PITTSBURGH, PA. 15220

DSGN: S. HESBIT DR: D. YOUNG
SUPV: CH. ENG: D. CANTRELL

SUBMITTED BY: (TITLE) (DATE)

CHECKED BY: (PRINC. MEMBERS)
DM: MD:
PRC: MD:
DIR:

OFFICER IN CHARGE
APPROVED DATE

REV.	DESCRIPTION	PREP BY	DATE	APPRVD

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monitoring wells adjacent to the sites of investigation (ranging in depth from 20 to 70 feet); placement of 54 soil borings (ranging in depth from surface to 5 feet) in areas of suspected soil contamination; a geophysical survey at Site 8 in an attempt to locate the former waste disposal area; and the collection of soil, surface water, groundwater and sediment samples to characterize site contaminants. Site contamination was found in surface and subsurface soil, stream sediments and groundwater. The study concluded that sufficient contamination existed to warrant additional study.

1.3.3 Remedial Investigation

A Remedial Investigation (RI) was conducted in two phases at the site between January 1989 and March 1993. The RI was conducted to further characterize hazards associated with the previously identified sites and to aid in the development of remedial actions plans for each. The RI involved: the placement of additional groundwater monitoring wells at all sites; collection of surface and subsurface soil, sediment, surface water and groundwater samples throughout the areas of investigation; collection of ecological data at all sites; performance of ground penetrating radar surveys at Sites 4 and 8; the completion of soil gas surveys at Sites 2, 3, 9 and 11; and the completion of slug tests and aquifer pumping tests at Site 11.

The results of the RI confirmed the presence of contamination at all sites. The analytical data was then used in the calculation of risk based on groundwater use for all seven sites. The calculated risks were determined to be high enough to support the development of the Feasibility Study for sites as described below.

1.3.4 Feasibility Study

The *draft* Feasibility Study (FS) was completed by Malcolm Pirnie in March 1993 and outlined the proposed remedial strategies for the facility. The FS evaluated the previous site characterization data to determine the most effective means to reduce environmental hazards at NSWCWODET.

1.4 CURRENT STUDIES

Halliburton NUS has been retained by Engineering Field Activity Chesapeake (EFACHES) to prepare remedial designs for Sites 2, 3, 4, 8, 9 and 11. After performing a review of the documents described in Section 1.3, field visits and discussions with personnel from NSWCWODET, EFACHES and the United States Geological Survey (USGS), Halliburton NUS has determined that while the available data may have been sufficient for the purposes of the RI/FS, it is insufficient for design purposes. Of particular concern is the uncertainty that exists with respect to quantities that require remediation. Secondly, it appears that the extent of contamination has not been completely characterized at some sites, and the depth of

contamination has not been ascertained. Thirdly, it appears that some errors exist in the information prepared to date which would critically impact the costs of remedies, for example, the area used for Site 2 - Apple Orchard Landfill. These issues must be addressed to facilitate the preparation of focused, cost-effective remedies.

Further sampling is required to verify the assumptions that have been used as the basis for the remedial direction to date. Accordingly, this Design Verification Sampling and Analysis Plan (DVSAP) has been developed.

1.5 PROPOSED REMEDIAL ACTIONS

The currently proposed remedial actions at Sites 2, 3, 4, 8, 9, and 11 include the following:

Site	Materials of Concern	Remedial Action(s)
Apple Orchard Landfill (Site 2)	PCBs in landfill surface soil and sediments.	• Sediment excavation with onsite thermal treatment and onsite disposal. • Synthetic/soil cap construction over the landfill surface.
Pistol Range Landfill (Site 3)	Volatile organic compounds in groundwater.	• Synthetic/soil cap construction over the landfill surface.
Chemical Burial Site (Site 4)	Volatile and semi-volatile organic compounds in groundwater.	• Excavation of contaminated soils and buried waste materials, onsite thermal treatment of soils, onsite disposal of treatment residuals, and offsite disposal of buried waste materials.
Abandoned Chemical Disposal Pit (Site 8)	Volatile and semi-volatile organic compounds in groundwater.	• Excavation of contaminated soils and buried waste materials, onsite thermal treatment of soils, onsite disposal of treatment residuals, and offsite disposal of buried waste materials.
Industrial Wastewater Disposal Area 300 (Site 9)	Nitroaromatic and volatile organic compounds in groundwater.	• Excavation of contaminated soils and buried waste materials, onsite thermal treatment of soils, onsite disposal of treatment residuals, and offsite disposal of buried waste materials.

Site	Materials of Concern	Remedial Action(s)
Industrial Wastewater Disposal Area 100 (Site 11)	Volatile organic compounds in groundwater.	• Excavation of contaminated so, buried waste materials, o, thermal treatment of soils, ons. disposal of treatment residuals, anc offsite disposal of buried waste materials.

The DVSAP has been designed to address the data needs associated with the proposed remedial actions which are soil/source removal efforts. Groundwater remedial actions are not addressed under CTO 180.

2.0 TECHNICAL APPROACH

2.1 SITE OVERVIEW

Halliburton NUS has reviewed the available documents and interviewed by telephone various Navy personnel with experience at the site. Based on this information, a summary of the pertinent information follows.

The focus of site activities has been to test and evaluate weapons systems for ships and submarines. Mine warfare has been an emphasis, as well as the development of explosives for specialized applications such as the lunar lander. The site has also been involved in the development of swimmers weapons, torpedo propulsion systems, and hydroacoustics.

The site features multiple laboratory buildings and related structures, including wind tunnels and an immersion tank. Support activities at the site included construction of models by various crafts. The site employed several hundred machinists at one time for this purpose.

The site also produced dummy ordnance referred to as shapes for drop testing. The shapes were filled with concrete or were hollow. The tests involved simulations of various field conditions in which ordnance might be dropped, rolled, or struck. The effects of such handling on ordnance reliability, the potential for damage to fuses, and the potential for accidental detonation were among the research objectives.

Site activities have been strictly research and development related. No full-scale deployment or production activities occurred on site. Bomb proofs were limited to five pounds of explosives, although as much as 50 pounds of explosives have been used for such purposes for special applications.

2.1.1 Waste Management Areas

As a result of these activities, numerous wastes were generated at the facility. Many of these wastes were disposed on site, although there was an informal policy prohibiting the disposal of ordnance. Available data suggests that some reactive materials may have been disposed, although this information is not conclusive.

Wastes generated included numerous shapes. These wastes are believed to have been disposed primarily in Site 3 - Pistol Range Landfill. This site received much of the bulky, heavy waste generated at the facility, as evidenced by the equipment, scrap metal, mill turnings, and other materials that are still evident at the

site. Batteries, and glass bottles containing hydrogen peroxide were also disposed at this site. Navy personnel interviewed have stated a belief that shapes would be prevalent throughout the Pistol Range Landfill (from the access road to the ravine). The site was disturbed in the 1970s, by the construction of a trunk line of the Washington Sanitary Sewer Commission, apparently without incident. In July of this year, an Explosive Ordnance Disposal team removed several shapes from the face of the landfill and destroyed them without encountering live or reactive material.

A wide range of waste was disposed at Site 2 - Apple Orchard Landfill. Wastes disposed included general refuse, several transformers (probably), drums containing waste oil from the shops, and reportedly fifty drums containing an unidentified yellow powder. The drums containing the yellow powder were disposed at a trench at the site. Shapes disposed at the site are still evident in the sediment of the tributary of Paint Branch Creek which runs along the toe of the landfill. After the site was removed from service and covered, it was used as a storage area for road salt, sand, and oil. An oil separator and two underground oil storage tanks were operated a the site but have since been removed.

Drummed wastes have been disposed at three locations. Most drum disposal occurred at Site 4 through placement in trenches. There is uncertainty with respect to the location of the trenches that was not resolved during the RI/FS. Some overnight explosions occurred at this site when it was active, reportedly as a result of white phosphorous disposal. Solvents have been detected in the groundwater at this site. Drummed wastes are also believed to have been disposed at Site 2, discussed above. Site 8, a small disposal pit, has also received drummed material. The exact location of the disposal pit is also uncertain and may lie under the pavement of the traffic circle in this area.

Chemical waste were typically disposed through drains leading to leaching wells, and possibly dry wells. These structures appear to be manholes with gravel bottoms. Waste streams containing explosive or reactive materials were primarily discharged from Buildings 4 and 30 in Site 11 and to a lesser extent in Site 9. Mercury was extensively used in these activities, and may be associated with these wastes. The leaching wells in Site 9 have reportedly been removed. Most of the leaching wells in Site 11 appear to be in place, although some were destroyed when a sewer system was placed in service.

Leaching wells and dry wells were used in the two courtyard areas of Buildings 1, 2, 3, 4, and 5. The installation of monitoring wells to investigate potential contamination in this area could not be completed due to its inaccessible nature. The placement of groundwater monitoring wells utilizing portable equipment was attempted in this area with no success.

2.1.2 Ordnance Issues

In the initial stages of this project, EFACHES alerted Halliburton NUS to the possibility of an Unexploded Ordnance hazard at the Pistol Range Landfill, based on the activities of an Explosive Ordnance Disposal team at the site during the summer of 1994. Reportedly, the team removed several shapes from the face of the landfill, destroyed them, and found that they did not contain ordnance.

Based on the available data, it does not appear that live ordnance will be encountered at the site. However, Halliburton NUS prefers to be conservative in situations involving ordnance or ordnance like materials.

Therefore, for purposes of executing this sampling plan, Halliburton NUS proposes to include an experienced UXO technician (trained at the Naval Explosive Ordnance Disposal School at Indian Head Maryland) on the sampling team. The technician will also participate in the routine sampling activities which will take place at other locations. Magnetometer type ordnance locators will be used for surface and down-hole work at the Apple Orchard and Pistol Range landfills. During all field investigative work, ordnance will be avoided.

2.1.3 Summary

Based on the available data and interviews summarized in the preceding discussion, the sites of greatest concern (from an environmental standpoint based on groundwater and soil analytical data) appear to be Sites 4 and 2. The leaching wells at Sites 9 and 11 would be of lesser concern.

2.2 INVESTIGATION

The following approach is envisioned for the investigation activities:

(1) At sites other than the landfills, the extent of the wastes will be estimated utilizing aerial photographs, file drawings, and non-intrusive subsurface techniques such as electro-magnetic (EM) surveys.

(2) The extent of subsurface contamination will be evaluated by subsurface soil sampling (borings).

(3) The EM survey results and trenches will be used to explore the limits of the landfills.

(4) Source sampling will occur at the leaching wells. All leaching well locations will be sampled, regardless if they were identified in the RI Report. The leaching wells will be sampled directly through the manhole cover if the leaching well is intact or through the utilization of boreholes. No confined space entry will occur.

(5) Boreholes will be used to explore the limits of contamination in soils surrounding selected leaching wells and the disposal sites, both laterally and vertically.

(6) A laboratory will be used for quick turnaround analysis of leaching well contents for parameters other than PCBs. The analytical results will be used to determine if additional sampling and analysis is warranted to define the extent of contamination. Additional soil borings will be used to define the extent of soil contamination, where necessary. The quality of data generated during these investigations will be sufficient for purposes of estimating the nature and extent of contamination.

(7) All soil cuttings will be analyzed to determine if they should be disposed of off site, or if the cuttings will be returned to the borehole or the excavation.

(8) Disturbed wastes, debris (i.e. concrete fragments) and soil which does not meet the screening criteria will be considered to be Investigation Derived Waste (IDW). IDW will be held on site for analysis in an approved facility, and properly disposed pursuant to characterization.

(9) Immuno-assay test kits will be used in the field to evaluate PCB contamination.

(10) A limited number of samples will be submitted as blind duplicates to evaluate the laboratory performance.

(11) The data will be tabulated and mapped in the field and the sampling plan will be adjusted accordingly.

(12) The anticipated depth and extent of waste materials that require excavation will be quantified.

A schedule for the proposed field operations has been provided in Appendix E.

3.0 FIELD OPERATIONS

3.1 FIELD OPERATIONS SUMMARY

The field operations at NSWCWODET are being performed as part of the Design Verification Phase 1, Source Removal Action. The goal of the field activities is to define the location and extent of contamination which may be present at Site 2, 3, 4, 8, 9 and 11 prior to source removal. Field operations will include soil borings, hand auger borings, test pit excavations, electromagnetic surveys, and the sampling of leaching wells, sediment and subsurface soils. Other field activities will include collecting water level measurements, site mapping and surveying. A summary of field activities is provided in Table 3-1. Environmental samples will be analyzed on a quick turnaround basis to facilitate rapid location of contaminated source areas and to allow command decisions with respect to expanding or reducing the extent of investigations at each site. Analytical results will be completed within 4 days to determine if additional sampling is necessary to define the extent of contaminated material. Duplicate samples will be collected at selected locations at each site to verify laboratory results. Field kits will be used to screen for PCBs in sediment and soil to determine the extent of PCB contamination. Note that groundwater sampling and monitoring well installation is to be performed in the Design Verification Phase 2 activities which will focus on groundwater remediation and are not a part of this investigation.

The following sections give detailed descriptions of each field activity that will be performed as part of the DVSAP. Table 3-1 summarizes the sampling program and field activities. A site by site description of field operations and sampling, and the rationale for each is included in Sections 5 through 10. All activities will be performed in accordance with the Health and Safety Plan (HASP) included as Appendix A.

3.2 MOBILIZATION

Following approval of the DVSAP, Halliburton NUS will prepare drilling specifications, obtain an analytical laboratory and drilling subcontractors, and mobilize. All field team members will review the DVSAP, 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 loaded into a vehicle in Pittsburgh, Pennsylvania and driven to the site

TABLE 3-1

PHASE 1 DESIGN VERIFICATION FIELD ACTIVITIES
NSWC WHITE OAK, SILVER SPRING, MARYLAND

Site	Activity(1)	Number	Number Of Samples To Be Collected For Analysis
Site 2 - Apple Orchard Landfill	EM Survey	1	--
	Test Trenches	5	--
	Sediment Sampling	25	25 by field kits
	Surface Soil Sampling	25	25 by field kits
Site 3 - Pistol Range Landfill	EM Survey	1	--
	Landfill Boring	4	--
	Test Trenches	5	--
Site 4 - Chemical Burial Site	EM Survey	1	--
	Soil Borings	14	14 by lab
	Hand Auger Borings	6	6 by lab
Site 8 - Abandoned Chemical Disposal Pit	EM Survey	1	--
	Soil Borings	4	4 by lab
	Hand Auger Borings	2	2 by lab
Site 9 - Waste Water Disposal Area 300	EM Survey	1	--
	Leaching Well Samples	17	17 by lab
	Soil Borings	8	24* by lab
Site 11 - Waste Water Disposal Area 100	EM Survey	1	--
	Leaching Well Samples	13	13 by lab
	Soil Borings	8*	24*by lab

(1) At all sites water levels from all existing monitoring wells will be collected and site mapping will be performed.

* Number of field activities and samples are estimated. Actual number will depend on field conditions and sample results.

by the FOL and additional field personnel. After field activities are completed, the FOL will demobilize the equipment and drive back to Pittsburgh.

3.3 ELECTROMAGNETIC (EM) SURVEYS

An electromagnetic (EM) survey will be completed at Sites 2, 3, 4, 8, 9 and 11 to locate buried metallic objects such as leaching wells, supply lines, drums, metal containers and utility lines. Each EM survey will be conducted using a Geonics EM-61 Time-Domain Metal Detector or Navy approved equivalent. This instrument will indicate the presence of metallic objects and has the ability to locate a single metal drum at approximately 10 ft bgs. At each survey location suspected to contain metallic objects, a grid will be set up at 10 foot intervals. Grid spacing will be wider in areas away from the central area of interest. The EM-61 will be pulled over the survey area and readings will be noted at each grid node and at any location between nodes which shows anomalous readings. The grid spacing will be refined as necessary to fully define the location and extent of any subsurface object which is detected. A sketch map will be constructed during the EM survey which indicates all node points and readings as well as any other site features including fencelines, roads, overhead utilities, light poles or other metallic objects which might interfere with the EM survey results or which may indicate the presence of buried utilities (HNUS SOP GH-3.1). All significant site features such as roads, buildings, sample locations, monitoring wells or surface features will be noted on the site sketch map.

At each survey grid the four corner end points will be staked and marked to permit exact location of the survey grid. EM survey results will be analyzed during the field activity to permit the expansion of the survey grid, if necessary. In addition, the location of any buried drums or leaching wells detected during the survey will be clearly marked using wooden stakes and surveyor's flagging to exactly locate buried objects. A digital data logger will be used to record the measurements taken by the instrument at each grid node and between grid nodes. The boundary of each EM grid will extend beyond the limits of the suspected burial area to assure that no significant objects lie at the edge of the survey area.

3.4 WATER LEVEL MEASUREMENTS

One complete round of water level measurements will be obtained from all existing monitoring wells at Sites 2, 3, 4, 8, 9 and 11 as a check on groundwater flow direction and previous source identification based on groundwater flow. Measurements will be taken within a 6-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 B, HNUS SOP GH-2.5).

3.5 LEACHING WELL SAMPLING

Mechanical or manual excavation methods will be used to uncover and confirm the location of those leaching wells at Site 9 and Site 11 which are currently buried below ground surface and are still intact. After buried leaching wells are located using an EM survey, each leaching well location will be excavated until the manhole cover of the leaching well is exposed and can be removed to allow sampling of the material inside the leaching well. It is estimated that the tops of the leaching wells are approximately 2 feet below grade. Excavations will not exceed 5 ft in depth. Samples will not be collected from these excavations although a sample will be collected from the material inside the leaching well if it is accessible.

All materials excavated will be placed on plastic sheeting next to the excavation. The soil overlying the leaching wells is not expected to be contaminated and will be returned to the excavation following sampling of the leaching well. All leaching wells located using mechanical or manual excavation methods will be marked with wooden stakes and surveyor's flagging to indicate the exact location of the well, the well ID number and the depth to the top of the leaching well. If the location of supply lines are noted during the excavation or the EM survey these features will be marked. A test pit log will be maintained for each excavation which will include soil lithology, soil moisture, soil color, depth to leaching well, PID/FID readings and location and direction (bearing) of any supply lines encountered. Each test pit log will be completed during excavation activities. A sample test pit log is included in Appendix B (HNUS SOP GH-1.8).

Once the leaching wells are uncovered, samples will be collected from the material present in the bottom of leaching wells at Site 9 and Site 11. The interior condition of these wells is unknown, although it is anticipated that residues may be present from past disposal activities. Leaching wells at Site 9 are reported to have been removed. Other leaching wells may have been filled with cement or may be used for other activities. Leaching wells at Site 11 have been inactive for several years and some may have been removed as a result of a rebuild of the area sewer system. It is unknown if all intact leaching wells contain water. Wastewaters disposed of at both sites may have contained solvents, metals, acids and explosives.

Samples will be collected from each leaching well after access is gained through the manhole which covers each leaching well. Following the removal of the manhole cover a reading will be taken with the PID/FID and the LEL/O_2 meters. If high levels of organic vapors are present the well will be left open and monitored with the PID/FID periodically until vapors have dissipated. The interior of the leaching well will be inspected visually from the surface and observations will be noted. The floor of the leaching well will be wetted as a

precautionary measure. Samples will be collected from the bottom of the well using a stainless steel hand auger. The sampling apparatus will be lowered into the leaching well and removed with the sample material. At no time will field personnel enter the leaching well to retrieve a sample. Samples will consist of a composite of surface materials (0 to 1 ft) and subsurface sediment (greater than 1.0 ft), if possible. Descriptions will be made of sediment lithology, color, moisture content, noticeable odor and PID/FID readings. All surface material samples retrieved from the leaching wells will be analyzed for full TCL/TAL scan, Method 8330 analytes, total Kjeldahl nitrogen (TKN), and pH. Soil borings and soil samples will be located in the vicinity of wells which contain contaminants above action levels. Following sampling activities, each leaching well will be re-sealed with the manhole cover and marked with sample location identification number. Barricades or hazard tape will be placed to alert pedestrians and traffic to the presence of a depression in the ground surface if excavation to uncover the manhole occurred. All leaching wells will be marked so the exact location of each well can be identified and surveyed (HNUS SOP GH-1.8).

3.6 SOIL BORINGS

Soil Borings will be performed at Sites 4, 8, 9 and 11 to determine the depth and extent of soil contamination. The hollow-stem auger drilling method will be used for advancing the soil borings. During drilling operations Standard Penetration Tests and split-spoon sampling shall be performed. Split spoon samples will be collected continuously to the bottom of the bore hole to define site geology, in accordance with ASTM D1586-84 (Section 7). Each split spoon sampler will have a minimum outside diameter of 2 inches and will be at least 2 feet long to fulfill the sample volume requirements for chemical analysis. Boreholes will typically be advanced to the water table or below in an attempt to define the extent of contamination.

A lithologic description will be made of each split-spoon sample and a complete log of each boring will be maintained by Halliburton NUS in accordance with NUS SOP GH-1.5: Sections 5.2, 5.4, and 5.5. A sample boring log is attached in Appendix B. At a minimum, the Halliburton NUS 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 will be included on each boring log. Each boring log will also describe the borehole location (NUS SOP GH-1.4). Distances to notable landmarks will be measured and noted on the log when possible. Upon completion of the boring placement, the boreholes will be backfilled with cement grout. Investigative Derived Wastes (IDW) generated during soil boring placement will be managed in accordance with the procedures outlined in Section 3.14.

3.7 SUBSURFACE SOIL SAMPLES

Subsurface soil samples will be collected from the soil borings at Sites 4, 8, 9 and 11 and from hand auger borings at Sites 4 and 8. The hand auger borings will be used to collect samples in the immediate vicinity of the wastes in order to minimize waste disturbance. These samples will be used to define the extent of contaminated soil which may be present at each site. All samples obtained from the boreholes and hand auger borings will be monitored with a PID/FID organic vapor monitor. Samples will be collected from the sampling device (split-spoon or hand auger bucket) and transferred to the appropriate sample containers. Sample containers for volatile organics (VOCs) will be filled first and the remaining soil will be composited in a stainless steel bowl before being distributed to the remaining sample containers. Notes will be made of the soil lithology, moisture content, color, noticeable odors and PID/FID readings. The sample location, sample time, sample method and other relevant data will be noted on sample log sheets and in the site logbook. A soil sample log sheet is included in Appendix B (HNUS SOP GH-1.3). IDW generated during the sampling activities will be managed in accordance with the procedures outlined in Section 3.14.

3.8 SURFACE SOIL SAMPLES

Surface soil samples will be collected from Site 2 in the vicinity of the base of the landfill and from the former location of a waste oil tank which may have existed in the area. These samples will be used to define the extent of PCB contaminated soil which may be present in these areas. Samples will be collected using a stainless steel trowel and mixing bowl. Samples will be analyzed for PCBs using an analytical test kit. Samples for PCB analysis will be collected from two intervals; the surface layer (0-6 inches) and at depth (1 to 2 feet.) Samples will be analyzed within 24 hours of collection. During soil sampling, notes will be made of the soil lithology, moisture content, color, noticeable odors and PID/FID readings. The sample location, sample time, sample method and other relevant data will be noted on sample log sheets and in the site logbook. A soil sample log sheet is included in Appendix B (HNUS SOP GH-1.3).

3.9 SEDIMENT SAMPLES

Sediment samples will be collected from the stream at the base of Site 2. Samples will be used to determine the extent of PCB contamination in the stream sediments upstream and downstream of the Apple Orchard Landfill (Site 2). Sediment will be collected from the stream channel from areas where sediment deposition is occurring. Samples will be taken using stainless steel sampling trowels or hand augers from the stream bed. Samples for analytical analysis will be collected from two sediment intervals, the surface layer (0 to 6 inches) and from depth (1 to 2 feet) to determine contaminant concentrations in the sediment profile. Samples will be analyzed for PCBs using portable analytical test kits. Sediment samples will be analyzed within 24 hours. Sample results will be used to select remaining sample locations to fully identify the extent of contamination (HNUS SOP GH-1.2). IDW generated during the sampling activities will be managed in accordance with procedures outlined in Section 3.14.

3.10 TEST TRENCHES

Test trenches will be used to determine the edge of fill materials present in the landfills at Site 2 and Site 3. Visual observations will be used to locate the edge of the landfill and test trench results will determine the extent of the capping for each site. At each site the procedures outlined below will be used:

Following the completion of the EM survey across the top of the landfill, test trench locations will be determined. If metallic objects are located during the EM survey the area will be considered to within the landfill and trenches will not be necessary in that location. Test trenches will be located along the outside edge of the landfill, starting at the perimeter road and continuing inward towards the center of the landfill. Test trenches will be excavated to a maximum depth of 6 to 10 feet bgs. Visual observations will be made of the sides of the test trench to determine if fill material is present. It is estimated that five test trenches will be necessary to define the extent of the fill material at each of the two sites. Additional test trenches will be added if necessary to define landfill limits. During trenching, the boundary of clean fill and landfill will be marked to be surveyed.

Prior to excavation, a Halliburton NUS UXO specialist will survey the area visually and with a magnetometer. Any metal objects detected will be interpreted to be fill material and the trench will be relocated outwards towards the edge of the landfill. The uncovering and identification of shapes will result in relocation of the test trench. No removal of shapes will occur. Soil will be removed across the length of each trench in intervals of 24 inches. The trench will be then resurveyed by the UXO specialist using a magnetometer. When sufficient excavation to delineate the interface between fill material and native soils has occurred,

trenching will be stopped. At no time will the trench be entered. Magnetometer survey methods and hand excavation of shapes is addressed in more detail within the HASP in Appendix A.

A test pit log will be maintained for each excavation which will include soil lithology, soil moisture, soil color, total depth of the excavation and any PID/FID readings. Each test pit log will be completed during excavation activities. A sample test pit log is included in Appendix B. All test trench locations will be marked with wooden stakes and surveyor's flagging to indicate the exact location of the trench including the starting and ending points of the trench, trench number, and any clean fill/landfill interface that is encountered.

Materials removed from the test trench will be placed on plastic sheeting. The contents of each backhoe bucket will be scanned with a PID/FID after being placed on the sheeting to determine if any volatile organic compounds are present in the soil. The results of each screening will be noted on the test pit excavation form. All excavated material will be returned to the trench following the completion of the excavation. All relevant features (i.e., landfill/clean fill contact) will be photographed.

Test trenches may be left open overnight to allow for inspection by regulators. If a trench is to remain open, fencing or barricades will be used to prevent unauthorized access to the trench. The project manager and Navy RPM will be notified of trenching activities 1 week and 1 day in advance of placement so that they may notify the appropriate regulatory agencies. Trenches which encounter clean fill/landfill interface should remain open for regulatory inspection.

3.11 LANDFILL BORING

The planned field activities will attempt to determine the extent, volume and distribution of waste materials associated with Site 3 - Pistol Range Landfill. The landfill may actually consist of debris scattered over the face of a steep hillside in which case the construction of a landfill cap may not be merited and waste removal and offsite disposal would be preferred.

However, if the wastes are extensive enough to favor a capping remedy (i.e., the wastes extend from the hillside towards the access road), then a determination is necessary as to whether the hillside debris can be removed from the hillside and consolidated in a smaller area for capping. If not (i.e., the hillside is actually formed from waste), then the waste would need to be sufficiently regraded to create a slope that is acceptable for cap construction. The applicable scenario must be determined for cap design.

The extent of the landfill will be determined by the EM survey, and trenching as necessary. The depth of materials on the hillside will be determined through the placement of borings. Since the slope is too steep for a conventional drilling rig, hand tools or manually held gas powered or hand augers will be utilized.

Prior to boring, a Halliburton NUS ordnance specialist will scan the area visually and with a magnetometer to identify any potential shapes. Metallic objects will be hand excavated and identified. Non-shapes will be removed and the boring will be advanced to a depth of two feet. The magnetometer survey will then be repeated, and metal objects and shapes will be addressed in the same manner. Boring advancement will continue in this manner until boring equipment depth limit has been reached or until natural soils are encountered. All cuttings will be returned to the boring. No samples for analysis will be taken. Magnetometer survey methods and hand excavation of shapes is addressed in more detail within the HASP in Appendix A.

3.12 SITE MAPPING/SURVEYING

To identify locations of important site features and sampling locations, a site map will be constructed for all sites being investigated. Site maps will be constructed using existing site diagrams in conjunction with distance measurements taken at the site. Existing site maps will be used to develop a base map, and site features will be compared to that map. Any discrepancies will be noted. Measured distances and compass directions (bearings) will be noted for all new sample locations and important site features. A hand held compass and measuring tape will be used when making additions to the site maps. If significant discrepancies are noted between existing maps and field conditions, the surveying of site features may be necessary to confirm the actual site geometry.

Surveying will be performed at all six sites. All sampling locations including surface soil, subsurface soil, sediment locations, test trench locations, existing monitoring wells will be surveyed. In addition, two corners of each EM survey grid will be marked and surveyed. Existing survey monuments within NSWCWODET may be utilized as reference points. Horizontal locations will be surveyed to state plane coordinates. Vertical elevations will be referenced to the NGVD 1929 North American Datum. 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.

A topographic survey will also be conducted at each landfill in order to develop an accurate site regrading plan for use during landfill closure. The landfill surveys will be performed by a licensed Maryland Land Surveyor, following completion of the landfill test trenching work and disposal limits delineation. It is anticipated that the landfill survey will be performed following completion of all of the DVSAP field work.

3.13 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, and all sampling equipment. All water or liquid generated during decontamination operations will be collected, containerized, labeled and stored on site in Department of Transportation (DOT) approved, 55-gallon drums.

3.13.1 Major Equipment

All downhole drilling equipment and sampling tools shall be steam cleaned prior to beginning work, between soil borings, any time the drilling rig leaves the site prior to completing a boring, and at the completion of the drilling program. 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.

3.13.2 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
Nitric acid rinse (when sampling for metals)
Methanol rinse (when sampling for VOCs, SVOCs or PCBs)
Analyte-free 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.

3.14 WASTE HANDLING

Five types of potentially contaminated Investigative Derived Wastes (IDW) are expected to generated during the implementation of the DVSAP, namely Personal Protection Equipment (PPE), drill rig decontamination fluids, sampling equipment decontamination fluids, and auger soil cuttings, and test trench soils. Based on the activities and types of contaminants present, none of these residues are expected to represent a significant risk to human health or the environment if properly managed. Planned management of these residues is provided below.

PPE - PPE will be placed in trash receptacles at the facility.

Drill Rig Decontamination Fluids - Drill rig decontamination fluids will be containerized in 55-gallon drums. Pending the results of subsequent sampling and analysis of these fluids, they will be removed from the site and disposed of by the drilling subcontractor.

Sampling Equipment Decontamination Fluids - Equipment decontamination fluids will be containerized and handled with the drill rig decontamination fluids.

Auger Soil Cuttings- All auger cuttings derived during soil boring activities will be containerized in 55-gallon drums at the point of origin. Auger soil cuttings will be screened with a PID/FID and samples will be collected from each boring to determine the if soil contamination is present at that location. Based on analytical results, if soils are clean they will be returned to the surface at the point of origin. However, if readings are detected above allowable levels for clean fill, the soils will be stored at the facility in an approved storage facility pending additional analyses. At the conclusion of the field investigation, analytical results will be compared to allowable levels from each drum of soil. Halliburtion NUS personnel will collect a composite sample for TCLP analysis from each of the drums suspected to contain RCRA Hazardous Waste (RHW). Using the results of these analysis and the analytical data from the soils, a determination will be made as to the required disposal location for the soils.

All IDW placed on drums will be labeled to indicate the type of material in each drum, point of origin (boring number), date, site number and amount of material in drum. Care will be taken to segregate soil from each soil boring to minimize to chance of mixing clean and contaminated soil in one drum. During mobilization, a storage area will be identified in concert with base personnel where IDW can be stored which satisfies RHW storage criteria. It is estimated that 20 to 40 drums will be stored during the investigation.

Test Trench Soil - All test trench soil will be returned to the excavation immediately following the completion of the test trench. Analytical samples will not be collected during trenching activities, as all trenches will be conducted in areas suspected to contain clean material and little or no fill. All trenching activities will be monitored using a PID/FID. The data collected from each test trench will be used to assist in the design of remedial options for the site.

All IDW placed in drums will be labeled to indicate the type of material in each drum, point of origin (well or boring number), date, site number and amount of material in drum. During mobilization, a centralized staging area will be identified (in concert with base personnel) where IDW will be stored. The staging area will satisfy RHW storage criteria. At the completion of field activities, base personnel will taken responsibility for disposal of IDW. It is estimated that 20 to 40 drums will be staged during the investigation.

4.0 SAMPLING PROCEDURES

4.1 SAMPLE ANALYSIS SUMMARY

Samples collected during the field investigation will be submitted for analysis as presented in Tables 4-1 and 4-2. These tables include the analytical parameters, preservation methods, holding times, bottle requirements and analytical methods for each sample. The majority of samples collected will be analyzed using quick turnaround to provide real time results. Blind duplicate samples will be collected from each site and will be submitted to the laboratory to confirm the results. Additionally, samples collected for PCB analysis will be screened using a field kit to obtain rapid sample results.

4.2 SAMPLE HANDLING

Each sample collected during the field operation will be assigned a unique sample tracking number. The sample tracking number will consist of a four-segment, alpha-numeric code that identifies the (1) site number, (2) sample medium, (3) location, and (4) the sample depth (in the case of subsurface soil samples). Any other pertinent information regarding sample identification will be recorded in the field logbooks and on sample log sheets.

4.2.1 Sampling Identification System

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

Site Number	Sample Medium	Sample Location	Sample Starting and Ending Depth (ft)
AA	NN	NN	NNNN

Character type:

A = Alpha

N = Numeric

TABLE 4-1

ANALYTICAL PROGRAM
NSWC WHITE OAK, SILVER SPRING, MARYLAND

Analytical Procedure	Analytical Parameter[1]	Sample Media	No. of Samples	Duplicates[2]	Trip Blanks[3]	Equipment Rinsates[4]	Field Blanks[5]	Total Samples
SITE 2 - APPLE ORCHARD LANDFILL								
Field Kit	PCBs	Sediment	25	-	-	-	-	25
		Surface Soils	25	-	-	-	-	25
Fixed Lab	TOC/TVS	Sediment	5	-	-	-	-	5
SITE 4 - CHEMICAL BURIAL AREA								
Field Kit	PCBs	Subsurface Soils	12	-	-	-	-	12
Fixed Lab	VOCs	Subsurface Soils	20	1	1	1	-	23
	SVOCs		20	1	-	1	-	22
	Inorganics		20	1	-	1	-	22
	Explosives/TKN		20	1	-	1	-	22
	pH		20	-	-	-	-	20
	Geotechnical Parameters		2		-	-	-	2
SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT								
Field Kit	PCBs	Subsurface Soils	3	-	-	-	-	3
Fixed Lab	VOCs	Subsurface Soils	6	1	1	1	-	9
	SVOCs		6	1	-	1	-	8
	Inorganics		6	1	-	1	-	8
	Explosives/TKN		6	1	-	1	-	8
	pH		6	-	-	-		6
	Geotechnical Parameters		2	-	-	-	-	2

TABLE 4-1 (Continued)
ANALYTICAL PROGRAM
NSWC WHITE OAK, SILVER SPRING, MARYLAND

Analytical Procedure	Analytical Parameter[1]	Sample Media	No. of Samples	Duplicates[2]	Trip Blanks[3]	Equipment Rinsates[4]	Field Blanks[5]	Total Samples
SITE 9 - INDUSTRIAL WASTEWATER TREATMENT AREA 300								
Fixed Lab	VOCs	Subsurface Soils	24	2	2	1	-	29
	SVOCs		24	2	-	1	-	27
	Inorganics		24	2	-	1	-	27
	Explosives/TKN		24	2	-	1	-	27
	Geotechnical Parameters		2	-	-	-	-	2
	VOCs	Leaching Well	17	2	2	1	-	22
	SVOCs		17	2	-	1	-	20
	Inorganics		17	2	-	1	-	20
	Explosives/TKN		17	2	-	1	-	20
SITE 11 - INDUSTRIAL WASTE WATER TREATMENT AREA 100								
Fixed Lab	VOCs	Subsurface Soils	24	2	2	1	-	29
	SVOCs		24	2	-	1	-	27
	Inorganics		24	2	-	1	-	27
	Explosives\TKN		24	2	-	1	-	27
	pH		24	-	-	-	-	24
	Geotechnical Parameters		2	-	-	-	-	2
	VOCs	Leaching Well	13	2	2	1	2	20
	SVOCs		13	2	-	1	2	18
	Inorganics		13	2	-	1	2	18
	Explosives/TKN		13	2	-	1	2	18

TABLE 4-1 (Continued)
ANALYTICAL PROGRAM
NSWC WHITE OAK, SILVER SPRING, MARYLAND

Analytical Procedure	Analytical Parameter[1]	Sample Media	No. of Samples	Duplicates[2]	Trip Blanks[3]	Equipment Rinsates[4]	Field Blanks[5]	Total Samples
SITE 11 - BACKGROUND SAMPLE LOCATIONS/EVAPORATION UNIT LOCATION								
Fixed Lab	VOAs	Subsurface Soils	3	2	-	-	-	3
	Semivolatiles		3	2	-	-	-	3
	Inorganics		3	2	-	-	-	3
	Explosives\TKN		3	2	-	-	-	3
	pH		3	-	-	-	-	3
	PCBs		3	-	-	-	-	3
	Geotechnical Parameters		2	-	-	-	-	2

(1) Analytical parameters include volatile organic compounds (VOCs); semivolatile organic compounds (SVOCs); PCBs (polychlorinated biphenyls); Total Organic Carbon (TOC) total Kjeldahl nitrogen (TKN); total volatile solids (TVS); explosives includes nitroaromatics, nitroamines, nitroglycerine and nitrocellulose; geotechnical parameters include soil class, grain size, moisture content, total organic carbon and pH.

(2) Duplicates are a single sample split into two portions and analyzed independently. A total of 5 percent of samples collected for screening level analysis (soil borings) will be taken. A total of 10 percent of samples will be taken as duplicates.

(3) Trip blanks will be collected only for samples shipped to fixed lab and will not be used for samples analyzed by on-site lab. Trip blanks are samples which originate from analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic compound (VOC) samples. One trip blank per cooler containing VOCs.

(4) Rinsate blanks will be collected only for samples being sent to the fixed based lab for analysis. Rinsates will not be collected for samples being analyzed by the on-site lab. The rinsate blank represents a equipment blank (i.e., analyte-free water run through a sampling device before use and collected as a rinsate). Rinsate blanks are collected at a frequency of 1/sampling train/day. Per NEESA guidelines (20.2-047B; 6/88), only rinsates collected from every other day will be analyzed unless significant levels of contaminants are noted in the previous rinsate. Those rinsate blanks to be analyzed will be marked accordingly on the chain-of-custody form.

(5) Field blanks will be collected from potable water and deionized water used for decontamination. Obtained at a frequency of 1/source/event. To be obtained early in field activity, during sampling of leaching wells at Site 11.

TABLE 4-2

SUMMARY OF ANALYSIS, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS AND HOLDING TIMES
SURFACE SOIL, SUBSURFACE SOIL, SEDIMENT, AND LEACHING WELL SAMPLES
NSWC WHITE OAK, SILVER SPRING, MARYLAND

Parameter	Sample Container	Container Volume	Preservation	Maximum Holding Time	Analytical Methodology
FIXED BASE LAB SAMPLES					
TCL Volatile Organic Compounds	Glass jar with Teflon-liner	120 mL	Cool to 4°C	14 days	EPA-CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration (Doc. #OLM01.8) 5/90
TCL Semivolatile Organic Compounds	Amber glass jar with Teflon-lined cap	1000 mL	Cool to 4°C	Extract 14 days; Analyze 40 days	EPA-CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration (Doc. #OLM01.8) 5/90
TCL Pesticides/ Polychlorinated Biphenyls (PCBs)	Amber glass jar with Teflon-lined cap	2000 mL	Cool to 4°C	Extract 14 days; Analyze 40 days	EPA-CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration (Doc. #OLM01.8) 5/90
TAL Metals/ Cyanide	Amber glass jar	8 oz	Cool to 4°C	180 days, except mercury 26 days; cyanide 12 days	EPA-CLP SOW for Inorganic Analysis, Multi-Media, Multi-Concentration (Doc. #ILM02.1)
Explosives (1)	TBA (2)	TBA (2)	TBA (2)	TBA (2)	EPA SW846 8330
Geotechnical Parameters (3)	Four (4) Clear wide mouth glass jars	32 oz (128 oz. total)	None	None	As needed
Total Organic Carbon (TOC) only	Clear wide mouth glass jar	32 oz	Cool to 4°C	To be arranged	As needed
Total Kjeldahl Nitrogen (TKN)	Plastic or glass	1000 mL	Cool to 4°C	14 days	EPA 351.2/351.3
Total Volatile Solids (TVS)	Plastic or glass	100 mL	Cool to 4°C	7 days	EPA 160.4

TABLE 4-2 (Continued)
SUMMARY OF ANALYSIS, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS AND HOLDING TIMES
SURFACE SOIL, SUBSURFACE SOIL, SEDIMENT, GROUNDWATER AND LEACHING WELL SAMPLES
NSWC WHITE OAK, SILVER SPRING, MARYLAND

Parameter	Sample Container	Container Volume	Preservation	Maximum Holding Time	Analytical Methodology
FIELD ANALYTICAL KITS					
PCBs	Glass jar with Teflon-liner	4 oz.	Cool to 4°C	Analyze within 24 hours	EPA SW846 4020 (using Ensys PCB Risc test)

(1) Explosives include nitroaromatics, nitroamines including two non-method analytes, nitroglycerine and nitrocellulose.

(2) TBA indicates to be arranged after fixed based laboratory is selected. Sample containers, holding times and preservation will be determine based on specific laboratory requirements.

(3) Geotechnical parameters include soil class, grain size, moisture content, pH, and total organic carbon (TOC).

Site Number:

02 = Site 02, Apple Orchard Landfill
03 = Site 03, Pistol Range Landfill
04 = Site 4, Chemical Burial Area
08 = Site 8, Abandoned Chemical Disposal Pit
09 = Site 9, Industrial Waste Water Disposal Area 300
11 = Site 11, Industrial Waste Water Disposal Area 300

Sample Medium:

SB = Subsurface soil sample
SO = Surface soil sample
SD = Sediment sample
LW = Leaching well sample
TP = Test pit (Note: Test pit will be labeled, although no samples to be collected for analysis)

Sample Location:

Sample station locations of a given medium will be numbered sequentially beginning with "01" for all media.

Sample Depth:

Sample depth will indicate the starting and ending depth of each soil or sediment sample. For example, samples labeled as 0010 indicate the sample was taken from 0.0 to 1.0 feet. Sample depth will only be used for subsurface soil samples.

Samples collected as duplicates and sent to a fixed base laboratory for confirmation analysis will be labeled in the same manner as listed above, except that a "D" will be added to the end of the sample label. This will indicate the sample is a duplicate of that sample location. Duplicate samples will be collected for confirmation analysis from subsurface soils at Site 4, Site 8, Site 9 and Site 11.

4.2.2 Example of Sample Labeling System

The following are examples of sample identification schemes:

The tenth leaching well sample collected from Site 09 will be labeled:

09 - LW - 10

The fifth surface soil sample collected at Site 03 would be labeled:

03 - SO - 05

Soil sample collected at depth 10-12' from second soil boring location at Site 11 would be labeled:

11 - SB - 02 - 1012

A duplicate of this sample sent to a fixed base laboratory would be labeled

11 - SB - 02 - 1012 - D

The first test pit at Site 3 would be labeled

03 - TP - 01

4.3 QUALITY CONTROL SAMPLES

Quality control (QC) samples will be collected or generated during environmental sampling activities. QC samples include trip banks, field blanks, and equipment rinsate blanks. Table 4-1 presents the type and number of required QC samples. Each type of field QC sample is defined as follows:

Trip Blanks: Trip blanks are samples which originate as analyte-free water taken from the laboratory to the sampling site and returned to the laboratory with the volatile organic (VOA) samples (such as TCL VOAs). One trip blank will be collected per each cooler containing VOAs. Trip blanks will be analyzed only for VOAs.

Field Duplicates: Field duplicates are two samples collected from a single sample split into two portions. Duplicates are obtained during a single act of sampling and are used to assess the overall precision of the sampling and analysis program. Five percent of all samples taken from the soil borings will be sent to laboratory for verification of laboratory analytical results.

Equipment Rinsate Blanks: Equipment rinsate blanks are obtained under representative field conditions by running analyte-free water through sample collection equipment (hand auger bucket, bailer, trowel, etc.) after decontamination, and collecting 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 only for samples sent to a fixed based laboratory for analysis such as leaching well samples and duplicate samples. Equipment blanks will be collected for each type of 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 Field Operations Leader (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 source water used for decontamination during the field investigation. Samples consist of the source water used in: (1) potable water used for decontamination, 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 may be contributing to sample contamination. Field blanks will be collected early in the field operation, during the leaching well sampling at Site 11. Samples will be collected from each type of water used for decontamination and will be submitted at a frequency of one per sampling event.

Quality Control and duplicate samples collected for all media will be identified by the following sample identification system:

QC Sample Identifier	Date	Sample Number
AA	NNNN	NN

QC Sample Identifier:

Trip Blank = TB
Field Blank = FB
Rinsate Blank = RB

Date:

The date the sample is collected (Month, Day).

Sample Number:

The sequential number of that sample type taken on the sampling date.
Note that the times that duplicates are collected will be noted as 0000 on the sample bottles and the chain of custody (COC) to assure that the laboratory cannot determine the original location of the sample. The correct time and the sample location of the duplicate will be noted in the field notebook and on the sample log sheets for the duplicate and the original sample.

4.4 SAMPLE CUSTODY

Custody of samples will be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. A sample is in custody if:

- It is in the field investigator's or the transferee's actual possession;
- It is in the field investigator's or the transferee's view, after being in his/her physical possession;
- It was in the field investigator's or the transferee's physical possession and then secured to prevent tampering;
- It is placed in a designated secure area.

A chain-of-custody record form shall be used to record the custody of all samples collected and maintained by Halliburton NUS personnel. The chain-of-custody (COC) also serves as a sample logging mechanism for the laboratory. Section 5.3 of Halliburton NUS SOP SA-6.1, contained in Appendix C, provides a description of the COC procedures that will be followed. An example of the COC record form is included in Appendix C.

Samples will be packaged and shipped in accordance with Standard Operating Procedure SA-6.2, contained in Appendix C. The field operations leader will be responsible for contacting the laboratory for notification of shipment and will report the following:

- Site name/code;
- Number(s), matrix, and concentration(s) of samples shipped;
- Method of shipment (e.g., hand delivered, overnight carrier);
- Date of shipment; and
- Suspected hazards associated with the samples or site.

4.5 SAMPLING FORMS

4.5.1 Sample Labels

One label will be filled out for each sample container sent for onsite and fixed base laboratory analysis. The sample label is a 2-inch by 4-inch white label with black lettering and an adhesive backing. These labels are required on every sample. The sample label description and procedures for completion are found in Halliburton NUS SOP SA-6.1 Section 5.2 (see Appendix C).

4.5.2 Chain-of-Custody Record

The Chain-of-Custody Record Form accompanies a sample (or group of samples) as it is transferred from person to person. This form must be used for any sample collected for chemical or geotechnical analysis, whether on site or off site. An example of the Chain-of-Custody Record Form is included in Appendix B. Procedures for using this form are contained in SOP SA-6.1 (see Appendix C). At the completion of field activities the Chain-of-Custody Record Form will be placed in the project file.

4.5.3 Custody Seal

The Custody Seal is a 1-inch by 3-inch adhesive backed label. It is part of a Chain-of-Custody process and is used to prevent tampering with samples after they have been collected in the field. It is used whenever samples are shipped to an offsite laboratory with an accompanying Chain-of-Custody Record Form. Procedures for using Chain-of-Custody seals are described in SOP SA-6.1 (see Appendix C).

4.5.4 Sample Logsheet and Logbook

A sample logsheet will be filled out for each sample collected during the field investigation. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems encountered during sampling. Sample information such as container source and description, sample description type, and disposition, as well as time, date and sample method are recorded on this form. All QA samples (duplicates, rinsates, trip blanks and field blanks) will have separate sample log sheets listing sample date and time, sample location and any other important sample data. Appendix B contains an example of a sample logsheet for various sample media. The sample logsheets are sequentially numbered when placed in the sample logbook, and the sample number and logsheet page numbers are recorded in the sample logbook table of contents (placed at the front of the logbook) for easy reference and access. At the completion of field activities the sample logbook containing all sample logsheets will be placed in the project file.

4.5.5 Equipment Calibration Log Form

Each Halliburton NUS field instrument requiring calibration will have a separate equipment calibration log form (see Appendix B) which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. The information placed on the form documents the accuracy, precision or sensitivity of the measurement, and, if necessary, will be used to determine if correction should be applied to the readings. A separate form will be established and maintained for the field instruments used during this sampling activity. Field monitoring and measuring equipment will be calibrated daily (at a minimum) and as needed if calibration problems with the instruments are noted. All forms will be maintained in a secured central file. At the completion of field activities the notebook containing the forms will be placed in the project file.

5.0 SITE 2 - APPLE ORCHARD LANDFILL

5.1 SITE DESCRIPTION

The Apple Orchard Landfill is an abandoned landfill located on the south side of Perimeter Road. The landfill is situated on a small hill at an elevation of approximately 340 feet mean sea level. A small unnamed stream is located adjacent to the west side of the site. The landfill is approximately 4.5 acres in size. Figure 5-1 show the major features of Site 2.

5.1.1 Past Disposal History

The Apple Orchard Landfill was operated as an open disposal area and landfill from 1948 until 1982. The landfill is a single unit that is composed of several disposal areas. In addition to domestic refuse, wastes reportedly disposed of consisted of oils containing polychlorinated biphenyls (PCBs), solvents, paint residue, acids and miscellaneous compounds. An estimated 500 gallons of PCB-contaminated oils were deposited at the site prior to 1970.

5.1.2 Site Geology/Hydrogeology

The Apple Orchard Landfill is underlain by two geologic units. The uppermost unit is the Upland Sand and Gravel and ranges in thickness from 4 feet to 10 feet, as determined during the installation of one groundwater monitoring well. The Upland Sand and Gravel unit at this site consists of a brownish-gray silt to a silty sand with a trace of gravel.

The shallow groundwater flow at the site is influenced by an unnamed tributary of Paint Branch Creek. Groundwater is present in the saprolite, the bedrock and to a minor extent in the Upland Sand and Gravel unit. Depth to the top of the water table measured in 1991 ranged from 6.40 feet to 19.39 feet as measured from the top of the PVC well casings. Groundwater flow underlying the site is toward the east-southeast in the direction of the intermittent stream. The groundwater underlying the site discharges into the intermittent stream. The transmissivity of the water table aquifer at Site 2 is approximately 26.04 ft^2/d (0.028 cm^2/sec). Based on slug test results, the velocity of the groundwater flow is estimated to be 0.02 ft/d (7.00×10^{-6} cm/sec) with and effective porosity of 26 percent.

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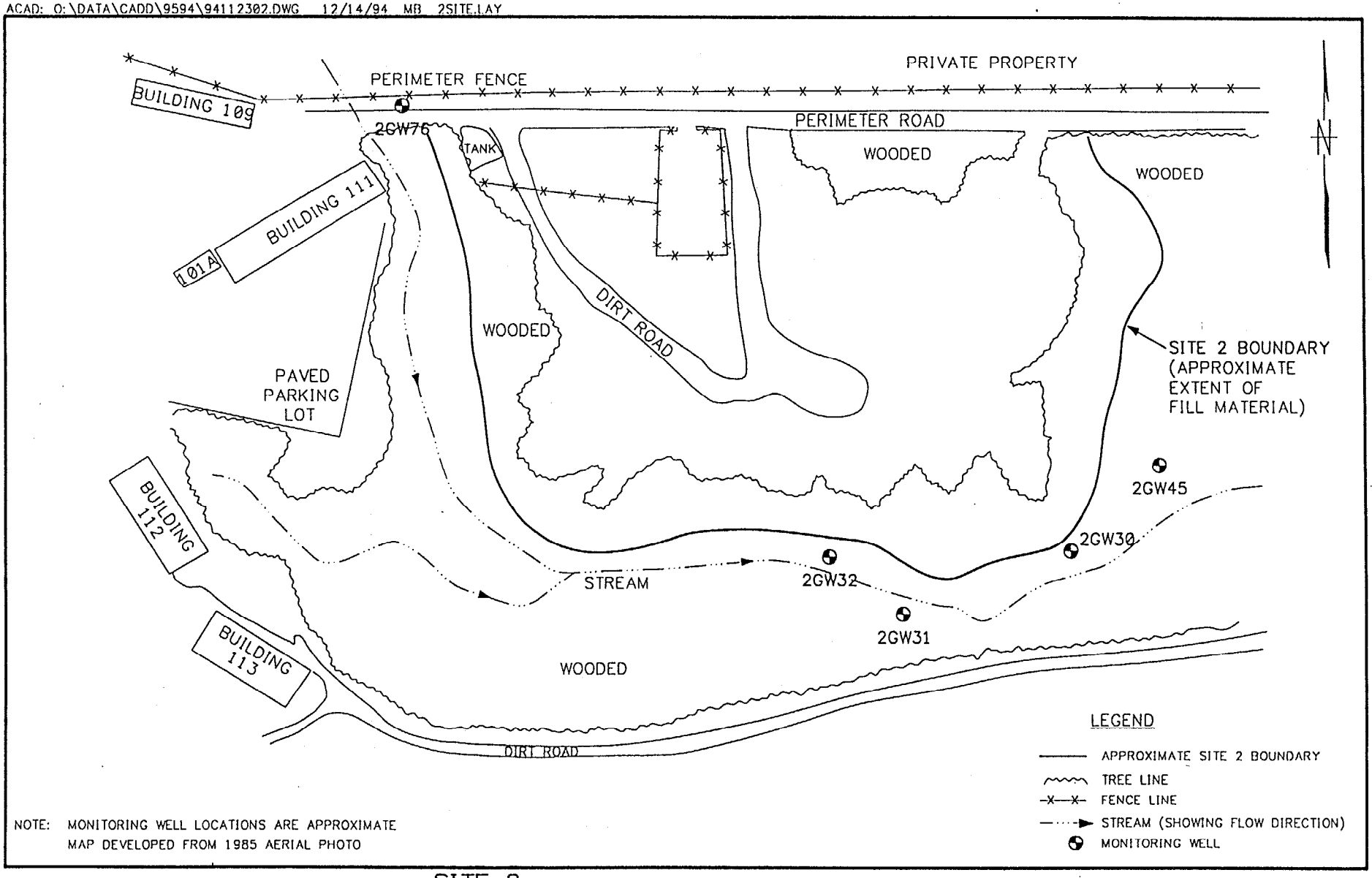

SITE 2
APPLE ORCHARD LANDFILL
NSWC WHITE OAK

0 125 250
APPROXIMATE SCALE IN FEET

FIGURE 5-1

Halliburton NUS CORPORATION

5.2 PREVIOUS INVESTIGATIONS

The rationale and purpose for the previous investigations conducted at the Apple Orchard Landfill have been discussed previously in Section 1.3. The earliest site investigation consisted of the Initial Assessment Study (IAS), which did not involve any intrusive investigations or field sampling. However, subsequent studies have included the following onsite investigative work:

Confirmation Study/Verification Phase - Involved the placement of 3 groundwater monitoring wells, collection of 10 sediment samples, collection of 4 surface water samples and the completion of a site GPR geophysical survey that was inconclusive. The analytical data suggested that the landfill leachate was migrating into the shallow groundwater, which was then discharging into the adjacent stream. TOC and TOX levels were elevated in the groundwater downgradient of the landfill, and low levels of PCBs, metals and VOCs were detected in the stream sediment.

Remedial Investigation (Phase I) - During the Phase I RI, samples were collected from six surface water and ten sediment locations within the small stream that passes to the south of the landfill. PCBs were detected above the RCRA Corrective Action level in the sediments. The concentrations indicate a progressive decrease in concentration in the downstream direction, and may suggest a possible contribution of PCB contaminants from an offsite source. The levels of metals in the sediment and surface water at the site were within the range of background conditions for NSWCWODET.

In addition two surface soil samples were collected to determine the chemical concentrations in the soil at Site 2. Metals (chromium, copper, lead and zinc), PCBs, VOCs and semivolatiles were detected in the surface soils. The semivolatiles consisted primarily of anthracene, fluoranthene, naphthlyene, phthalate and pyrene species.

A soil gas survey was also conducted to document volatile organic concentrations and potential contaminant migration through the vadose zone. The results of the soil gas survey indicated the presence of VOCs in the soil vapor near Building 111 and to the east of the landfill near Perimeter Road.

One groundwater monitoring well was placed during the Phase I, RI and sampled along with the three wells installed previously. During the well installation, split spoon samples were collected to characterize the subsurface lithology. Cadmium, mercury and TCE were detected in the groundwater and are believed to be the contaminants of greatest concern with the groundwater at the site.

Remedial Investigation (Phase II) - As with the Phase I RI, the Phase II RI included sample collection from six surface water and ten sediment locations within the small stream that passes to the south of the landfill. The results of this sampling were similar to those obtained during the Phase I investigation. PCB levels in the stream sediment exceeded the RCRA Corrective Action level of 0.009 mg/kg.

A 14 point sampling grid was also established to collect surficial soil samples. Additional soil samples (three samples) were also collected within the grid, beyond the landfill boundary (nine samples), and from three borings located beyond the landfill boundary (nine samples). These samples were collected to predict contaminant movement through the vadose zone and to quantify chemical contamination in the surface soils. As with the Phase I sampling, PCBs were found in the site soils above the RCRA Corrective Action level. Metals (copper, lead and zinc), PCBs and VOCs (acetone and methylene chloride) were detected in the subsurface soil at the site.

During Phase II of the RI, a fifth groundwater monitoring well was installed and all five wells present at the site were sampled. During the well installation, split spoon samples were collected to characterize the subsurface lithology. Elevated levels of metals, mercury and TCE were found in the groundwater.

Ecological investigations were also conducted during Phase II to assess conditions on site. Included in the investigation were terrestrial vegetation, mammal, fish, and benthic invertebrate surveys.

5.3 PROPOSED DESIGN VERIFICATION FIELD ACTIVITIES

Field activities to be conducted at Site 2 during the design verification activities include sampling of soil and sediment to determine the extent of site PCB contamination above proposed site action levels. In addition, an EM survey of the landfill will be conducted to identify the location of subsurface metallic objects. Test trenches will be excavated to define the extent of the fill material. Water level elevations at existing site wells will be measured and a refined map site will be constructed.

5.3.1 EM Survey

A regularly space grid will be measured out across the sides of the landfill from the beginning of the break in slope of the landfill to the stream. The EM survey will be extended as necessary along the toe of the landfill until the edge of the fill is determined. The edge of the landfill near the Perimeter Road will also be included in the survey grid. Figure 5-2 shows the area that will be surveyed. This area will be surveyed using a Geonics EM-61 conductivity meter or Navy approved equivalent. This instrument will provide continuous readings of the soil conductivity to a depth of approximately 20 ft and should detect the location

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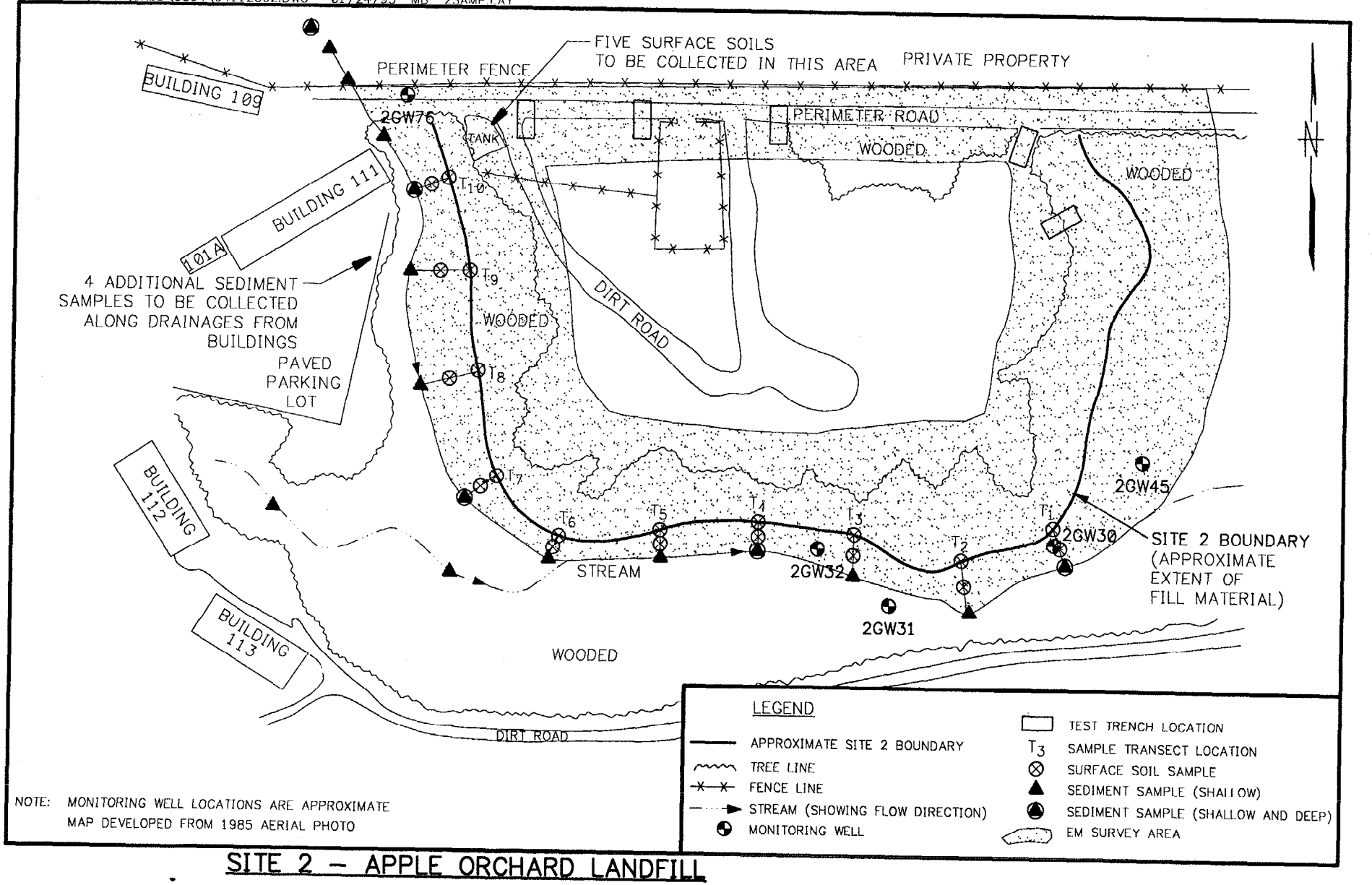

SITE 2 – APPLE ORCHARD LANDFILL
SAMPLING LOCATIONS
NSWC WHITE OAK

0 125 250
APPROXIMATE SCALE IN FEET

FIGURE 5–2

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of the any buried metallic objects such as scrap metal, drums or bomb shapes. Following the completion of the EM survey, the results will be used to delineate the landfill boundary and to finalize the locations of test trenches.

5.3.2 Surface Soil Samples

Soil samples will be collected along the toe of the landfill to determine the extent of PCB contamination in surface soil near the base of the landfill. The extent of soil contamination (above action levels) along the edge of the landfill has not been determined during previous investigations. Approximately 25 surface soil samples will be collected from Site 2. The location of sampling transects are illustrated on Figure 5-2. Sampling transects will be set up beginning in the vicinity of existing well 2GW30. Each sampling transect will extend from the edge of the landfill slope to the stream bed. At each sample transect two samples will be taken between the edge of the landfill and the stream bed. One sample will be collected immediately below the break in slope at the interface of fill and natural material. The second sample along each transect will be collected half way between this first sample and the stream bed. Sampling transects will be spaced every 80 feet along the base of the landfill.

Previous soil sampling results indicate that PCBs are present near the southern edge of the landfill and along the northwest corner of the landfill. Surface soil samples will be collected in the vicinity of the former location of a waste oil storage tank that may have been present at the northwest corner of the landfill. Sampling will continue until the extent of PCB contamination is determined. Surface soil samples will be collected from the top 0.5 ft of soil and will consist of a composite of 5 points within a 2 foot radius. Samples will be tested for PCBs using field screening kits to determine the extent of surface soil contamination. It is estimated that 5 soil samples will be taken in the vicinity of the former waste oil tank that may have been present. Additional soil sampling procedures are listed in Section 3.8.

5.3.3 Sediment Samples

Sediment samples will be collected along the stream located at the toe of the Apple Orchard Landfill. Samples will be collected to determine the extent of PCB contamination in the streambed which exceeds action levels. Previous sediment sampling results indicate that PCBs are present in the stream along at the northwest corner of the landfill and immediately downgradient of the landfill. The extent of sediment contamination upstream and downstream of the landfill has not been determined during previous investigations.

Approximately 25 sediment samples will be collected from the stream, beginning downstream of the landfill in the vicinity of monitoring well 2GW30. The location of sampling transects are illustrated on Figure 5-2. The results of previous sampling has indicated that stream sediment in this area does not contain PCBs above action levels. If the PCB concentration at the initial sampling location is not below action levels, samples will be collected downgradient until the edge of contamination is located. Sampling of the stream bed sediments will continue approximately every 80 feet along the stream, or as determined by the location of areas of sediment deposition in the stream bed. Sampling locations will include the drainage ditches which lead to maintenance buildings to the west of the landfill. Four samples will be collected from the stream bed upgradient of the landfill, across the Perimeter Road.

At each sampling location sediment will be collected from the top of the sediment layer (0 to 1.0 ft). Every third sample location will also include a sample from depth in the sediment column, at approximately 2 to 3 ft deep, if possible. If bedrock in encountered prior to the target depth of 2 to 3 feet, the sample will be taken as deep as possible. Approximately 25 samples will be collected for PCB analysis from the stream bed. Additional sampling may be required within and adjacent to the stream to better define areas of PCB contamination. This determination will be made in the field.

One in five sediment samples (5 samples total) will be collected and analyzed for total organic carbon (TOC). These samples will be used to calculate the average carbon content of the sediment which will be used to determine the action level for PCBs in the stream sediment. Samples collected for TOC will be analyzed at a fixed lab. These samples will also be analyzed for total volatile solids to evaluate the potential remediation of the sediment using the proposed evaporation unit.

Samples will be collected beginning with the downstream locations and will proceed in the upstream direction. The locations of all sampling locations will be marked with a wooden stake and surveyor's flagging. Samples will be tested for PCBs using field screening kits to determine the extent of sediment which exceeds the action level. Additional sediment sampling procedures are listed in Section 3.9.

5.3.4 Test Trenches

Test trenches will be excavated along the northern boundary of Site 2 to define the extent of fill material present in the landfill. In this area the location of the fill material is unknown, although it is believed to be near the Perimeter Road. A total of five test trenches will be excavated in locations shown on Figure 5-2. Trench locations will be evenly spaced along the landfill boundary approximately every 150 feet. Test trenches will be completed in areas which are not wooded and which allow for access of a backhoe.

Test trenches will be completed after the EM survey across the site. If metallic objects are detected near the Perimeter Road, these areas will be considered to be fill, and test trenches will not be necessary in that area. Each test trench will be started at the Perimeter Road and will continue inward towards the center of the landfill. The trench will be considered complete when the perimeter of fill material is determined. Visual observations will be made of the material in the sides of the trench and from materials removed from the excavation. All trenches will be photographed and a record made of the photos taken during the investigation. Test trenches may be left open overnight to allow for inspection by State or base personnel. If a trench is to remain open, it will be fenced off to prevent unauthorized access. At no time will the test trench be entered.

Materials removed from the test trench will be returned to the trench. The results of each PID/FID screening during excavation will be noted on the test pit excavation form. The excavation will be considered to be completed when the edge of the fill material and natural material is defined. All test trench locations will be marked with wooden stakes and surveyor's flagging to indicate the exact location of the trench and the trench number. Additional test trench procedures are detailed in Section 3.10.

5.3.5 Groundwater Elevations

One round of synoptic groundwater elevations will be measured at all 5 existing monitoring wells to determine groundwater flow directions in the vicinity of Site 2. In addition, groundwater elevations will be measured at the 20 monitoring wells located at Site 11 during the same time period. Water levels will be collected from all wells during a 4 hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Additional groundwater elevation measuring procedures are detailed in Section 3.4.

5.3.6 Site Mapping

Review of available information indicates that site drawings may not include all important site features. After sampling activities are completed at the site, a general evaluation of the site will be made to compare the existing site-specific drawings with the observed features. A determination will then be made regarding the need for additional site mapping information. All important site features such as the locations of power lines, fence lines, soil sampling locations, sediment sampling locations, EM survey grid locations and utilities will be included on the site map. In addition, any anomalies detected during the EM survey will also be included. Additional site mapping procedures are detailed in Section 3.12.

6.0 SITE 3 - PISTOL RANGE LANDFILL

6.1 SITE DESCRIPTION

The Pistol Range Landfill is located directly north of Dahlgren Road, adjacent to the northeast facility boundary. A small unnamed stream located adjacent to the western edge of the site flows southward past the site. The landfill is approximately 1.1 acres in size. Figure 6-1 shows the major features of Site 3.

6.1.1 Past Disposal History

The Pistol Range Landfill was operated as a landfill from the late 1940s until the mid-1970s. Fill materials were pushed into a gully adjacent to the site that was formed by a small perennial tributary to Paint Branch Creek. Wastes reportedly disposed in the landfill include solid wastes, ordnance cases, solvents, oils possibly containing PCBs, sodium nitrate, and miscellaneous metallic objects. An estimated 8,000 gallons of solvents and oils were reportedly disposed of at the site during a 30 year period.

6.1.2 Site Geology/Hydrogeology

Two geologic units are present at the Pistol Range Landfill. The sand facies of the Potomac Group occurs at the surface and continues to a depth of approximately 6 to 8 feet below ground surface. It consists of a brown to light-brown silty sand with quartz pebbles and cobbles. Underlying the Potomac Group is the saprolite member and the fractured gneiss of the Wissahickon Formation. The saprolite thickness ranged from 4 to 7 feet across the site.

Rock cores collected during previous field work at the site contain slight to moderate fracturing. Several of the fractures were clay filled which indicates that some groundwater seeps along the fracture zones. A water bearing zone was encountered in a fracture zone in a well approximately 65 feet below ground surface.

Groundwater flow at the Pistol Range Landfill is similar to that described for the Apple Orchard Landfill. Groundwater flow direction at the site is generally to the west (towards the unnamed tributary) and to the south in the general direction of the surface water flow of the unnamed tributary. Graphical analyses indicate that the groundwater gradient ranges from 1.8 to 5 percent with a geometric mean of 3.5 percent. The estimated groundwater velocity beneath the site is 0.02 ft/day (6.2×10^{-6} cm/sec), based upon the

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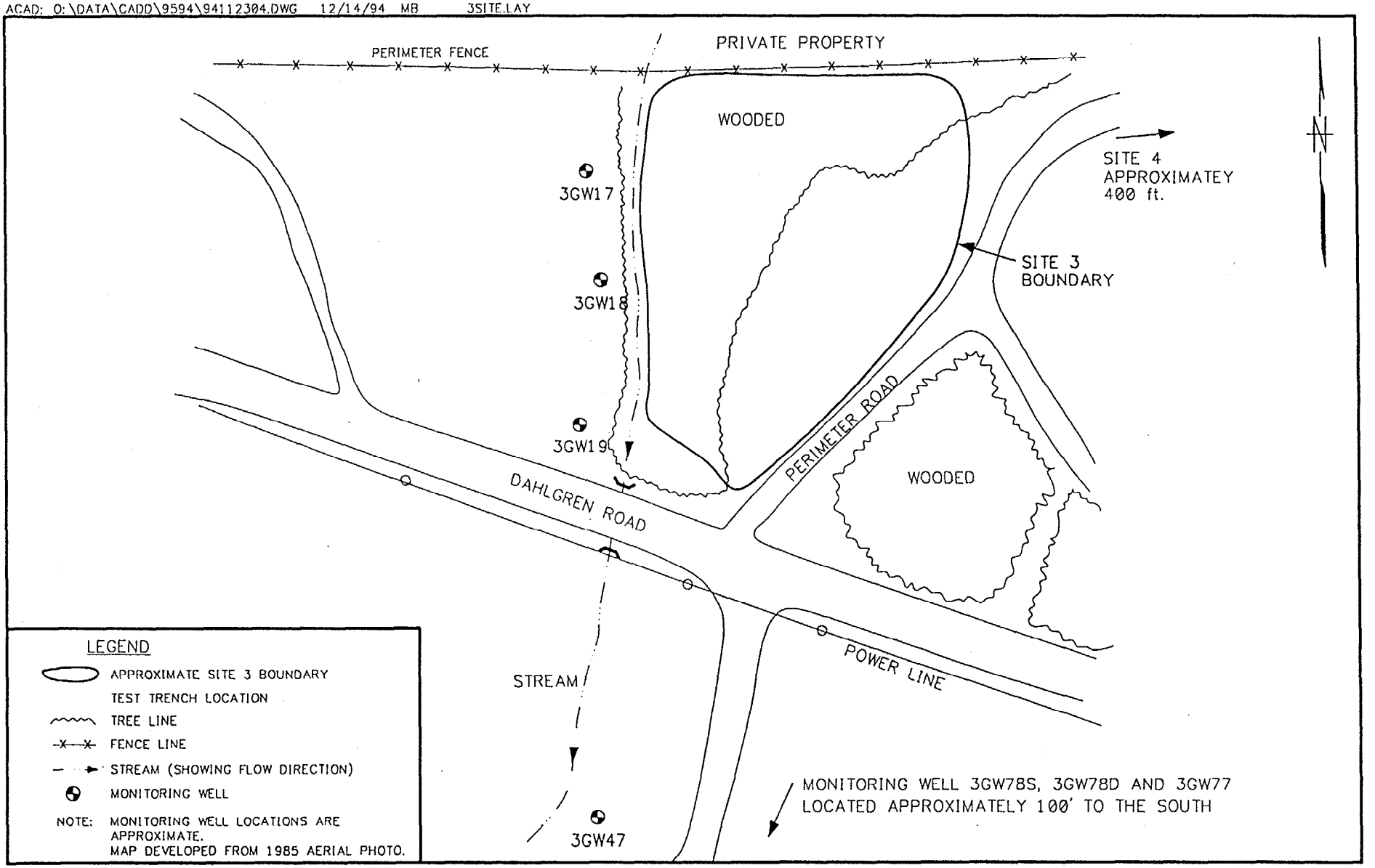

SITE 3
PISTOL RANGE LANDFILL
NSWC WHITE OAK

0 90 180
APPROXIMATE SCALE IN FEET

FIGURE 6-1

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results of multi-well pump test analyses conducted on similar stratigraphic units adjacent to the site. Based on 1991 water level data, the saturated thickness of the water table aquifer within the saprolite unit is approximately 20 feet.

The potentiometric surface of the groundwater confined in the fractured bedrock underlying the site is comparable to the elevation of the nearby perennial stream flowing on the saprolite and fractured bedrock. Groundwater flow from fractured bedrock probably supports the stream since the thin veneer of overlying unconsolidated Coastal Plain sediments and regolith probably would not be sufficient to supply adequate groundwater to the stream.

6.2 PREVIOUS INVESTIGATIONS

The rationale and purpose for the previous investigations conducted at the Pistol Range Landfill have been discussed previously in Section 1.3. The earliest site investigation consisted of the Initial Assessment Study (IAS), which did not involve any intrusive investigations or field sampling. However, subsequent studies have included the following onsite investigative work:

Confirmation Study/Verification Phase - During the Verification Phase of the Confirmation Study, three groundwater monitoring wells, three surface water and six stream sediment sampling locations were sampled. The analytical data gathered during this investigation suggested that leachate from the landfill was migrating from the landfill to the shallow groundwater. However, the results of this sampling did not conclusively indicate that leachate from the landfill was discharging into the stream. Slight VOC and metals contamination was found in the shallow groundwater. Sampling of groundwater and surface water indicated low levels of TOX and TOC were present.

Remedial Investigation (Phase I) - During the Phase I RI, surface water and stream sediment were sampled at four locations from the stream that passes to the west of the landfill. Little impact on the stream quality was observed through the surface water and sediment sampling. Low levels of metals were found in the stream both upgradient and downgradient of the landfill.

A vadose zone investigation was conducted which included the collection of two surficial soil samples and a soil gas survey of the soil adjacent to the landfill. A soil gas survey sampling grid was also established west and south of the landfill to measure the release of gaseous volatile organic contamination through the soil. The results of the soil gas survey indicated the presence of VOCs in the soils with the highest concentrations along the landfill side of the stream and in the area south of Dahlgren Road. The results of

the surficial soil sampling confirmed the presence of metals contamination along the face of the landfill. Semivolatile organic compounds were identified in the surface soil during the Phase I investigation.

During Phase I, one groundwater monitoring well was installed and the four wells at the site were sampled. During the well installation, split spoon samples were collected to characterize the subsurface lithology. The groundwater analytical results confirmed the presence of VOCs and metals.

Remedial Investigation (Phase II) - During Phase II of the RI, sediment samples were collected from the same locations as during Phase I, however no surface water samples were collected. Two additional surface soil samples were also collected. The semivolatile contamination found during the Phase I investigation was not detected during Phase II.

During Phase II, three additional wells were installed and samples were collected from all seven wells at the site. During the well installation, split spoon samples were collected to characterize the subsurface lithology. Methylene chloride, 1,2-dichloroethene, TCA, and chlorobenzene were found in the groundwater above the MCL during Phase II. The metals found in unfiltered samples above the MCLs during Phase II included, cadmium, chromium and lead.

Ecological investigations were also conducted during Phase II to assess conditions on site. Included in the investigation were terrestrial vegetation, mammal, fish, and benthic invertebrate surveys.

6.3 PROPOSED DESIGN VERIFICATION FIELD ACTIVITIES

Design Verification Field activities at the Pistol Range Landfill will include conducting and EM survey across the surface of the landfill to detect any buried metallic objects in the subsurface. Five test trenches will be excavated to determine the perimeter of the landfill material. In addition, water levels will be measured at all wells in the vicinity of the site and a refined site map will be constructed.

6.3.1 EM Survey

A regularly space gird will be measured out across the top of the landfill from the location of the former pistol range to the beginning of the break in slope of the landfill and extending to the east past the Perimeter Road. The EM survey will be conducted along the flat portion of the top of the landfill from the Perimeter Road to the tree line. Figure 6-2 shows the area that will be surveyed. This area will be surveyed using a Geonics EM-61 conductivity meter or Navy approved equivalent. This instrument will provide continuous readings of the soil conductivity to a depth of approximately 20 ft and should detect the location of the any

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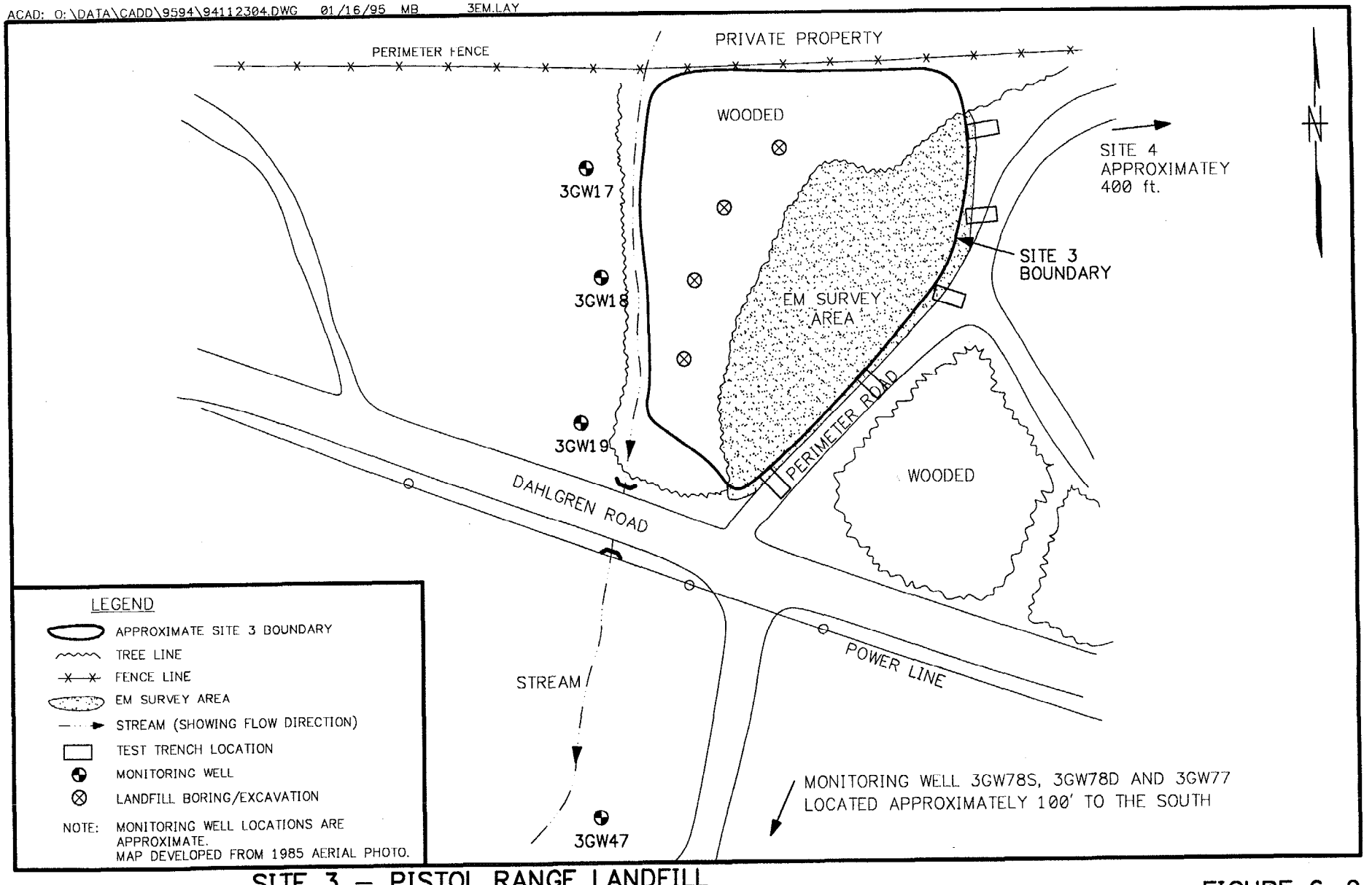

SITE 3 – PISTOL RANGE LANDFILL
EM SURVEY LOCATION
NSWC WHITE OAK

0 90 180
APPROXIMATE SCALE IN FEET

FIGURE 6–2

Halliburton NUS CORPORATION

buried metallic objects such as scrap metal, drums or bomb shapes. Due to the size of the EM equipment, the steeply sloping sides of the landfill, between the tree line and the stream, cannot be surveyed. Following the completion of the EM survey, the results will be used to delineate the landfill boundary and to finalize the locations of test trenches. Additional EM Survey Procedures are detailed in Section 3.3.

6.3.2 Test Trenches

Test trenches will be excavated along the eastern boundary of Site 3 to define the extent of fill material present in the landfill. In this area the location of the fill material is unknown, although it is believed to be near the Perimeter Road. A total of five test trenches will be excavated in locations shown on Figure 6-2. Trench locations will be evenly spaced along the landfill boundary approximately every 180 feet. Test trenches will be completed in areas which are not wooded and which allow for access of a backhoe.

Test trenches will be completed after the EM survey across the site. If metallic objects are detected near the Perimeter Road, these areas will be considered to be fill, and test trenches will not be necessary in that area. Each test trench will be started a the Perimeter Road and will continue inward towards the center of the landfill. The trench will be considered complete when the perimeter of fill material is determined. Visual observations will be made of the material in the sides of the trench and from materials removed from the excavation. Additional test trenches will be excavated, if necessary, to define the extent of the landfill. Test trenches will be approximately 6 to 10 feet deep. At no time will the trench be entered.

Materials removed from the test trench will be returned to the trench. The contents of each backhoe bucket will be scanned with a PID/FID after being placed on the sheeting to determine if any volatile organic compounds are present in the soil. The results of each screening will be noted on the test pit excavation form. The excavation will be considered to be completed when the edge of the fill material and natural material is defined. All test trench locations will be marked with wooden stakes and surveyor's flagging to indicate the exact location of the trench and the trench number. All trenches will be photographed and a record made of the photos taken during the investigation. Test trenches may be left open overnight to allow for inspection by regulators. If a trench is to remain open, it will be fenced or barricaded to prevent unauthorized access. Additional test trench procedures are detailed in Section 3.10.

6.3.3 Groundwater Elevations

One round of synoptic groundwater elevations will be measured at all seven existing monitoring wells to determine groundwater flow directions in the vicinity of Site 3. In addition, groundwater elevations will be measured at the 18 monitoring wells located at Site 4 and the 14 monitoring wells at Site 9 during the same

time period. Water levels will be collected from all wells during a 6 hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Additional groundwater elevation measuring procedures are detailed in Section 3.4.

6.3.4 Site Mapping

Review of available information indicates that site drawings may not include all important site features. After sampling activities are completed at the site, a general evaluation of the site will be made to compare the existing site-specific drawings with the observed site features. A determination will then be made regarding the need for additional site mapping. All important site features such as the locations of power lines, fence lines, EM survey grid locations and utilities will be included on the site map. In addition, any anomalies detected during the EM survey will also be included on the site map. Additional site mapping procedures are detailed in Section 3.13.

6.3.5 Landfill Borings

In order to identify the location and depth of waste disposed at the site, four borings will be advanced manually along the face of the landfill. The borings will be used to identify the depth to the soil/waste interface beneath the landfill slope in order to better define landfill capping options. The borings will be advanced manually adhering to safety requirements for UXO sites (refer to HASP, Appendix A). Due to the steepness of the landfill face, and the potential presence of UXO, metal scrap and bulking waste materials, the anticipated depth of each boring is three feet (measured at an angle normal to the landfill face). During boring placement, the soil and waste characteristics will be noted for the entire boring depth. No soil or waste samples will be collected during the landfill boring operation.

7.0 SITE 4 - CHEMICAL BURIAL SITE

7.1 SITE DESCRIPTION

The Chemical Burial Site is located south of Perimeter Road and is 400 yards northeast of the Pistol Range Landfill. The overall area of the site is approximately 1.1 acres (including the four reported disposal sites). Figure 7-1 identifies potential disposal areas. Past investigations have identified two disposal areas within the northern most disposal site shown on Figure 7-1. Two distinct disposal sites may be present within the large suspected disposal trench area; however, only one large trench was suggested from the review of an aerial photograph of the site taken in 1985.

7.1.1 Past Disposal History

The site was reportedly used from the mid-1950s until the early 1970s for chemical disposal in four discrete locations within the site. Wastes reportedly disposed at this location included acids, explosive compounds, kerosene, chlorinated solvents and numerous unidentified laboratory compounds. The total estimated volume of chemicals disposed in the areas is estimated to be 400 cubic feet.

7.1.2 Site Geology/Hydrogeology

Three geologic units underlie the Chemical Burial Site. The unconsolidated Upland Sand and Gravel unit forms the uppermost unit and occurs at the surface and is underlain by the Potomac Group. Due to the similarity in lithology and sedimentary features, the contact between the two units is not well defined. The unconsolidated sediments range in thickness from 45 to 65 feet. Within the unconsolidated sediments, a thin (1.0 to 1.75 feet) tan to buff clayey silt to silty clay member of the Potomac Group was observed at the site. The silty clay seam dips to the south, and in at least one location grades into a very thin (0.1 to 0.4 feet) silty seams.

Underlying the unconsolidated sediments is the saprolite member of the Wissahickon Formation. From the results of the previous investigations, it appears that the surface bedrock and the saprolite unit dips steeply to the east at this area. The weathered gneiss was encountered in only one boring at the site, at a depth of 65 feet.

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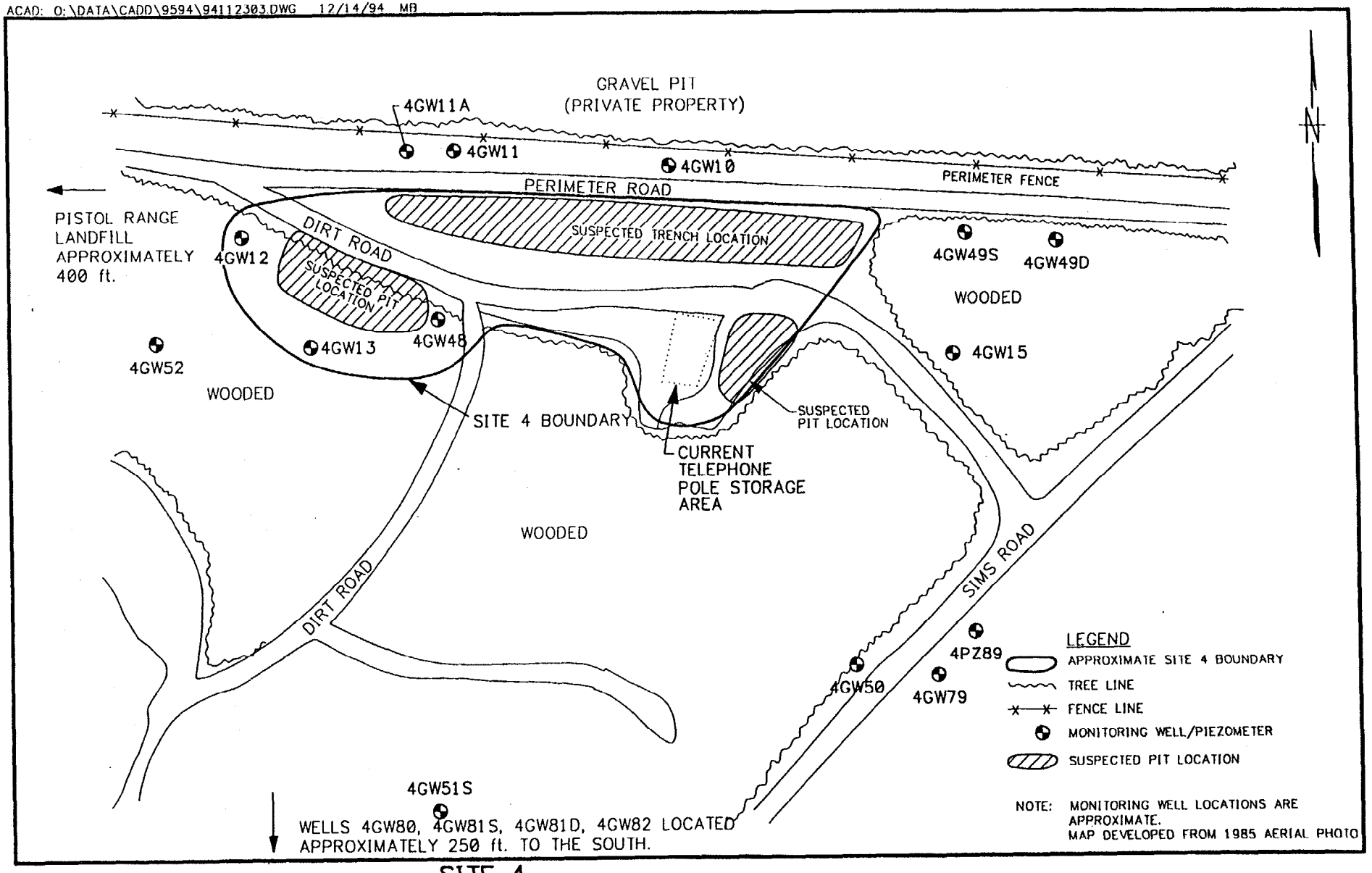

SITE 4
CHEMICAL BURIAL AREA
NSWC WHITE OAK

0 80 160
APPROXIMATE SCALE IN FEET

FIGURE 7-1

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Groundwater at this site occurs under unconfined conditions in the unconsolidated sediment-regolith unit and the very uppermost portion of the saprolite. The saprolite in this area is an aquitard which restricts groundwater movement from the water table aquifer downward into the underlying competent bedrock. Depth to the water table measured from the top of the monitoring wells ranged from 28.14 to 58.10 feet. The average saturated thickness of the water table aquifer was measured to be 21 feet.

Graphical analysis of the water level data collected from monitoring wells screened in the unconsolidated sediment indicate that groundwater flow is to the south southeast. A groundwater divide exists along the western portion of the site where groundwater flow is to an unnamed stream in the west. Groundwater flow at the base of the aquifer may be diverted and channeled in a different direction due to changes in surface elevations of the top of bedrock and saprolite. The geometric mean of the groundwater gradient was measured to be 1.4 percent.

Silty clay to clayey silt layers, 0.5 to 1.0 feet thick, approximately 20 to 25 feet below ground surface appears to influence the downward percolation of groundwater beneath the site. Sediments overlying this layer are found to be either moist to wet or saturated, while sediments directly under this layer were dry. The low permeability clay seams appear to limit downward percolation of groundwater, forming a perched groundwater zone above these units. These seams can stratify vertical groundwater movement and influence horizontal groundwater flow and contaminate migration. The clay seam appears to be limited to the northern area beneath the site.

Slug tests were conducted at the site to estimate permeability. The results of the tests provided and estimate of 0.003 ft/day (9.4×10^{-4} cm/sec). Two constant rate pumping tests were also conducted at the site. Transmissivity (T) and Storativity were calculated from the results of these tests. A significant change was observed in the hydraulic characteristics of the aquifer based upon the pump test data. Values of T ranged between 47.06 and 10.32 ft^2/day (5.06×10^{-2} and 1.11×10^{-2} cm^2/sec). This variation is attributed to the variable nature of the sediments underlying the site. Storativity values ranged between 1.9×10^{-3} and 5.21×10^{-3}.

7.2 PREVIOUS INVESTIGATIONS

The rationale and purpose for the previous investigations conducted at the Chemical Burial Site have been discussed previously in Section 1.3. The earliest site investigation consisted of the Initial Assessment Study (IAS), which did not involve any intrusive investigations or field sampling. However, subsequent studies have included the following onsite investigative work:

Confirmation Study/Verification Phase - Six groundwater monitoring wells were installed and sampled during the Verification Phase of the Confirmation Study. The results indicated that the buried wastes were leaching organic compounds to the shallow groundwater. This was suggested by the TOC and TOX data for the shallow groundwater samples. Low levels of VOCs, oils and grease and metals were also found at the site.

Remedial Investigation (Phase I) - This investigation included the collection of six soil sample samples and a soil gas survey. No compounds were detected above background levels in the subsurface soils.

The soil gas survey was conducted to document VOC concentrations in the soil and to determine the movement of these compounds in the upper soil and vadose zone. The soil gas survey indicated the presence of VOCs in the site soils.

During Phase I, six groundwater monitoring wells were installed at the site. Two wells were installed as a well cluster, with one deep and one shallow well. Following installation all twelve wells at the site were sampled. During the well installation, split spoon samples were collected to characterize the subsurface lithology.

Remedial Investigation (Phase II) - A Ground Penetrating Radar (GPR) survey was conducted at the site during Phase II of the RI. The GPR was conducted to identify the four distinct burial areas at the site. In addition two surface soil samples were collected to measure the concentration of contaminants in the surface soil. The analytical results for the surficial soils indicate that elevated concentrations of VOCs and semivolatiles were present within the surface soils. VOCs detected included: methylene chloride, acetone, TCE, carbon disulfide, 1,1,-trichloroethane and m- and p-xylene. The only semivolatile identified above background was pyrene.

During Phase II, an additional six well groundwater monitoring wells were installed. Two wells were installed as a cluster, with one deep well and one shallow well. Groundwater samples from seventeen wells were then collected (one well installed for a constant rate pumping test was not sampled). Seven slug tests and two constant rate pumping tests were also conducted. During the well installation, split spoon samples were collected to characterize the subsurface lithology.

Ecological investigations were also conducted during Phase II to assess conditions on site. Included in the investigation were terrestrial vegetation and mammal surveys.

7.3 PROPOSED DESIGN VERIFICATION FIELD ACTIVITIES

In order to evaluate remedial alternatives for Site 4, the extent and levels of soil contamination present at the site must be defined. In addition, any drums or containers which may have been disposed of at the site must be located. To determine the location of buried drums or containers present in the waste pits at Site 4, an EM survey will be conducted across the site. The result of the EM survey will be used to determine the sampling locations at the site. Subsurface soils will be collected from hand auger borings to determine the levels of contamination present in the soil.

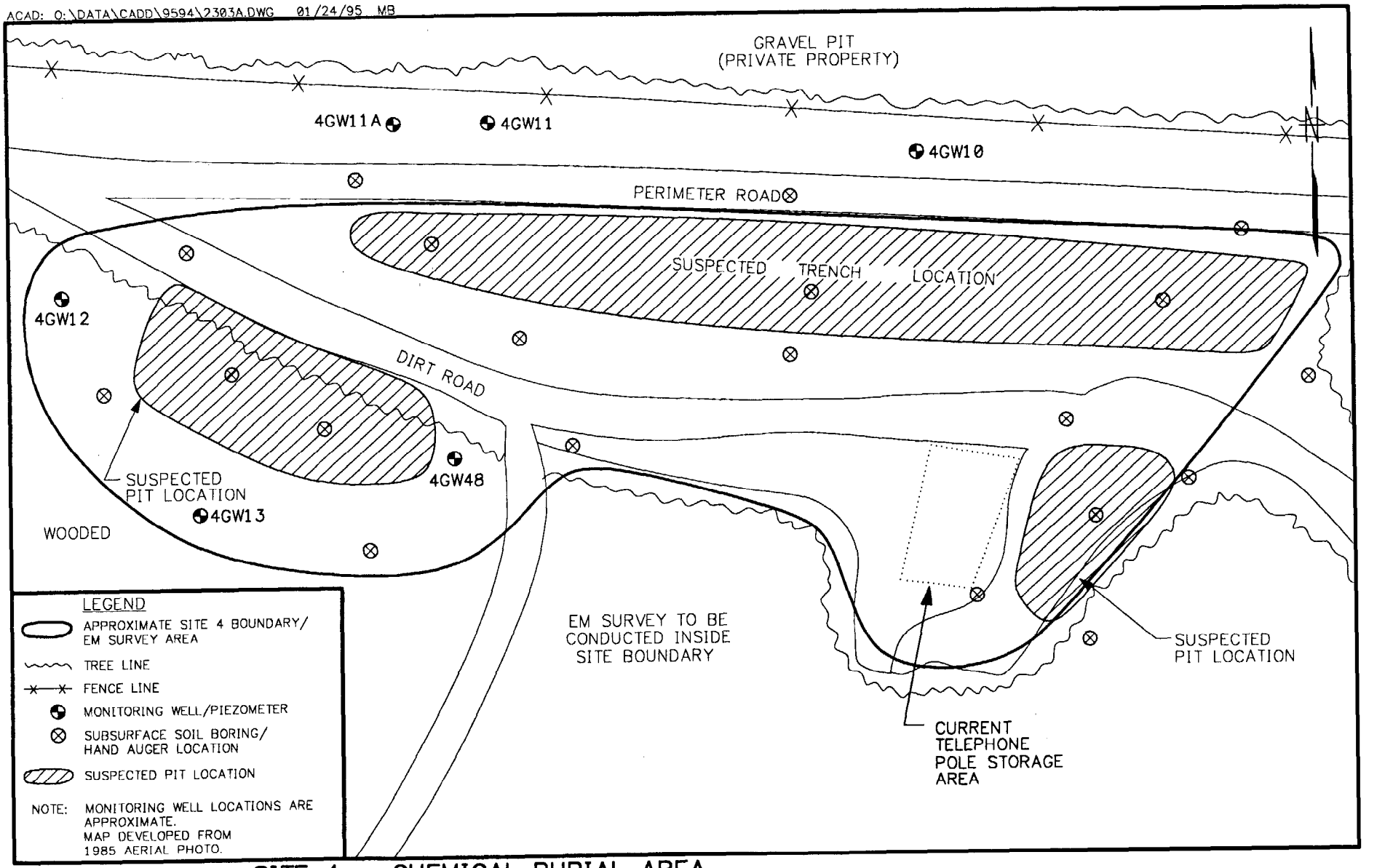
7.3.1 EM Survey

A regularly spaced grid will be measured out across the area which contains the waste disposal pits. The location of the EM survey area is shown on Figure 7-2. This area will be surveyed using a Geonics EM-61 conductivity meter or Navy approved equivalent. This instrument will provide continuous readings of the soil conductivity to a depth of approximately 20 ft and should detect the location of the any buried, metallic objects such as drums or containers. Following the completion of the EM survey, the results will be used to determine where hand auger borings will be completed to locate the extent of soil contamination.

7.3.2 Hand Auger Borings

Shallow subsurface soil samples will be collected from the interior of the waste pits using a hand auger. The extent of the waste pits will determined by the EM survey. To define the extent of contaminated soils samples will be taken from areas suspected to be outside the limits of contaminated soil, in natural material or in clean fill. In addition, samples will be collected at each pit from the area suspected to contain the waste material. A total of six hand auger borings will be taken at Site 4. One sample will be collected from each hand auger boring. Sample locations are shown on Figure 7-2.

The final sample locations will be determined in the field based on visual observations of the extent of the waste pits, EM survey results, and obvious signs of contamination. The use of a hand auger for collecting soil samples will minimize excavations at the site as well as minimizing disturbance of the wastes while providing subsurface soil contamination data. Hand auger borings will extend to 5 to 10 feet below ground surface. Borings will be used to visually identify the extent of fill material which has been placed in the waste pits. Fill will be identified based on lithology, color, knowledge of the waste disposed, and PID/FID readings. At each location soil characteristics will be described continuously during the soil boring.



SITE 4 – CHEMICAL BURIAL AREA
SAMPLING LOCATIONS
NSWC WHITE OAK

FIGURE 7-2

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7.3.3 Soil Borings

For purposes of characterizing soil contamination outside of the immediate area of the disposal pits, 14 soil borings will be placed at the site. The borings will be used to collect soil samples adjacent to the disposal area in order to better define the extent of contaminant migration into surrounding soils. Refer to Section 3.6 for additional information related to the soil borings. Refer to Figure 7-2 for the proposed locations of the soil borings. The number of soil borings may be altered during the implementation of the sampling plan, dependent upon the conditions observed during the field operations.

7.3.4 Subsurface Soil Samples

One sample will be collected from each auger boring location (20 samples total) based on obvious indications of contamination, such as stains or chemical odor, elevated PID/FID readings or presence of fill material. Samples will be analyzed for VOCs, SVOCs, explosives/TKN, metals and pH. Samples will be sent for 4-day laboratory analysis. Twelve soil samples will be tested for PCBs using field kits. Analytical results will be used to guide the selection of the additional soil sample locations, if needed. In this way, the lateral extent of the waste pits can be defined while the number of samples is minimized. Soil sampling procedures are detailed in Section 3.7.

A total of 5 percent of samples collected for chemical analysis by the onsite laboratory will be sent as duplicate samples to a fixed base laboratory. In addition to samples collected for chemical analysis, two subsurface soil samples will be collected for determination of geotechnical parameters, including soil class, grain size, moisture content, and pH. These samples will consist of site representative soils collected at sampling locations to be determined in the field.

7.3.5 Groundwater Elevations

One round of synoptic groundwater elevations will be measured at all existing monitoring wells to determine groundwater flow directions in the vicinity of Site 4. In addition, groundwater elevations will be measured at the seven monitoring wells located at Site 3 and the 14 monitoring wells at Site 9 during the same time period. Water levels will be collected from all wells during a 4 hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Additional groundwater elevation measuring procedures are detailed in Section 3.4.

7.3.6 Site Mapping

Review of available information indicates that site drawings may not include all important site features. After sampling activities are completed at the site, a general evaluation of the site will be made to compare the existing site-specific drawings with observed site features. A determination will then be made regarding the need for additional site mapping. All important site features such as the locations of power lines, fence lines, hand auger borings, EM survey grid locations and utilities will be included on the site map. In addition, any anomalies detected during the EM survey will also be included. Additional site mapping procedures are detailed in Section 3.13.

8.0 SITE 8 - ABANDONED CHEMICAL DISPOSAL PIT

8.1 SITE DESCRIPTION

The Abandoned Chemical Disposal Pit is located along the southern facility boundary, at the end of Perimeter Road. The site has been described as a pit 10-feet by 10-feet by 12-feet. The location of the site has been estimated based upon previous knowledge of the site activities and from the results of several subsurface studies. The major features of Site 8 are shown on Figure 8-1.

8.1.1 Past Disposal History

Site 8 was used from 1951 until 1971 for disposal of miscellaneous waste chemicals from laboratories at the NSWCWODET facility. Wastes disposed at this site included acids, mercury, solvents and numerous unidentified waste chemicals. The primary wastes of concern include solvents and mercury. It has been estimated that approximately 180 pounds of mercury were disposed at this location.

8.1.2 Site Geology/Hydrogeology

Two geologic units are present below the site. The upper unit is the Upland Sand and Gravel which ranges in thickness from 0 to 10 feet. This unit is underlain by the saprolite member of the Wissahickon Formation which was encountered approximately 5 to 10 feet below ground surface. Based onsite borehole data, the thickness of this unit ranges from 20 to 39 feet.

The groundwater flow direction was determined from graphical analysis of water levels in monitoring wells measured during previous studies. Flow direction was measured to be predominately to the north. However, due to the topography of the site, some radial flow may be present. To this date, conclusions regarding radial flow at the site cannot be confirmed due to a lack of groundwater data adjacent to the site. Groundwater underlying the site discharges north of the Site into an unnamed, intermittent tributary of Paint Branch Creek adjacent to the site's northern boundary. The unnamed, intermittent tributary also receives runoff from Site 11 (described in Section 9).

The graphical analysis of water level data at the site indicates that the water table gradient ranges from 2 to 4 percent with a geometric mean of 3 percent. Depth to groundwater ranged from 30.89 to 38.22 feet below the top of the well casing at the site, with the average saturated thickness of the water table aquifer measured at 20 feet.

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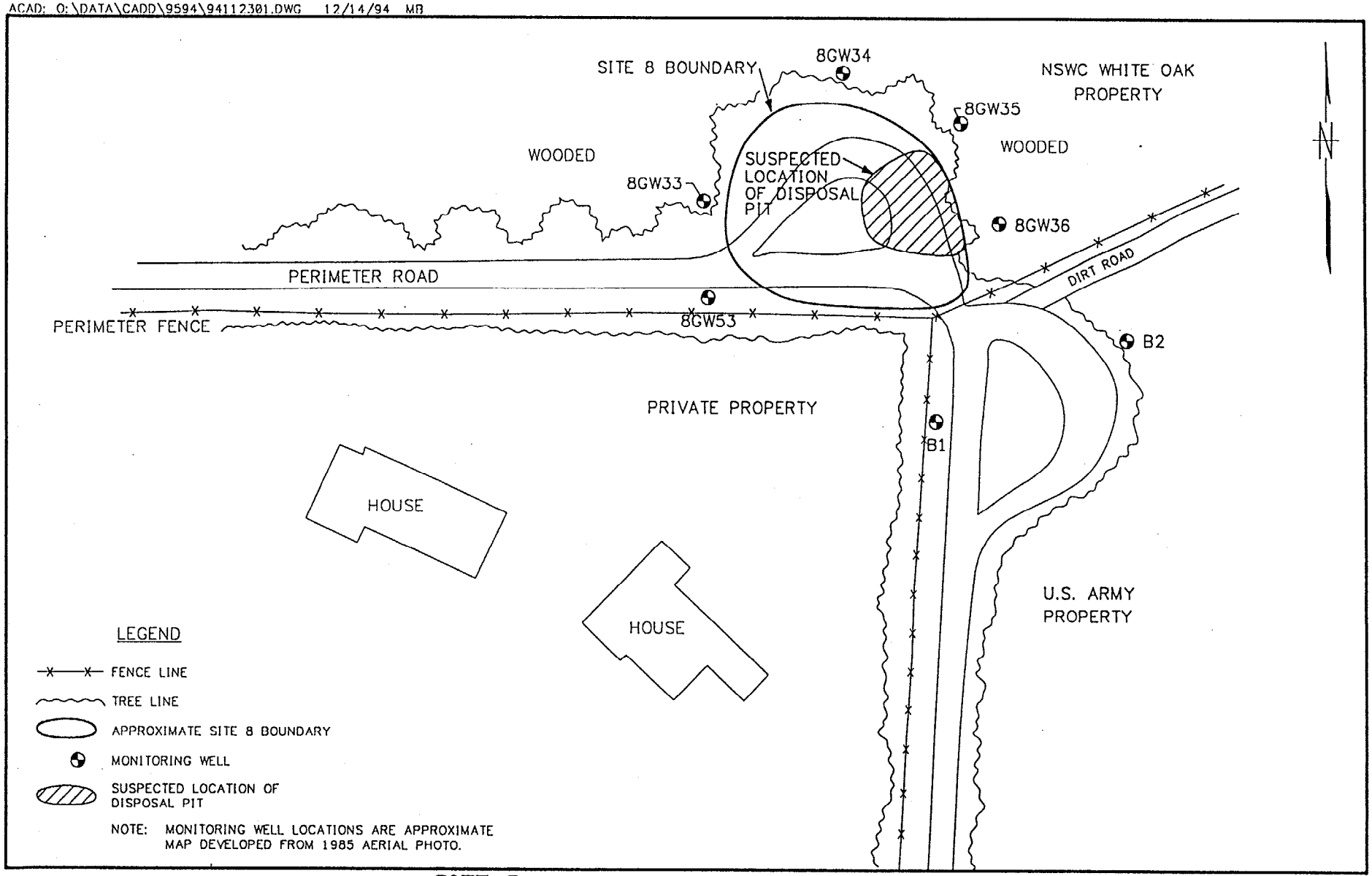

SITE 8
ABANDONED CHEMICAL DISPOSAL PIT
NSWC WHITE OAK

0 60 120
APPROXIMATE SCALE IN FEET

FIGURE 8-1

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Rising head aquifer slug tests were conducted at the site. The estimated hydraulic conductivity for the unconfined aquifer is 6.46 ft/day (2.28×10^{-3} cm/sec). The hydraulic conductivity for the saprolite unit, based onsite well pump test data has been calculated to be 0.13 ft/day (4.62×10^{-5} cm/sec). Groundwater velocity for the saprolite unit is estimated to be 0.13 ft/day (4.62×10^{-5} cm/sec). Transmissivity of the water table aquifer underlying Site 8 is approximately 26.04 ft^2/day (2.8 x 10-2 cm^2/sec). The velocity of groundwater flow is estimated to be 0.01 ft/day (4.78×10^{-6} cm/sec) with and assumed effective porosity of 26 percent.

8.2 PREVIOUS INVESTIGATIONS

The rationale and purpose for the previous investigations conducted at the Abandoned Disposal Pit have been discussed previously in Section 1.3. The earliest site investigation consisted of the Initial Assessment Study (IAS), which did not involve any intrusive investigations or field sampling. However, subsequent studies have included the following onsite investigative work:

Confirmation Study/Verification Phase - Four groundwater monitoring wells were installed and sampled during this investigation. In addition, a GPR geophysical survey was conducted in an attempt to locate the former underground disposal area although results were inconclusive. The analytical data collected during this investigation suggested that no mercury contamination in the groundwater existed. Some metal and VOC contamination was detected in the groundwater, but only in significant concentrations in one well. TOC, TOX and oil and grease results were relatively low.

Remedial Investigation (Phase I) - During Phase I, two surficial soil samples were collected and a GPR survey was conducted. The GPR survey was conducted to better define the location of the abandoned disposal pit. The sampling was performed in an attempt to measure chemical concentrations in the soil, determine the potential presence of buried drums and to assist in the prediction of contaminant movement.

The Phase I investigation also included the addition of one additional groundwater monitoring well. This well and the four previously installed wells were sampled during the Phase I RI. During the well installation, split spoon samples were collected to characterize the subsurface lithology.

Remedial Investigation (Phase II) - During Phase II of the RI, all five monitoring wells were sampled. In addition, single- and multiple-well tests were conducted to characterize the hydraulic characteristics of the water table aquifer.

Ecological investigations were also conducted during Phase II to assess conditions on site. Included in the investigation were terrestrial vegetation and mammal surveys.

In addition, the Army installed two monitoring wells on the opposite side of the perimeter fence, on the Adelphi Laboratory Property in 1994, both of which had reasonable levels of contaminants.

8.3 PROPOSED DESIGN VERIFICATION FIELD ACTIVITIES

An EM survey will be performed at the site to determine the location of buried metallic objects which may indicate the location of the former chemical disposal pit. In order to evaluate remedial alternatives for Site 8, the extent and the levels of soil contamination present at the site must be defined. Soil borings placed with a hand auger will be used to define the perimeter of the waste pit. Subsurface soil samples will be collected from soil borings to determine the levels of contamination present at the site.

8.3.1 EM Survey

A regularly space gird will be measured out across the area which may contain the abandoned chemical disposal pit. The EM survey will include the open area between the perimeter fence and the tree line, as shown on Figure 8-2. This area will be surveyed using a Geonics EM-61 conductivity meter or Navy approved equivalent. This instrument will provide continuous readings of the soil conductivity to a depth of approximately 20 ft and should detect the location of the any buried metallic objects such as drums or containers. Following the completion of the EM survey, the results will be used to determine the location where hand auger borings will be completed in order to define the extent of soil contamination.

8.3.2 Hand Auger Borings

A total of two hand auger borings will be taken from in the central portion of the abandoned chemical disposal pit to define the extent of the material deposited in the waste pit, without using intrusive sampling methods such as soil borings or trenches. Hand auger borings will be completed inside the pit (in potentially contaminated soil). Final sampling locations will be selected based on field conditions such as soil discoloration, stressed vegetation or the identification of obvious contamination and following review of the EM survey results. Material collected during the boring placement will be used to visually identify the extent of fill material placed in the disposal pit. Fill will be identified based on lithology, color, obvious waste material, and PID/FID readings. At each location soil characteristics will be described continuously during the soil boring.

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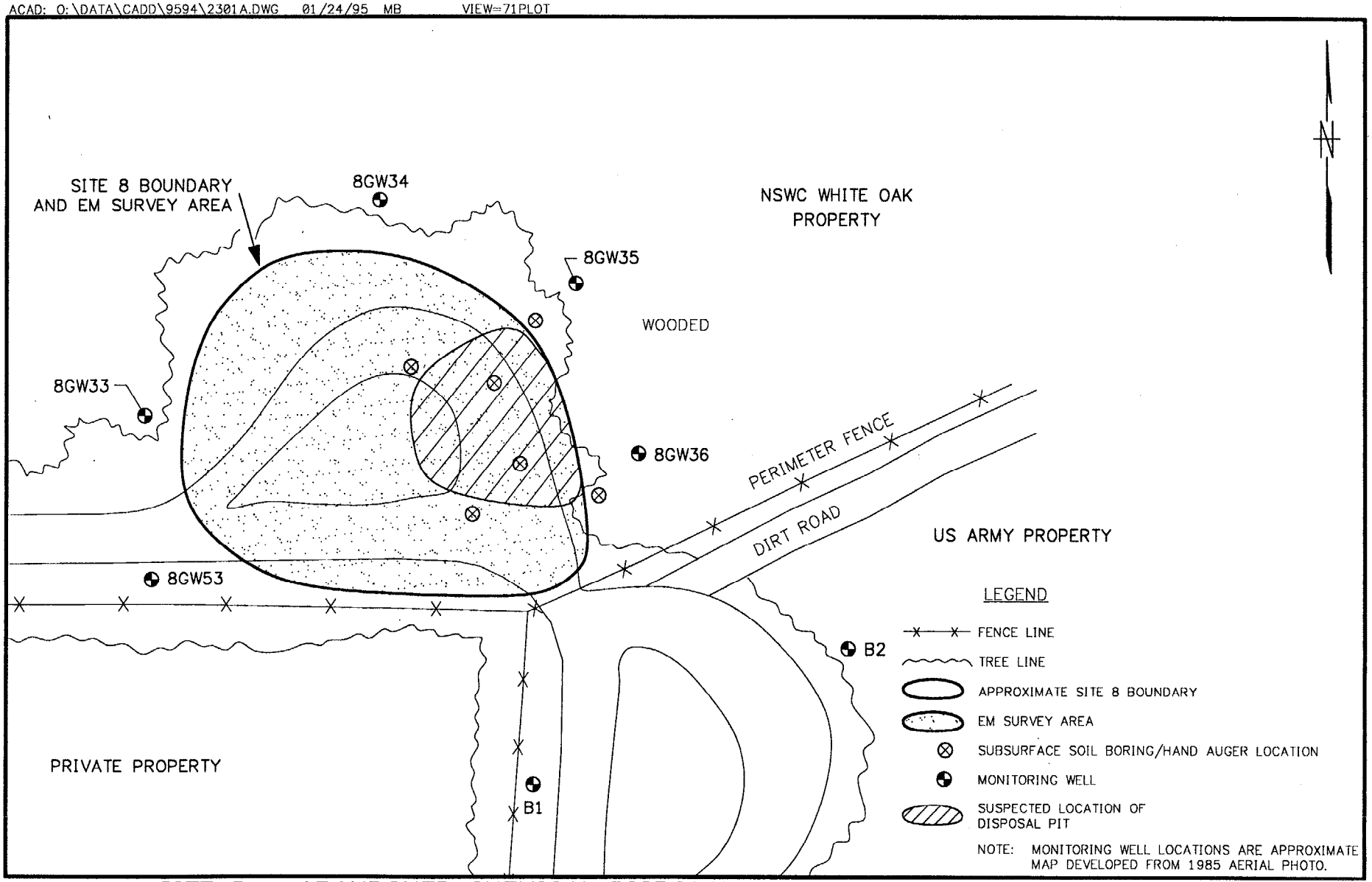

SITE 8 – ABANDONED CHEMICAL DISPOSAL PIT
SAMPLING LOCATIONS
NSWC WHITE OAK

FIGURE 8–2

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8.3.3 Soil Borings

For purposes of characterizing soil contamination outside of the immediate area of the disposal pit, four soil borings will be placed at the site. The borings will be used to collect soil samples adjacent to the disposal pit in order to better define the extent of contaminant migration into surrounding soils. Refer to Section 3.6 for additional information related to the soil borings. Refer to Figure 8-2 for the proposed locations of the soil borings. The number of soil borings may be altered during the implementation of the sampling plan, dependent upon the conditions observed during the field operations.

8.3.4 Soil Samples

Soil samples will be collected from each boring location to determine the perimeter of the abandoned chemical disposal pit. A total of six samples will be collected at the site. These samples will be used to determine the extent of soil contamination and to confirm the limits of the disposal pit identified in previous investigations. At each sampling location, one sample will be collected approximately 5 feet bgs, or at a depth determined from visual observations of contamination (such as staining, odor or elevated PID/FID readings). The final sampling locations will be determined in the field based on accessibility and indications of obvious contamination at ground surface. All samples will be analyzed for VOCs, SVOCs, explosives, metals and pH. Three soil samples will be analyzed for PCBs using field kits. Analytical results from the laboratory will be available within 4 days after the soil samples are collected and will be used to guide the collection of additional soil samples if needed. In this way, the lateral extent of the disposal pit can be defined while minimizing the number of samples. Soil sampling procedures are detailed in Section 3.7 and 3.8.

In addition to samples collected for chemical analysis, two subsurface soil samples will be collected for determination of geotechnical parameters, including soil class, grain size, moisture content, and pH. These samples will consist of site representative soils collected at sampling locations identified in the field.

8.3.5 Groundwater Elevations

One round of synoptic groundwater elevations will be measured at all five existing monitoring wells to determine groundwater flow directions in the vicinity of Site 8. In addition, groundwater elevations will be measured at the 2 monitoring wells located on the adjacent Army property during the same time period. Authorization to access these wells will be received prior to entrance onto the Army property. Water levels will be collected from all wells during a 2 hour period of consistent weather conditions to minimize atmo-

spheric/precipitation effects on groundwater levels. Additional groundwater elevation measuring procedures are detailed in Section 3.4.

8.3.6 Site Mapping

Review of available information indicates that site drawings may not include all important site features. After sampling activities are completed at the site, a general evaluation of the site will be made to compare the existing site-specific drawings with the observed site features. A determination will then be made regarding the need for additional site mapping. All important site features such as the locations of monitoring wells, power lines, fence lines, sampling locations and utilities will be included on the site map. Additional site mapping procedures are detailed in Section 3.13.

9.0 SITE 9 - INDUSTRIAL WASTEWATER DISPOSAL AREA 300

9.1 SITE DESCRIPTION

The Industrial Waste Water Disposal Area 300 is located south of Dahlgren Road along the Montgomery/Prince George County line and extends southward to the facility boundary. A perennial tributary of Paint Branch Creek is located west and south of the site and an intermittent tributary of the creek is located to the east. Figure 9-1 shows the major features of Site 9.

9.1.1 Past Disposal History

The Industrial Waste Water Disposal Area 300 was used from the early 1950s until the mid-1970s. Several leaching wells and above ground discharges to the soil were used in this area for disposal of liquid wastes containing explosive related compounds. Waste water disposed at the site contained TNT, RDX and several other explosive related compounds. It is estimated that at least 7,200 pounds of these waste waters were disposed at this site over a period of approximately 25 years. It is also reported that solvents were disposed in the same manner as the explosive compounds.

9.1.2 Site Geology/Hydrogeology

Three geologic units underlie Site 9. The uppermost geologic unit is the Upland Sand and Gravel which is underlain by the Potomac Group. The saprolite member and fractured gneiss of the Wissahickon Formation underlie the unconsolidated sediments. Portions of the uppermost geologic units have been eroded due to the proximity of the site to perennial and intermittent tributaries of Paint Branch Creek. The northern part of the site is topographically higher than the southern part and has experienced less erosion.

Based on borehole data at the site, the northern portion of the site is underlain by approximately 40 to 65 feet of unconsolidated sediments. Within the unconsolidated sediments, several silty clay seams were observed. These layers appear to be local in nature and do not appear laterally continuous. The saprolite member of the Wissahickon Formation was encountered at 40 feet below ground surface in one borehole and was approximately 25 feet thick. Below the saprolite/weathered gneiss, a highly weathered gray-green chlorite schist was encountered at approximately 65 feet below ground surface. The chlorite schist is a local, more highly metamorphosed member of the Wissahickon Formation.

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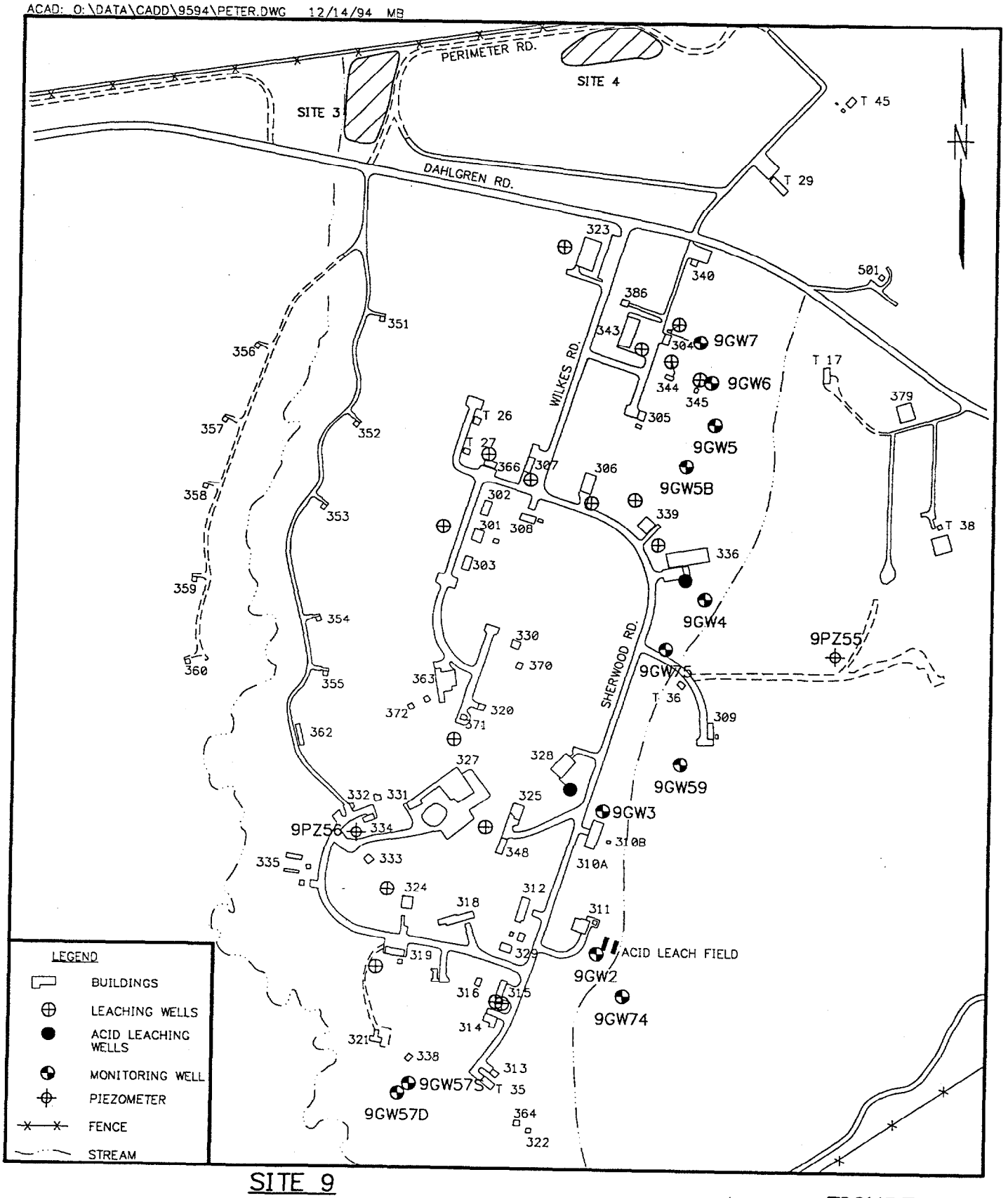

SITE 9

INDUSTRIAL WASTEWATER DISPOSAL AREA 300

NSWC WHITE OAK

FIGURE 9-1

0 400 800

SCALE IN FEET

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Based on borehole data at the site, the Upland Sand and Gravel unit has been completely eroded and some of the upper portion of the Potomac Group has been eroded. The southern portion of Site 9 is covered by a thin veneer of interbedded red-gray sands approximately 5 to 15 feet thick. This is underlain by the saprolite member of the Wissahickon Formation. The saprolite was encountered in a range approximately 5 to 18 feet below ground surface during previous investigative work at the site. This variation in thickness is a result of more erosion of the unconsolidated sediments along stream valleys in the southern portion of Site 9.

From previous studies, the groundwater flow direction has been estimated to the south-southwest in the northern portion of Site 9. This flow is towards a perennial stream and appears only slightly influenced by a nearby intermittent stream. In the southern portion of the site, groundwater flow is affected by the intermittent stream and flows to the southeast. During periods of high water table elevations, the groundwater in this area discharges into the intermittent stream. Graphical analysis of groundwater data indicates a groundwater gradient with a geometric mean of 3 percent.

The physical characteristics of the water table change across the site from the north to the south. In the northern portion of the site, the water table aquifer occurs in the Upland Sand and Gravel unit and to a minor extent in the underlying saprolite. In the southern portion of the site, the water table aquifer occurs in the saprolite unit. The estimated average saturated thickness of the water table aquifer is 18 feet in the northern portion of the site (in the Upland Sand and Gravel unit) and 5 feet in the southern portion of the site (in the saprolite unit).

Slug test data was used to estimate the hydraulic conductivity at the site. The estimated hydraulic conductivity for Site 9 based on slug tests is 1.93 ft/day (6.8×10^{-4} cm/sec). Pump tests were used to estimate transmissivity in both the northern and southern portions of the site. The estimated transmissivity beneath the northern portion of the site ranges from 113.47 to 217.64 ft^2/day (1.22×10^{-1} to 2.34×10^{-1} cm^2/sec). The estimated groundwater velocity beneath the northern portion ranges from 1.34 to 2.65 ft/day (4.71×10^{-4} to 9.33×10^{-4} cm/sec). Pump test results indicate the hydraulic conductivity for the saprolite unit is approximately 0.13 ft/day (4.63×10^{-5} cm/sec). The transmissivity of the water table aquifer beneath the southern portion of the site is approximately 0.07 ft^2/day (7.0×10^{-5} cm^2/sec). The groundwater velocity in the southern portion of the site is estimated at 0.02 ft/day (8.01×10^{-6} cm/sec).

9.2 PREVIOUS INVESTIGATIONS

The rationale and purpose for the previous investigations conducted at Site 9 have been discussed previously in Section 1.3. The earliest site investigation consisted of the Initial Assessment Study (IAS),

which did not involve any intrusive investigations or field sampling. However, subsequent studies have included the following onsite investigative work:

Confirmation Study/Verification Phase - Seven groundwater monitoring wells were installed and sampled during this investigation. In addition, fifteen sediment locations were sampled. Generally, TOC and TOX values were detected at low concentrations throughout the site. Metal concentrations were low at all sampling locations. Nitroaromatic contamination was found in one sediment sample and in one groundwater monitoring well.

Remedial Investigation (Phase I) - During Phase I of the RI, three surface water and ten sediment samples were collected from the small stream east of the site and from the stream west of the site. In addition, two surficial soil samples were collected and six soil gas surveys of the soil near former leaching well fields were conducted. This investigation was conducted to measure the release of gaseous VOCs, predict the contaminant movement through the vadose zone, and measure the chemical contamination in the surface soil.

Three piezometers and six groundwater monitoring wells were installed during Phase I. Two wells were installed as a cluster, one shallow and one deep. Thirteen groundwater monitoring wells were then sampled. During the well installation and piezometer installation, split spoon samples were collected to characterize the subsurface lithology.

Remedial Investigation (Phase II) - As during the Phase I investigation, three surface water and ten sediment samples were collected from the small stream east of the site and from the stream west of the site during the Phase II investigation.

During Phase II one additional groundwater monitoring well was installed. Groundwater samples were then collected from 13 monitoring wells (one of the previous wells was damaged and not sampled). During the well installation, split spoon samples were collected to characterize the subsurface lithology.

Ecological investigations were also conducted during Phase II to assess conditions on site. Included in the investigation were terrestrial vegetation, fish, benthic invertebrate and mammal surveys.

9.3 PROPOSED DESIGN VERIFICATION FIELD ACTIVITIES

A records search indicates that two known acid leach wells and one acid leach field are present at Site 9. Approximately 14 other leaching wells are present at the site although it is unknown if these wells were used

to dispose of hazardous materials. Figure 9-1 shows the locations of the known acid leaching wells and the other leaching wells at Site 9. An estimate of the volume of contaminated soil present within the leach fields and the levels of contaminants in the soil are required to evaluate remedial options for the site. To achieve these goals several field activities will be undertaken. The locations of all leaching wells (known and suspected) that cannot be field identified will be located using an EM. The survey will be coordinated with a review of existing site drawings. After each well is located, samples will be collected to determine if contamination is present. Leaching wells will be sampled directly if they can be uncovered and exposed. If a well cannot be exposed, a sample of the subsurface soil will be collected from a soil boring located immediately downgradient of the leaching well. Following the analysis of these samples, soil borings will be drilled in the vicinity of two representative leaching wells which contained significant contamination. Subsurface soil samples collected from these soil borings will be used to determine the depth of soil contamination and the chemicals of concern at each leaching well location. Based on analytical results for the initial samples, additional soil borings will be completed at increasing distances until the full extent of soil contamination which requires removal/treatment is determined.

9.3.1 EM Survey

Prior to beginning an EM survey, all leaching wells at Site 9 will be field investigated to determine if their locations are identifiable at the ground surface. A regularly spaced grid will be measured out across each area suspected to contain a leach well, which can not be located during the field survey of the site. All areas will be surveyed using a Geonics EM-61 conductivity meter or Navy approved equivalent. This instrument will provide continuous readings of the soil conductivity to a depth of approximately 20 ft and should detect the location of the leach wells and the associated supply lines. Following the completion of the EM survey at each location, the results will be compared to utility maps of the area to determine the location of all underground objects which are present in study area. These may include utility lines, acid drainage lines and leaching wells. The exact location of the buried leaching wells will be verified by excavation, if possible. It is anticipated that the acid leaching wells are still intact and are located within 1 to 2 feet of ground surface. If the leaching wells cannot be excavated due to access difficulties, a soil boring will be used to collect a sample of soil from the vicinity of the leaching well.

9.3.2 Leaching Well Access

The location of each of the leaching well located during the EM survey will be verified by excavation, if possible. It is estimated that the top of the leaching wells is approximately 1.0 to 2.0 feet bgs and the base of the leaching wells is approximately 9.0 feet bgs. Total excavation depth will not exceed 5 feet. Notes will be taken during test pit excavation detailing leaching well condition, soil types, soil moisture and

PID/FID. No soil samples will be collected for analysis from the test pit. During the excavation, all soil will be placed on plastic sheeting. After a leaching well is located and fully investigated, the excavation will be backfilled with the excavated soil, as the soil located above the leaching well is not likely to be contaminated, and the location will be marked and labeled. Leaching wells may currently be in use at Site 9 and excavation activities will not interfere with the continued operation of the leaching wells. It is estimated that 17 test pits will be excavated to locate all leaching wells at Site 9. Additional excavation procedures are detailed in Section 3.5.

9.3.3 Leaching Well Samples

Samples will be collected from the material present at the bottom of each leaching well to determine if the soils in and around the well may be a source of contamination. The condition of each leaching well is unknown although they are likely to contain sediment from disposal activities. Notes will be taken during leaching well sampling which detail well condition, well fill materials, soil types, soil moisture and PID/FID readings at each location. One sample will be collected from each well. Each sample will consist of composite surface material and deeper material in the leach well. Each sample from the Site 9 leach wells will be analyzed for TCL VOCs, TCL SVOCs, TAL metals, TKN, and Method 8330 compounds. During the sampling activities, a PID/FID will be used to screen all materials removed from the well. The interior contents and the condition of the well will also be noted. Additional procedures for leaching well sampling are detailed in Section 3.5.

9.3.4 Soil Borings

Soil borings will be used to collect subsurface soils near leaching wells if access to the interior of the leaching well is not possible. An initial soil boring will be installed in the vicinity of each leaching well under the following conditions:

- If the well cannot be uncovered and sampled due to access problems;
- If the leaching well cannot be located with an EM survey and no obvious features exist to indicate the location of the leaching well.

One sample will be collected from each soil boring for chemical analysis. The analytical results from the soil samples taken outside the leaching well will determine if the leaching well contains contamination and if additional soil borings are required.

Additional soil borings will be conducted at representative leaching wells if the analytical results for the initial soil boring or the sample collected from inside the leaching well indicates significant contamination is present. Additional soil borings will determine the extent and magnitude of soil contamination which may be present in the vicinity of representative leaching wells.

9.3.4.1 Initial Round of Soil Borings

If leaching wells cannot be uncovered due to access problems, a soil boring will be drilled immediately downgradient (within 5 feet) of the leaching well location to determine if the well is a likely source of contamination. One sample will be collected at the approximate total depth of the leaching well, approximately 10 to 15 feet bgs. Continuous split-spoon samples will be collected to the sample depth (10 to 15 feet bgs) or to the water table. If zones of obvious contamination or elevated PID/FID readings are noted during the soil boring, the zone with the highest PID/FID reading will be sampled for chemical analysis. If no zone of obvious contamination is encountered, one sample will be analyzed from the target interval. Note that one leach field is present at Site 9 and will be investigated in the same manner as a leaching well which cannot be uncovered. One soil boring will be installed and a sample collected from the leach field to determine if additional soil borings and soil sampling are required at the leaching field.

If a leaching well has been removed or backfilled, no EM signature may be present for that well. If no leaching well is located in an area using an EM survey, soil borings will be drilled based on the reported location of the leaching well. Existing utility maps will be used to determine the approximate location of the leaching well. Soil borings and subsurface soil samples will be completed as discussed above. A detailed description of soil boring and subsurface soil sampling is provided in Sections 3.6 and 3.7.

9.3.4.2 Secondary Round of Soil Borings

In order to determine the depth and lateral extent of contamination which may be present in subsurface soils near leach fields, soil borings will be completed in the vicinity of two representative leaching wells suspected to contain contamination. The initial sample collected of material within each leaching well, or from soils immediately downgradient of the well, will be used to determine which of the leaching wells contain contamination and require additional sampling. If no elevated levels of contamination are detected in the initial sample collected from the well, then those wells will be assumed to be clean and no further action will be conducted at that location. However, where elevated levels of contamination are detected, a total of three downgradient borings and one upgradient boring will be completed at two representative leaching well locations which may contain contamination.

Soil borings conducted during this phase will be placed within a 30 foot radius of the location of the leaching well. Three subsurface soil samples will be collected from each boring, at shallow, intermediate and deep intervals. The shallow sample will be collected from the depth of the bottom of the leaching well, estimated to be 10 ft bgs. The intermediate sample will be taken at a depth directly above the water table (estimated at 15 ft bgs). The deep sample will be taken at a depth approximately 5 feet below the water table. Soil borings will not exceed 25 feet in depth. Each soil boring location will be marked and labeled to permit the determination of its exact location through surveying.

9.3.5 Subsurface Soil Samples

At the representative leaching well locations four soil boring will be completed. Three soil samples will be collected from each boring (12 samples per leaching well). It is estimated that 24 soil samples will be collected at the site for chemical analysis at the onsite laboratory (2 wells X 4 boring per well X 3 samples per boring = 24 samples). Subsurface soil samples collected from the vicinity of each leaching well will be analyzed for identified in the initial samples collected from each leaching well. Subsurface soil samples will be analyzed within 4 days and results will be used to determine if additional soil borings are required to define the extent and magnitude of soil contamination around these leaching wells. This will facilitate placement of additional soil borings within the same field mobilization. If levels of contamination are present in the subsurface soils above action levels, additional soil borings will be required to determine the full extent of soil contamination. Additional borings will be drilled at increasing distances from the leaching well and sampled from intervals which show levels of contamination above established action levels. During these drilling activities, similar drilling and sampling procedures will be followed as listed above.

In addition to samples collected for chemical analysis, two subsurface soil samples will be collected for determination of geotechnical parameters, including soil class, grain size, moisture content, and pH. These samples will consist of representative soils collected at sampling locations identified in the field.

9.3.6 Groundwater Elevations

One round of synoptic groundwater elevations will be measured at all 14 existing monitoring wells to determine groundwater flow directions in the vicinity of Site 9. In addition, groundwater elevations will be measured at the 7 existing monitoring wells at Site 3, and the 18 monitoring wells located at Site 4 during the same time period. In addition, an existing base well located east of Building 301 will be measured, if possible. Water levels will be collected from all wells during a 4 hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Groundwater elevations for all three sites will be analyzed in concert to determine the groundwater flow directions for the entire area.

9.3.7 Site Mapping

Review of available information indicates that site drawings may not include all important site features. After sampling activities are completed at the site, a general evaluation of the site will be made to compare existing site-specific drawings with observed site features. A determination will be made regarding the need for site mapping. All important site features such as the locations of acid leaching wells, supply lines, EM survey locations, soil borings, sampling locations, and utilities will be included on the site map.

10.0 SITE 11 - INDUSTRIAL WASTEWATER DISPOSAL AREA 100

10.1 SITE DESCRIPTION

Site 11, Wastewater Disposal Area 100, contains thirteen acid leaching wells in nine areas that were used for wastewater Disposal from laboratory activities. The wells are located in an area covering approximately 16 acres. The wells are believed to be abandoned while the associated supply lines are believed to be in place. The wells were used for liquid waste disposal until 1976. To date, eleven of the wells have been located although the condition and contents of the wells has not been field verified. The location of two wells thought to be adjacent to Building 30 have not yet been identified. These wells may have been removed during the reconstruction of the facility's sewer system. Original construction consisted of a five foot diameter, brick or concrete well approximately nine feet in depth. Each well was accessible through a 24 inch diameter manhole cover. One supply line transported wastewater to each well. The major features of Site 11 are shown on Figure 10-1.

10.1.1 Past Disposal History

Wastes that were disposed at Site 11 include metals, acids, chlorinated and non-chlorinated solvents, alcohols, lead, and organic explosive compounds. An estimated 20,000 gallons of waste were disposed in these leaching wells. Both listed and characteristic hazardous wastes are believed to have been disposed.

10.1.2 Site Geology/Hydrogeology

Based on data from previous investigations, two geologic units are believed to be present at the site. The uppermost unit is a thin layer of Upland Sand and Gravel with a thickness of 0 to 20 feet. The unit is thickest in the east and southeast area of the site and consists of brown silt and red-brown fine to medium sand with some gravel. Clayey silt seams less than one foot thick are present near the base of the unit. Underlying the Upland Sand and Gravel is the Wissahickon Formation. This unit consists of a saprolite (weathered bedrock) member ranging from 5 to 55 feet thick and a deeper weathered schist member which was encountered in only one deep boring. Bedrock underlying the site consist of a gray-green slate or gneiss and was encountered between 50 and 70 feet below the ground surface.

Groundwater is most commonly found in the Wissahickon Formation saprolite and bedrock. Previous investigations have indicated that groundwater within the saprolite and bedrock units flows along fracture

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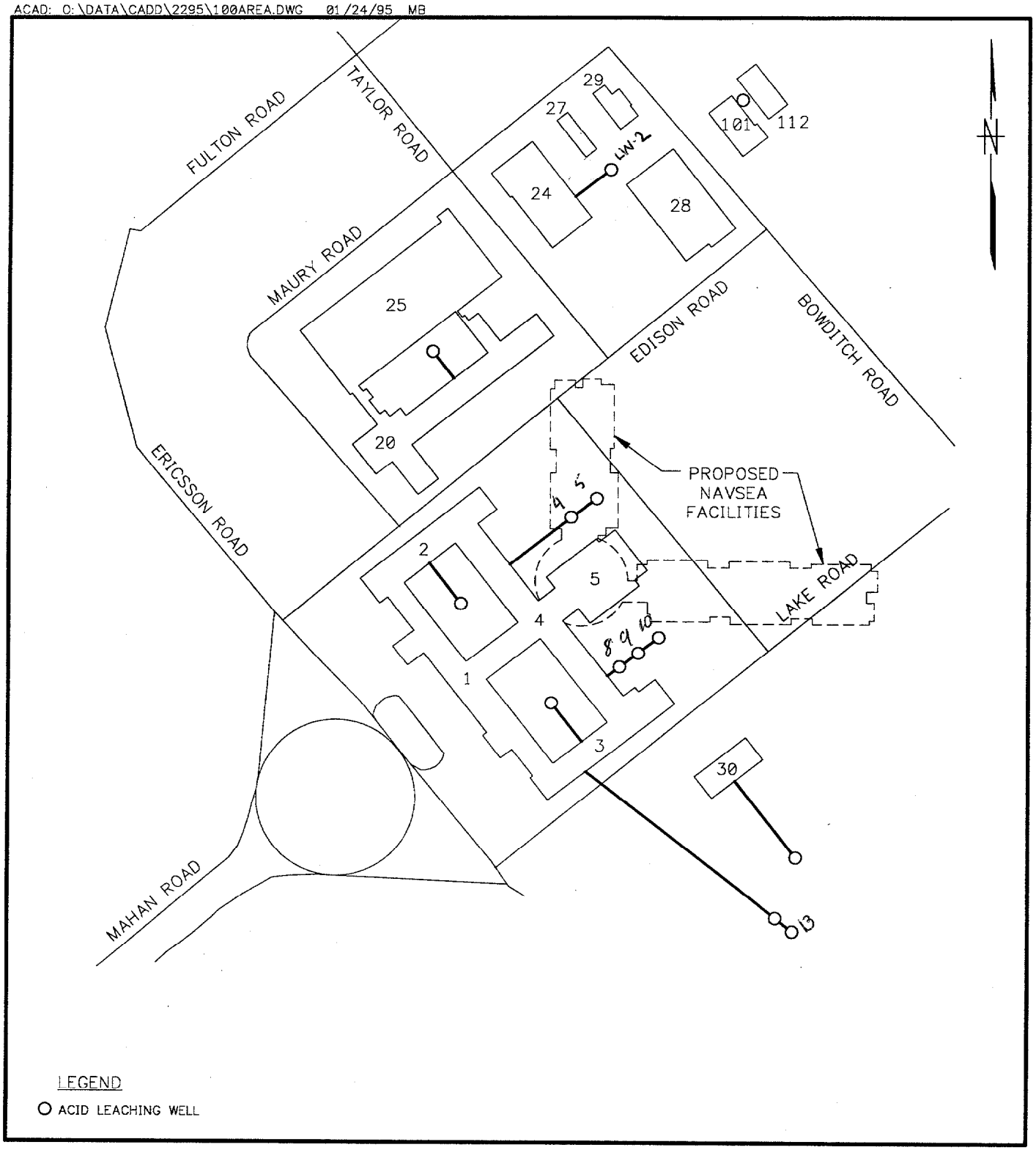

SITE 11
INDUSTRIAL WASTEWATER DISPOSAL AREA 100
NSWC WHITE OAK

0 300 600
SCALE IN FEET

FIGURE 10-1

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zones which provide vertical and horizontal flow paths. Groundwater is influenced by a shallow groundwater divide which transects the site from northwest to southeast, passing approximately through the Main Administration Building. Groundwater at the site flows away from the divide towards streams to the northeast and southwest.

Data from a pumping test at the site indicates that the saprolite layer has a hydraulic conductivity of 0.13 ft/day (4.62×10^{-5} cm/sec). Other aquifer testing performed at the site included thirteen slug tests. The geometric mean of the slug test data indicated a hydraulic conductivity of 2.84 ft/day (1×10^{-3} cm/sec). The effective porosity of these units has been estimated to be 26 percent.

10.2 PREVIOUS INVESTIGATIONS

The rationale and purpose for the previous investigations conducted at Site 11 have been discussed previously in Section 1.3. The earliest site investigation consisted of the Initial Assessment Study (IAS), which did not involve any intrusive investigations or field sampling. However, subsequent studies have included the following onsite investigative work:

Confirmation Study/Verification Phase - During the Verification Phase at Site 11, eight monitoring wells were installed, sampled and analyzed for VOCs, metals, TOC, TOX, and oil and grease. Results from the groundwater analysis indicated that numerous site wells contained elevated levels of VOCs and metals. The areas with the highest level of contamination were those downgradient of Buildings 2, 3 and 4, which are located nearest the former leaching well locations.

Remedial Investigation (Phase I) - During the RI, four piezometers and nine groundwater monitoring wells were installed at the site. All site wells were then sampled and analyzed for VOCs total and soluble metals, TOC, TOX, TDS, and TSS. Results indicated that elevated levels of chromium, lead, and VOCs (including TCE, TCA, DCE, and DCA were present in the groundwater. Contamination was highest in wells downgradient of Building 2 and 5.

Three surface water and three sediment samples were collected from the stream west of the site. Sediment samples were found to contain elevated levels of semivolatile organic compounds and metals including chromium and lead. The sediment samples were not analyzed for VOCs. One surface water sample was found to contain an elevated level of lead, with all other parameters within background levels. Two surface soil samples were collected at the site and analyzed for semivolatiles and metals. Sample results indicated that no contaminants were present in surface soils.

Three soil gas surveys were completed at abandoned leaching well locations to determine if VOCs were present in the soil. Results of the soil gas survey were inconclusive.

Remedial Investigation (Phase II) - During Phase II, five additional monitoring wells were installed at Site 11. Groundwater samples were collected and analyzed for metals and VOCs. Analytical results indicated that elevated levels of cadmium, chromium, lead, TCE, TCA, DCE and DCA were present. As in the Phase I investigation, the highest levels of contamination was found downgradient of Buildings 2, 5 and 30. In addition to groundwater sampling, slug tests and one pumping test were performed. Three monitoring wells were also abandoned during this phase of the site investigation.

Three surface water and three sediment samples were collected from the stream west of the site at the same locations as used during the Phase I investigation. The samples were collected in and effort to determine a trend of contamination with time. Samples were analyzed for VOCs, semivolatiles and metals. No significant contaminant concentrations were found in the surface water. Elevated levels of cadmium, chromium and lead were found in the sediment samples. No semivolatile compounds were detected in these sediment samples.

During both the Phase I and Phase II sediment sampling activities, the largest sediment contaminant concentrations were found at sampling locations nearest the property limits of the facility. These results may indicate that an upgradient source may exist for these contaminants. Therefore sediment contamination may be originating from an offsite location.

Ecological investigations were also conducted during Phase II to assess conditions on site. Included in the investigation were terrestrial vegetation, fish, benthic invertebrate and mammal surveys.

10.3 PROPOSED DESIGN VERIFICATION FIELD ACTIVITIES

Records search indicates that 13 acid leach wells are present across the site at eight leach fields. The approximate locations of the acid leach wells (near Buildings 112, 24, 32, 2, 5, 3 and 30) have been based on utility maps, and these locations have been field identified. An estimate of the volume of contaminated soil present at these leach fields and the level of contaminants present is required to evaluate remedial options for the site. To achieve these goals several field activities will be undertaken. The former location of the two acid leaching wells that have not been field identified will be determined using an EM survey, performed in conjunction with a review of existing site drawings. After each of these wells is located, all acid leach wells will be sampled to determine if contamination is present. Soil borings will be drilled in the vicinity of two representative leaching wells which contain significant contamination. Subsurface soil and

groundwater samples collected from these soil borings will be used to determine the depth of soil contamination and the chemicals of concern at each leaching well location. Based on soil analytical results, additional soil borings will be completed at increasing distances until the full extent of soil contamination is determined.

10.3.1 EM Survey

A regularly space gird will be measured out across the area suspected to contain the two former acid leach wells whose location could not be field verified (in the vicinity of Building 3). This area will be surveyed using a Geonics EM-61 conductivity meter or navy approved equivalent. This instrument will provide continuous readings of the soil conductivity to a depth of approximately 20 ft and should detect the location of the leach wells and the associated supply lines. Following the completion of the EM survey, the results will be compared to utility maps of the area to determine the location of all underground objects, including utility lines, acid drainage lines and leaching wells. The exact location of the two leaching wells will be verified by excavation. It is anticipated that the acid leaching wells are still intact and are located within 5 feet of ground surface.

10.3.2 Leaching Well Access

The location of each of the two leaching wells located during the EM survey will be verified by excavation. After the leaching well is uncovered the condition of the leaching wells will be determined. It is estimated that the top of the leaching wells are approximately 1.0 to 2.0 feet bgs and the base of the leaching wells is at approximately 9.0 feet bgs. Excavation depth will not exceed 5 feet. Notes will be taken during test pit excavation detailing leaching well condition, well fill materials, soil types, soil moisture and PID/FID readings during each excavation. No soil samples will be collected for analysis from the test pit. During the excavation, all soil will be placed on plastic sheeting. The soil located above the leaching well is not likely to be contaminated. After a leaching well is located and fully investigated, the pit will be backfilled with the excavated soil and the location will be marked and labeled. Both suspected leach well locations will be excavated. Additional excavation procedures are detailed in Section 3.5.

10.3.3 Acid Leaching Well Samples

Sediment samples will be collected from the bottom of each acid leaching well to determine if the soils in and around the well may be a source of contamination. The condition of each acid leaching well is unknown although they are likely to contain sediment from disposal activities. Notes will be taken during leaching well sampling which detail leaching well condition, well fill materials, soil types, soil moisture and

PID/FID readings at each location. One sample will be collected from each well. Each sample will consist of a composite of surface material and deeper material from the acid leach well. Each sample from the leach wells will be analyzed for TCL VOCs, TCL SVOCs, TAL metals, TKN, and Method 8330 volatiles. During the sampling activities, a PID/FID will be used to screen all materials removed from the well. The interior contents of the well and the condition of the well will also be noted. Additional sampling procedures for acid leaching well sampling are detailed in Section 3.5.

10.3.4 Soil Borings

In order to determine the depth and lateral extent of contamination which may be present in subsurface soils near leach fields, soil borings will be completed in the vicinity of two representative leaching wells. The initial sample collected from each leaching well will be used to identify the need for additional sampling. A total of three downgradient borings and one upgradient boring will be completed at the representative leaching well locations which may contain contamination. Soil borings will be located within a 30 foot radius of the leaching well. Three subsurface soil samples will be collected from each boring, at shallow, intermediate and deep intervals. The shallow sample will be collected at a depth adjacent to the bottom of the leaching well, estimated at approximately 10 ft bgs. The intermediate sample will be taken at a depth directly above the water table (estimated at 15 ft bgs). The deep sample will be taken at a depth approximately 5 feet below the water table. Soil borings will not exceed 25 feet in depth. Each soil boring location will be marked and labeled to permit the determination of its exact location through surveying.

10.3.5 Subsurface Soil Sampling

Three soil samples from each soil boring will be collected for chemical analysis, for an estimated total of 24 soil samples (2 wells X 4 boring per well X 3 samples per boring = 24 samples). Subsurface soil samples collected from the soil borings will be analyzed for compounds identified in the sediment inside each leaching well. All soil samples will be analyzed for pH. Soil samples will be analyzed within 4 days and results will be used to determine if additional soil borings are required to define the extent and magnitude of soil contamination around each leaching well. This will facilitate the placement of additional soil borings within the same field mobilization as required. If levels of contamination are present in the subsurface soils above established action levels, additional soil borings will be placed to determine the full extent of contamination. Additional borings will be drilled at increasing distances from the leaching well and sampled from intervals which show levels of contamination above established action levels.

In addition to the sample collected for chemical analysis, two subsurface soil samples will be collected for determination of geotechnical parameters, including soil class, grain size, moisture content, pH and TOC.

These samples will consist of site representative soils collected at sampling locations to be identified in the field.

If a leaching well was removed and backfilled during previous abandonment activities, no EM signature may be present for that leaching well. If a leaching well cannot be located in an area using a EM survey, soil borings will be drilled based on the well's reported location. One sample will be collected at a depth equal to the depth of the leaching well (approximately 10 to 15 feet bgs). Continuous split-spoon samples will be collected to the sample depth (10 to 15 feet bgs) or to the water table. If zones of obvious contamination or elevated PID/FID readings are noted during the soil boring, the zone with the highest PID/FID readings will be sampled for chemical analysis. If no obvious zones of contamination are encountered, one sample will be sent for analysis from the target interval.

At locations which are not accessible to a drilling rig, a hand operated soil sampler will be utilized. Soil samples will be collected from similar intervals, if possible, as listed above. All other analytical parameters and sampling procedures will be identical. A detailed description of soil boring and subsurface soil sampling is provided in Sections 3.6 and 3.7.

10.3.6 Groundwater Elevations

One round of synoptic groundwater elevations will be measured at all 20 existing monitoring wells to determine groundwater flow directions in the vicinity of Site 11. In addition, groundwater elevations will be measured at the 6 monitoring wells located at Site 2 during the same time period. Water levels will be collected from all wells during a 4 hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Groundwater elevations for both sites will be analyzed in concert to determine the groundwater flow directions for the entire area. Additional descriptions of groundwater elevation measurement procedures are given in Section 3.4.

10.3.7 Site Mapping

Review of available information indicates that site drawings may not include all important site features. After sampling activities are completed at the site, a general evaluation of the site will be made to compare the existing site-specific drawings with observed site features. A determination will then be made regarding the need for site mapping. All important site features such as the locations of acid leaching wells, supply lines, soil borings, sampling locations, and utilities will be included on the site map.

11.0 BACKGROUND AND EVAPORATION UNIT SAMPLES

11.1 BACKGROUND SAMPLE LOCATIONS

In order to determine the background level of chemicals which are present in and around NSWCWODET, samples will be collected from locations at the facility where past or present operations are not expected to have contaminated site media. To accurately determine what background levels of compounds are present, samples will be collected in areas where industrial activities have not occurred, which are hydraulically upgradient, and, where possible, upwind of industrial operations or other potentially contaminated areas. The results of the background sampling will be used for comparison to the analytical results obtained from the sampling activities at sites described in Sections 5 through 10.

A total of three background samples will be collected. One sample will be collected in the vicinity of Sites 2 and 11. The second background sample will be collected in the vicinity of Sites 3, 4 and 9. The third sample will be collected in the vicinity of Site 8.

11.2 BACKGROUND SAMPLING ACTIVITIES

Subsurface soils will be collected at each background location from below the organic horizon and will avoid collecting roots and other organic material. At each background sampling location one subsurface soil will be collected from approximately 5 ft bgs. A hand auger will be used to collect the sample from the required depth. The Field Operations Leader will determine the location of each background sampling location based on visual observation of the area to determine that industrial operations have not effected the background location. All background samples will be analyzed for volatiles and semivolatiles, PCBs, metals, TKN, and Method 8330 analytes. Samples will be analyzed at the onsite laboratory. Sample analytes, bottle requirements, and holding times are listed in Tables 4-1 and 4-2. Each background sampling location will be marked with a wooden stake and surveyors flagging. The sample ID number will be noted at each location.

11.3 EVAPORATION UNIT LOCATION

Samples will be collected for geotechnical analysis from areas being considered for the evaporation unit. Results will be used to design the evaporation unit foundation systems and determine if the selected location is appropriate for the treatment activities. Two test borings will be advanced to a depth of 25 feet. Visual

observations of split-spoon samples will be made to the bottom of each soil boring. One Shelby tube will be collected from each soil boring and will be analyzed for USCS classification, gradation, moisture content, Atterburg limits and consolidation. The selection of the locations of the borings will be determined following the analytical results of samples collected from Sites 9 and 11. The evaporation unit will be sited in a location central to areas which require remediation and which have the necessary access and parking requirements.

12.0 CONCLUSIONS AND RECOMMENDATIONS

The existing data for the six sites are outdated and further investigation is necessary for the purposes of design engineering. The major design engineering needs pertain to an accurate delineation of the boundaries of the two landfills (Sites 2 and 3), delineation of the extent of contamination at the two chemical burial areas (Sites 4 and 8) and delineation of the extent of contamination at the two leaching well areas (Sites 9 and 11).

For Sites 2 and 3, the boundaries of the landfills will be determined by EM surveys and test pits. As a precautionary measure, a Halliburton NUS UXO specialist will supervise these activities. At Site 2, PCB contamination in the adjacent tributary will be delineated by the use of field kits. At Site 3, the depth of the landfill will be checked for purposes of evaluating alternatives during the design phase.

For Sites 4, 8, 9, and 11, this DVSAP specifies phased sampling. Sources will undergo broad characterization (TCL, TAL, nitroaromatics and nitroamines, TKN, and PCBs) to identify the parameters of concern. More focused sampling emphasizing contaminants of concern will follow for purposes of determining extent and depth of contamination.

All parameters except PCBs will be analyzed by a fixed laboratory. PCBs will be analyzed by field analytical kit. TKN is included as a surrogate for nitroaromatics and nitroamines. The use of a laboratory offering a four day turnaround on analytical services will allow the sampling to occur in one continuous field effort. At Sites 9 and 11, where the extent of contamination is expected to be sufficiently comparable from site to site for design purposes, extent and depth of contamination will be investigated at four locations, and the information obtained will be interpreted and applied to the remaining locations that may require remedial action.

In addition, limited geotechnical sampling will occur at location near Site 3, to determine suitability of the site to accommodate soil treatment equipment. Background samples will also be collected.

The scope of the investigation presented herein calls for test borings (44 estimated total), trenches (10), excavations (5), surface and subsurface soil sampling (74), sediment sampling (25), residue sampling (30), and geophysical surveys.

APPENDIX A

HEALTH AND SAFETY PLAN (HASP)

DVSAP HEALTH AND SAFETY PLAN

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ATTACHMENT A-II	MEDICAL DATA SHEET
ATTACHMENT A-III	TICK CONTROL
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Appendix A
Health and Safety Plan
for
Remedial Actions at Sites 2, 3, 4, 8, 9, and 11 Naval Surface Warfare Center White Oak

Silver Spring, Maryland

Engineering Field Activity Chesapeake
Naval Facilities Engineering Command
Northern Division Contract Number N62472-90-D-1298
Contract Task Order 0180

January 1995

R-12-94-10

APPENDIX A
HEALTH AND SAFETY PLAN
FOR
REMEDIAL ACTIONS AT
SITES 2, 3, 4, 8, 9, AND 11
NAVAL SURFACE WARFARE CENTER
WHITE OAK
SILVER SPRING, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Chesapeake
Design Branch Code 04
Naval Facilities Engineering Command
Washington Navy Yard, Building 212
Washington, D.C. 20374-2121

Submitted by:
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0180

JANUARY 1995

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A-II	Medical Data Sheet
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A-IV	OSHA Poster
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1.0 PURPOSE

The purpose of this plan is to assign responsibilities, establish personnel protection standards and mandatory safety practices and procedures, and provide for contingencies that may arise while operations are being conducted at the site during the Design Verification Sampling and Analysis Plan (DVSAP).

2.0 APPLICABILITY

The provisions of the plan are mandatory for all on-site employees engaged in hazardous material management activities including, but not limited to, initial site reconnaissance, geophysical surveys, soil borings, collection of soil samples, collection of sediment samples, leaching well sampling, installation of test trenches and demobilization. This plan has been developed under U.S. Environmental Protection Agency (EPA) guidelines and complies with all regulations including OSHA 29 CFR 1910, and specifically 1910.120, and applicable 1926 OSHA Construction Industry standards, and State and local regulations as applicable. This plan is based on available information regarding possible contaminants and physical hazards that may exist at the site. If more information concerning the nature and/or concentrations of contaminants becomes available, this HASP will be modified accordingly. It will be the Halliburton NUS Project Manager's responsibility to communicate any such information to the Project Site Safety Officer (SSO) who will, in turn, determine the need for modifying the HASP.

2.1 AUTHORITY

The Northern Division of the Naval Facilities Engineering Command issued Contract Task Order (CTO) 0180, under the Comprehensive Long-term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298 to HALLIBURTON NUS Environmental Corporation (HALLIBURTON NUS).

This Health and Safety Plan (HASP) for the NSWCWODET, Silver Spring, Maryland facility has been prepared by HALLIBURTON NUS under Contract N62472-90-D-1298, Contract Task Order 0180.

PERSONNEL ASSIGNMENTS

Site Name: Naval Surface Warfare Center, Dahlgren Division, White Oak Detachment

Client Contact: Bill Spicer

Address: Silver Spring, Maryland Phone Number: (301-394-2439)

Purpose of Fieldwork: To perform field activities, as described in Section 3.1 of this Health and Safety Plan.

Proposed Dates of Work: February - April 1995

Project Team:

Halliburton NUS Personnel:	Discipline/Tasks Assigned:
Don Olmstead	Project Manager
Pete Nimmer	Geologist
TBA	Sampling Task Leader (TL)/Geologist
TBA	Project Site Safety Officer (SSO)
Ray Willoughby / Phil Blackwell	EOD Specialist

Non-Halliburton NUS Personnel:

TBA	

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Health and Safety Manager: Matthew M. Soltis, CSP, CIH

Reviewed:

Halliburton NUS

Project Manager: Donald Olmstead

Follow Up Report:

Responsible Person: TBA

3.0 SITE DESCRIPTION

3.1 GENERAL INFORMATION

This HASP has been developed to address the potential hazards recognized in performing the Design Verification Sampling and Analysis Plan (DVSAP) activities at the Naval Surface Warfare Center, Dahlgren Division, White Oak Detachment (NSWCWODET) located in Silver Spring, Maryland. These activities will include investigative efforts at the following six sites:

Site 2 - Apple Orchard Landfill
Site 3 - Pistol Range Landfill
Site 4 - Chemical Burial Area
Site 8 - Abandoned Chemical Disposal Pit
Site 9 - Industrial Waste Water Treatment Area 300
Site 11 - Industrial Waste Water Treatment Area 100

The activities, including site reconnaissance, performing geophysical surveys, surface water and sediment sampling, soil borings (using multiple drilling methods including drill rigs with hollow-stem augers and hand-operated augering), soil sampling, leaching well sampling, and test pit excavation will be performed to determine the nature and extent of actual or potential site contamination. This information will also be used to determine potential remediation scenarios for these sites.

3.2 SITE HISTORY AND FACILITY DESCRIPTION

The site history and a detailed description of the facility and each of the six sites are provided in Sections 5.0 to 10.0 in the DVSAP. Copies of these documents will be maintained on-site, and be made available to all site personnel.

3.3 HAZARD EVALUATION

This hazard evaluation has been developed based on the planned DVSAP activities (as described in Section 3.1). In addition to the chemical substances (presented in Table 3-1) which may be

TABLE 3-1
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NAVAL SURFACE WARFARE CENTER, DALHGREN DIVISION, WHITE OAK DETACHMENT

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Benzene	71-43-2	I.P 9.24 eV, 100% response with PID and 10.2 eV lamp	150% response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07	1 ppm OSHA 10 ppm ACGIH . 0.1 ppm NIOSH	Inadequate - OSHA accepts the use of air-purifying respirators with organic vapor cartridge up to 10 ppm despite the inadequate warning properties **Recommended gloves:** Nitrile	**Boiling Pt:** 80°C **Melting Pt:** 5.5°C **Solubility:** 0.07% **Flash Pt:** -11°C **LEL/LFL:** 1.3% **UEL/UFL:** 7.9% **Vapor Density:** 2.77 **Vapor Pressure:** 75 mm **Specific Gravity:** 0.88 **Incompatibilities:** Strong oxidizers, perchlorates, acids **Appearance and Odor:** Colorless to a light yellow liquid with an aromatic odor	Overexposure may result in irritation to the eyes, nose, throat, and respiratory system. CNS effects include giddiness,lightheadedness, headaches, staggered gait, fatigue, and lassitude and depression. Additional effects may include nausea. Long duration exposures may result in respiratory collapse. Regulated as an OSHA carcinogen. May cause damage to the blood forming organs and may cause a form of cancer called leukemia.
1-2-Dichloroethylene	540-59-0	I.P. 9.65 eV, High response with PID and 10.2 eV lamp	50% response with FID	Air sample using charcoal tube and carbon disulfide, OSHA 07	200 ppm TWA, OSHA, ACGIH, and NIOSH	Limited data available. Should use pressure-demand supplied air respirator above exposure limits. **Recommended glove:** nitrile	**Boiling Pt:** 47°C **Melting Pt:** -13.8°C **Solubility:** 0.4% **Flash Pt:** 2.2°C **LEL/LFL:** 5.6% **UEL/UFL:** 12.8% **Vapor Density:** 2.0 **Vapor Pressure:** 180-260 mm **Specific Gravity:** 1.27 @ 32°C **Incompatibilities:** Strong oxidizers, alkalis, potassium hydroxide, and copper. When heated to decomposition temperatures will emit toxic fumes of phosgene. **Appearance and Odor:** Colorless liquid with an acrid odor.	Overexposure may result in CNS depression potential to cause sleepiness, hallucinations, distorted perceptions, and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, weakness, tremors, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, liver, kidney, and lung damage.
1,1,2- Trichloroethane	79-00-5	I.P. 11.0 eV,	105% response with FID	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromotography-flame ionization detector; OSHA 07, NIOSH 1003	OSHA, NIOSH, ACGIH 10 ppm TWA, IDLH ~500 ppm	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 500 ppm Recommended glove: Nitrile	**Boiling Pt:** 114°C **Melting Pt:** -35°C **Solubility:** 0.6% **Flash Pt:** N/A **LEL/LFL:** None established **UEL/UFL:** None established **Vapor Density:** Not available **Vapor Pressure:** 40 mm @ 20°C **Specific Gravity:** 1.44 **Incompatibilities:** Strong oxidizers, caustics, and chemically active metals **Appearance and Odor:** Colorless liquid with a sweet chloroform-like odor.	Overexposure to this substance may cause irritation to the eyes, skin, and mucous membranes of the respiratory and gastrointestinal tract. CNS effects may include sleepiness, incoordination, depression similar to a narcotic. Chronic exposure may cause liver, kidney and lung damage.

BLE 3-1 (Continued)
EMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NAVAL SURFACE WARFARE CENTER, DALHGREN DIVISION, WHITE OAK DETACHMENT

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Chloroform	67-66-3	I.P. 11.42 eV,	100% response with FID	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromotography- flame ionization detector; NIOSH 1003	OSHA 50 ppm (ceiling); NIOSH 2 ppm; ACGIH 10 ppm ~ IDLH 1000 ppm	Inadequate - Chloroform has poor warning properties but will adhere to organic vapor cartridges. Supplied air respirators are recommended. Recommended glove: Polyvinyl Alcohol	**Boiling Pt:** 143°F **Melting Pt:** N/A **Solubility:** 0.5% **Flash Pt:** N/A **LEL/LFL:** None established **UEL/UFL:** None established **Vapor Density:** Not available **Vapor Pressure:** 160 mm @ 20°C **Specific Gravity:** 1.48 **Incompatibilities:** Strong caustics, chemically active metals such as aluminum or magnesium powder, sodium and potassium, strong oxidizers **Appearance and Odor:** Colorless liquid with a pleasant odor.	Overexposure to this substance may cause dizziness, mental dullness, nausea, headache, fatigue, anaesthesia, and irritation of the skin and eyes. Chronic overexposure may result in damage to the liver, kidneys, heart, eyes and skin.
1,2-Dichloroethane	107-06-2	I.P. 11.05 eV,	80% response with FID	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromotography- flame ionization detector; NIOSH 1003	OSHA 50 ppm; ACGIH 10 ppm; NIOSH 1 ppm IDLH ~ 1000 ppm	Inadequate - This compound has poor warning properties OSHA allows the use of organic vapor cartridges in certain circumstances. Recommended glove - Polyvinyl alcohol	**Boiling Pt:** 182°F **Melting Pt:** N/A **Solubility:** 0.9% **Flash Pt:** 56°F **LEL/LFL:** 6.2% **UEL/UFL:** 16% **Vapor Density:** Not available **Vapor Pressure:** 64 mm @ 20°C **Specific Gravity:** 1.24 **Incompatibilities:** Strong oxidizers and caustics, chemically active metals such as aluminum or magnesium powder, sodium and potassium. **Appearance and Odor:** Colorless liquid with a pleasant, chloroform-like odor.	Exposure to this substance may cause CNS depression, nausea, vomiting, dermatitis, and irritation of the eyes. Chronic overexposure may result in damage to the kidneys, liver, eyes, skin and CNS.
1,1,2,2-Tetrachloroethane	79-34-5	I.P. 11.1 eV	100% response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07, or NIOSH method 1003	1 ppm TWA OSHA, ACGIH, and NIOSH Overall exposure to this substance may be contributed through skin absorption IDLH ~150 ppm	Odor threshold for this substance has been determined to be at airborne concentrations of approximately 1.5 ppm, which is considered adequate. Recommended glove: Nitrile	**Boiling Pt:** 47°C **Melting Pt:** -36 to -43.6°C **Solubility:** 0.3% **Flash Pt:** N/A **LEL/LFL:** N/A **UEL/UFL:** N/A **Vapor Density:** Not available **Vapor Pressure:** 9mm @ 66°F **Specific Gravity:** 1.59 @ 25°C **Incompatibilities:** Strong oxidizers, alkalis, fuming sulfuric acid, and chemically active metals. When heated to decomposition temperatures will emit toxic fumes of chlorine. **Appearance and Odor:** Colorless to pale yellow liquid with a pungent chloroform like odor.	Overexposure may result in CNS depression potential to cause sleepiness, hallucinations, distorted perceptions, and stupor (narcosis). Systemically, symptoms may result in nausea, vomiting, weakness, tremors, and cramps. May also irritate the eyes, skin, and mucous membranes. Chronic exposures may result in dermatitis, enlarged tender liver, kidney, and lung damage.

TABLE 3-1 (Continued)
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NAVAL SURFACE WARFARE CENTER, DALHGREN DIVISION, WHITE OAK DETACHMENT

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Toluene	108-88-3	I.P 8.82 eV, High response with PID and 10.2 eV lamp	110% response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07	100 ppm TWA OSHA 150 ppm STEL OSHA 50 ppm TWA ACGIH	Adequate - Can use air-purifying respirator with organic vapor cartridge up to 500 ppm **Recommended gloves:** Butyl rubber, Viton, neoprene or nitrile	**Boiling Pt:** 232°F **Melting Pt:** -139°F **Solubility:** 0.05% (61°F) **Flash Pt:** 40°F **LEL/LFL:** 1.2% **UEL/UFL:** 7.1% **Vapor Density:** 3.14 **Vapor Pressure:** 20 mmhg @ 65°F **Specific Gravity:** 0.87 **Incompatibilities:** Strong oxidizers **Appearance and odor:** Colorless liquid with a sweet pungent aromatic odor. Odor Threshold of 0.16-37 ppm.	Overexposure to this substance may result in mild to moderate irritation at all points of contact, CNS changes. At 200-500 ppm exposure has resulted in headaches, nausea, eye irritation, loss of appetite, bad taste, impair coordination, fatigue, and weariness
Trichloroethylene	79-01-6	I.P. 9.45 eV, High response with PID and 10.2 eV lamp	100% Response with FID	Air sample using charcoal tube and carbon disulfide desorption, OSHA 07	50 ppm OSHA TWA 200 ppm OSHA STEL 50 ppm ACGIH TWA 25 ppm NIOSH TWA	Inadequate - Should use pressure-demand supplied air respirator above exposure limits **Recommended gloves:** Viton or nitrile	**Boiling Pt:** 86.7°C **Melting Pt:** -73°C **Solubility:** 0.1% @ 25°C **Flash Pt:** 32°C **LEL/LFL:** 12.5% **UEL/UFL:** 90% **Vapor Density:** 4.53 **Vapor Pressure:** 100 mm @ 32°C **Specific Gravity:** 1.46 **Incompatibilities:** Strong caustics and alkalis, chemically active metals (barium, lithium, sodium, magnesium, titanium, and beryllium) **Appearance and Odor:** Colorless liquid with a chloroform type odor.	Central nervous system effects (euphoria, analgesia, anesthesia, paresthesia, headaches, tremors, vertigo, and somnolence) are the limiting factors in decreasing the exposures. Damage to the liver, kidneys, heart, lungs, and skin have also been reported. Contact may result in irritation to the eyes, skin, and mucous membranes. Ingestion may result in GI disturbances including nausea, and vomiting NIOSH lists this substance a potential human carcinogen.
Vinyl chloride	75-01-4	I.P. 9.99 eV, High response with PID and 10.2 eV lamp	40% response with FID	Air sample using charcoal or Anasorb CMS sorbent tube and carbon disulfide desorption with gas chromotography-flame ionization detector; NIOSH 1007, OSHA 75	1.0 ppm TWA, OSHA 5.0 ppm Ceiling, OSHA 5 ppm TWA, ACGIH Lowest Feasible Concentration; NIOSH	Inadequate - Must use an open-circuit, self-contained breathing apparatus, pressure demand type, with full facepiece. Refer to 29 CFR 1910.1017(g) for specific requirements based on atmospheric concentrations of vinyl chloride. **Recommended gloves:** Silver shield, nitrile, or Viton	**Boiling Pt:** -13.9°C **Melting Pt:** -160°C **Solubility:** slight **Flash Pt:** -6°C **LEL/LFL:** 4% **UEL/UFL:** 22% **Vapor Density:** 2.15 **Vapor Pressure:** 2600 mm @ 25°C **Specific Gravity:** N.A. **Incompatibilities:** Oxidizers, copper, aluminum, peroxides, iron, steel, **Appearance and Odor:** Colorless gas or liquid (below 56°F) with a pleasant odor at high concentrations. Odor Threshold of 10-20 ppm.	A severe skin, eye, and mucous membrane irritant. Narcotic effect causing weakness, abdominal pains, GI bleeding, and paller skin or cyanosis. Regulated primarily because of its depresant effects on the CNS and its association with the formation of malignant tumors originating from blood lymphatic vessels in the liver and kidneys (angiosarcoma and nephroblastoma). Listed as a carcinogen by NTP, IARC and ACGIH.

BLE 3-1 (Continued)
EMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NAVAL SURFACE WARFARE CENTER, DALHGREN DIVISION, WHITE OAK DETACHMENT

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Cadmium	7440-43-9	Substance is not volatile. Unable to be easily detected by PID or FID.	Not detected by FID.	Air sample using a mixed cellulose-ester filter / acid desorption and analysis by atomic absorption-flame; NIOSH 7300 or 7048.	5 $\mu g/m^3$ (.005 mg/m^3) TWA; OSHA 0.01 mg/m^3 TWA (total particulate); ACGIH 0.002 mg/m^3 (respirable particulate); ACGIH	The use of an air purifying, full face-piece respirator with a high efficiency particulate air filter.	**Boiling Pt:** 767°C **Melting Pt:** 320.9°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N.A. **Vapor Pressure:** 1 mm @ 394°C **Specific Gravity:** 8.65 @ 32°C **Incompatibilities:** Strong oxidizers, elemental sulfur, selenium, tellerium, zinc, nitric acid, and hydrazoic acid **Appearance and Odor:** Metal: Silver-white, blue-tinged lustrous, odorless solid. Fume: yellow-brown, finely divided particulate dispersed in air.	Overexposure to this substance may result in irritation to the respiratory tract, dyspnea, tightness in the chest, coughing, possibly pulmonary edema. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Chronic exposure may result in damage to the lungs, kidneys and liver. This substance has been identified as a confirmed animal; potential *human* carcinogen by IARC and NTP.
Chromium Compounds	7440-47-3 (Element)	Properties vary depending upon the *specific compounds*. Not detectable by PID.	Not detectable by FID.	Air sample using mixed cellulose -ester filter / acid *desorption and analysis* by atomic absorption; NIOSH 7024.	0.5 mg/m^3 TWA OSHA & NIOSH. 0.05 mg/m^3 TLV; ACGIH.	The use of a air purifying, full face-piece respirator with a high efficiency particulate filter.	**Boiling Pt:** 2642°C **Melting Pt:** 1900°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N.A. **Vapor Pressure:** 0 mm **Specific Gravity:** 7.14 **Incompatibilities:** Strong oxidizers, peroxides, and alkalis **Appearance and Odor:** Appearance and odor vary depending upon the specific compound.	Health hazards are characterized normally through chronic exposure manifesting as histologic fibrosis of the lungs and ulceration of the nasal septum and skin. IARC, NTP and ACGIH list various chromium compounds as possessing carcinogenic properties.
Copper	7440-50-8 (Cu) 1317-38-0 (CuO)	Substance is not volatile. Unable to be detected by PID or FID.	Not detected by FID.	Air sample using a mixed cellulose ester filer / inductively coupled *plasma/atomic emission* spectroscopy; NIOSH 7300.	0.10 mg/m^3 TWA; OSHA and NIOSH. 0.2 mg/m^3 TWA; ACGIH.	The use of an air-purifying full-face respirator with a high efficiency particulate air filter. *Recommended gloves: This is* in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 2324°C **Melting Pt:** 1083°C **Solubility:** Insoluble **Flash Pt:** *Not applicable (Airborne dust may* burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N.A. **Vapor Pressure:** 1 mm @ 1628°C **Specific Gravity:** 8.94 **Incompatibilities:** Oxidizers, alkalis, sodium azide, acetylene, bromates, chlorates, iodates, and acids. **Appearance and Odor:** Metal: Reddish, lustrous malleable, odorless solid. Fume: Finely divided black particulate dispersed in air.	Irritation to the nose, throat, and respiratory tract. Metallic taste Discoloration of skin (potential dermatitis) *and hair. Chronic exposure may result in* dermatitis and damage to the liver and kidneys. Overexposure to fumes causes symptoms characteristic of the flu (headaches, chills, muscle aches, nausea, vomiting, diarrhea). Ingestion may cause burning in the mouth, throat, and stomach. Metallic taste with colicky abdominal pain. Individuals with Wilson's disease are at greater risk of chronic exposure as a result of the bodies tendency to absorb and retain copper.

TABLE 3-1 (Continued)
CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NAVAL SURFACE WARFARE CENTER, DALHGREN DIVISION, WHITE OAK DETACHMENT

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Lead	7439-92-1	Substance is not volatile. Unable to be detected by either PID or FID.	Unable to be detected by FID.	Air sample using a mixed cellulose ester filter / HNO_3 or H_2O_2 desorption / Atomic absorption; NIOSH 7082 or 7300.	0.05mg/m^3 TWA; OSHA 0.15mg/m^3 TWA; ACGIH 0.10mg/m^3 TWA; NIOSH	The use of a air purifying, full-face respirator with high efficiency particulate air filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 1740°C **Melting Pt:** 327°C **Solubility:** Insoluble **Flash Pt:** Not applicable (Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** Not applicable **UEL/UFL:** Not applicable **Vapor Density:** N.A. **Vapor Pressure:** 0 mm **Specific Gravity:** 11.34 **Incompatibilities:** Strong oxidizers, peroxides, sodium acetylide, zirconium, and acids **Appearance and Odor:** **Metal:** A heavy ductile, soft gray solid.	Overexposure to this substance via ingestion or inhalation may result in metallic taste in the mouth, dry throat, thirst, Gastrointestinal disorders (burning stomach pain, nausea, vomiting, possible diarrhea sometimes bloody or black, accompanied by severe bouts of colic), CNS effects (muscular weakness, pain, cramps, headaches, insomnia, depression, partial paralysis possibly coma and death. Extended exposure may result in damage to the kidneys, brain, and blood.
Mercury	7439-97-6	Jerome Mercury Vapor Analyzer	Particulate form - This substance is unable to be detected by PID/FID	NIOSH Method # 6009	OSHA NIOSH ACGIH as alkyl compounds 0.01 mg/m^3; STEL 0.03 mg/m^3	No identifiable warning properties to indicate presence and thereby detection **Recommended APR Cartridge:** Suitable for Metallic mercury with HEPA filter. Preferably, with an end-of-service life indicator. **Recommended gloves:** This is in the liquid form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 356.8°C **Melting Pt:** -38.89°C **Solubility:** Insoluble **Flash Pt:** N.A. **LEL/LFL:** N.A. **UEL/UFL:** N.A. **Vapor Density:** N.A. **Vapor Pressure:** 0.0012 mm @ 25°C **Specific Gravity:** 13.6 **Incompatibilities:** Acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, lithium, rubidium, and copper **Appearance and odor:** Silvery-white heavy mobile liquid, odorless	This substance is corrosive to all points of contact. Systemic symptoms include irritability, wakefulness, muscle weakness and tremors, increased reflexes, gingivitis, anorexia, headache, tinnitus, hypermotility, GI disturbances (nausea, vomiting), diarrhea (sometimes bloody), liver changes, dermatitis, and fever. Symptoms experienced via inhalation include to those above coughing, chest pain, dyspnea, bronchial pneumonitis, and excessive salivation.
Zinc	7440-66-6	Nondetectable (particulate)	Nondetectable (particulate)	NIOSH method 7030 or 7300	OSHA 10 mg/m^3 Total dust 5 mg/m^3 Respirable fraction NIOSH 5 mg/m^3 15 mg/m^3 as a TWA ceiling ACGIH 10 mg/m^3 These TWAs are based on zinc oxide dust	No identifiable warning properties to indicate presence and thereby detection **Recommended APR Cartridge:** Suitable for dust and fume. Organic vapor acid gases with HEPA filter. **Recommended gloves:** This is in the particulate form. Therefore any glove suitable to prevent skin contact (Nitrile has been the one most widely used for the other substances).	**Boiling Pt:** 908°C **Melting Pt:** 419.8°C **Solubility:** Insoluble **Flash Pt:** N.A.(Airborne dust may burn or explode when exposed to heat, flame, or incompatible chemicals) **LEL/LFL:** N.A. **UEL/UFL:** N.A. **Vapor Density:** N.A. **Vapor Pressure:** 0 mm **Specific Gravity:** 7.14 **Incompatibilities:** Strong acids, halogens, catalytic metals, combustibles, oxidizers, nitryl fluoride **Appearance and odor:** Bluish-white, lusterous metal, odorless	Inhalation of fumes may result in metal fume fever. This condition is characterized by metallic taste, dryness of the throat, coughing with generalized aching and flu-like symptoms. Effects through ingestion may include coughing, difficulty in breathing, and sweating. A human skin irritant. Irritation to the eyes may result from mechanical action.

BLE 3-1 (Continued)
EMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
NAVAL SURFACE WARFARE CENTER, DALHGREN DIVISION, WHITE OAK DETACHMENT

Substance	CAS No.	Air Monitoring/Sampling Information			Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Aroclor-1260 (Polychlorinated Biphenyl, PCB)	11096-82-5	Substance is not volatile (VP=0.00006 mmHg), no I.P. exists, therefore PID will not detect substance	Substance is non combustible and as a result will not be detected by FID	Air sample using a Florisil sorbent tube with glass fiber filter. Hexane desorption and gas chromotography-electron capture detector, NIOSH 5503	0.5 mg/m^3 TWA, OSHA, ACGIH 0.001 mg/m^3 TWA, NIOSH	Inadequate - However due to the low volatility it is assumed, unless adgitated, this substance does not present a volatile vapor or gas respiratory threat. For dusty conditions where this material may cling to particulates, use a HEPA filter. Recommended glove: Silver shield or Viton (for pure product). Nitrile will be acceptable for incidental contact.	Boiling Pt: distallation range 385-390°C Melting Pt: N.A. Solubility: insoluble Flash Pt: Not applicable LEL/LFL: Not applicable UEL/UFL: Not applicable Vapor Density: N.A. Vapor Pressure: 0 mm Specific Gravity: 1.566 @ 15.5°C Incompatibilities: Strong oxidizers Appearance and Odor: Colorless to pale yellow, viscous liquid or solid (below 50°F) with a mild, hydrocarbon odor	Regulated primarily because of its potential to cause liver damage and chloracne. This substance is irritating to the eyes and skin. Recognized a possessing carcinogenic properties by NIOSH, and NTP.
Bis(2-ethylhexyl) phthalate	117-81-7	No information found	This is a combustible liquid therefore the FID should detect it however the relative response ratio is unknown	NIOSH Method # 5020	OSHA NIOSH ACGIH 5 mg/m^3 STEL 10 mg/m^3	Irritating, tingling sensation Recommended APR Cartridge: Suitable for dust and fume. Organic vapor acid gases with HEPA filter. Recommended gloves: Nitrile has been the one most widely used for the other substances and is acceptable for this substance. Other options include butyl rubber or neoprene	Boiling Pt: 386°C Melting Pt: freezes -14°C Solubility: insoluble Flash Pt: 215°C LEL/LFL: 0.3% @ 245°C UEL/UFL: N.A. Vapor Density: N.A. Vapor Pressure: <0.01 mm Specific Gravity: 0.99 Incompatibilities: Nitrates, strong oxidizers, acids, and caustics. Appearance and odor: Colorless, oily liquid, odorless	This substance is a mild skin, eye, mucous membrane irritant, and mild gastric disturbance.

encountered in the conduct of planned site activities, physical hazard potentials are also addressed in Section 3.4 of this HASP. A task-specific hazard assessment summary is provided in Table 3-2.

Evaluation of the chemical hazard potentials identified will be predominantly accomplished through the use of real-time direct reading monitoring instrumentation and adherence to action level responses (specified in Section 4.0 of this HASP). To some extent, these evaluation means will be supplemented by personnel attention to substance warning properties such as appearance, characteristic odor, and recognition of symptoms as specified in Table 3-1.

Evaluation of physical hazards will be predominantly accomplished through direct observations by the Site Safety Officer and other field team personnel.

Based on limited available information, the following have been identified as primary hazards of concern for the sites to be investigated:

Contaminant(s):

Volatile Organic Compounds
Semivolatile Organic Compounds
Metals
PCBs
Unexploded Ordnance (UXO)

The exposure limits, recognition qualities, acute and chronic effects, and first aid treatments are presented in Table 3-1.

Upon arrival at the base, the Halliburton NUS TL/SSO will meet with personnel from the Base Fire Protection Department, Base Security, Emergency Services, Public Works, OSH, Explosive Safety, and Environmental Department to notify coordinators of the activities to be undertaken and where. All personnel will be required to follow base emergency procedures when needed. Emergency medical services will be obtained from off-site services as needed.

TABLE 3-2

TASK SPECIFIC HAZARD SUMMARY

TASK	ASSOCIATED HAZARDS	APPLICABLE CONTROLS
Geophysical surveys	• Uneven or unstable terrain • Fall from elevated surfaces • Natural hazards • Exposure to site contaminants • Contact with UXO	1. Strict adherence to standard work practices. 2. Proper use of appropriate PPE. 3. Performance of air monitoring.
Sampling activities (surface water, sediment, groundwater and soil sampling)	• Exposure to site contaminants • Water hazards • Natural hazards • Heat/cold stress • Inclement weather • Strain/muscle pulls • Uneven/unstable terrain • Contact with UXO	1. Performance of air monitoring. 2. Proper use of appropriate PPE. 3. Decontamination activities. 4. Strict adherence to standard work practices. 5. Follow UXO guidelines and monitoring with Magnetometer.
Soil borings	• Exposure to site contaminants • Exposure to pinch and compression points • Potential to be struck by or entangled in heavy machinery • Contact with energized sources • Noise in excess of 85 dBA • Natural hazards • Inclement weather • Contact with UXO • Heat/cold stress • Cuts from sharp objects	1. Performance of air monitoring. 2. Proper use of appropriate PPE. 3. Decontamination activities. 4. Strict adherence to standard work practices. 5. Follow UXO guidelines and monitoring with Magnetometer. 6. Use of hearing protection.
Test pit excavations	• Exposure to site contaminants • Potential to be struck by or entangled in heavy machinery • Contact with energized sources • Noise in excess of 85 dBA • Natural hazards • Inclement weather • Contact with UXO • Heat/cold stress • Cuts from sharp objects	1. Performance of air monitoring. 2. Proper use of appropriate PPE. 3. Decontamination activities. 4. Strict adherence to standard work practices. 5. Follow UXO guidelines and monitoring with Magnetometer. 6. Use of hearing protection.

3.4 PHYSICAL HAZARDS

Physical hazards which could be involved in the execution of this scope of work include, but are not limited to, the following items:

- Uneven or unstable terrain (slip/trip hazards)
- Strain/muscle pulls from manual lifting
- Fall from elevated surfaces
- Exposure to pinch/compression points
- The potential for a worker to be struck by or entangled in heavy machinery
- Contact with energized sources
- Noise in excess of 85 dBA
- Water hazards
- Natural hazards (e.g., snakes, ticks, mosquitos, poisonous plants, etc.)
- Inclement weather
- Heat stress
- Cold stress
- Contact with UXO

Control efforts for these potential hazards will encompass and possibly combine use of proper equipment maintenance, guarding, and operation. Additionally, adherence to proper standard work practices and standard operating procedures (located in DVSAP) will aid in the elimination of these hazards. Each of the above-mentioned items is further detailed below.

No confined space entry is planned during this field investigation.

3.4.1 Uneven/Unstable Terrain

Planned activities described in the scope of work for of this DVSAP will bring field personnel into areas where this potential hazard exists (e.g., river and pond banks, marshy areas, loose and shifting ground cover of disposal areas, landfills). In addition, test pits are anticipated to be excavated. At no time shall workers or equipment be located within 2 feet of the edge of the test pit, as this area is susceptible to cave-ins. Personnel will not be permitted to enter any excavation. Excavations should be performed in accordance with OSHA 29 CFR 1926 Subpart P.

As it has been determined that this hazard may exist in various locations, it will be the Task Leader's responsibility (in accordance with SOP and Safe Work Practices) to inspect, document, and put in place control measures to prevent placing equipment or personnel at risk.

3.4.2 Strain/Muscle Pulls

Strain/muscle pulls may result from improper lifting techniques during mobilization, sampling, or demobilization. Proper lifting techniques or help should be used in activities involving manual material handling, such as placement, positioning, packing, or unpacking of heavy equipment. This information will be covered as part of the Site-Specific Training.

3.4.3 Elevated Working Surfaces

Due to variations in elevation (e.g. steep drop-offs, cliffs, mounded debris) employees should be aware of the hazards associated with such features. A steep embankment borders Sites 2 and 3. In view of the hazards associated with a vertical drop, employees should execute extreme caution when working at these sites. Geophysical work and any sampling shall be restricted to no closer than 5 ft. from the edge of the drop-off.

3.4.4 Pinch/Compression Points

Pinch and Compression Points of sampling equipment may result in injury. All equipment must be maintained in proper working order, with machine guarding devices in place. Any equipment found to be lacking in these areas shall be removed from service. Additionally, all personnel shall be properly trained in the use and function of all equipment used within the investigating activity. All equipment associated with this operation will be initially and periodically inspected by the SSO in an effort to avert hazards of this type. All equipment on which maintenance has been performed will be reinspected by the SSO prior to its return to service.

3.4.5 Struck by or Entangled in Heavy Machinery

The performance of soil borings will be accomplished through drilling operations which will require the use of a drill rig and backhoe. The most predominant physical hazard associated with this type of work is entanglement of safety equipment or clothing into the rotating augers. To address this hazard, a thorough inspection of all equipment will be performed to remove potential snag points and to ensure

emergency stop devices operate properly and all members of the field team know the location and operation of these devices. Persons working in close proximity of the drill rig will be required to secure all loose clothing or protective equipment to avoid possible entanglement. The use of a long-handled shovel or the equivalent will be used to remove drill cuttings away from the hole and from rotating tools. In addition, pins that protrude from augers shall not be allowed.

The performance of test pits will be accomplished through excavation operations which will require the use of a backhoe or the equivalent. Workers have the potential to be struck by the boom of the backhoe during excavation operations. To address this hazard, workers will remain a safe distance (a distance greater than that at which the boom can extend) and maintain two-way visual contact with the operator. In addition, no sampling activities of the test pits will be permitted while excavating activities are being performed. No, one under any circumstances, shall enter a test pit. Personnel must use remote samples to collect samples (if required) or collect the samples from the backhoe bucket.

All mechanized equipment brought on-site to complete this scope of work will be inspected initially prior to the commencement of on-site activities and then periodically thereafter. These inspections will be performed by the SSO and will include that the following are ensured:

- All safety guards are in place
- All safety-restraints (i.e. seatbelts) are in place and functioning properly as required by Federal regulations
- All mobile equipment is equipped with a backup alarm and emergency stop device
- All operators are qualified to do so. All drivers will be required to have their Commercial Drivers License
- Traffic Control Measure Routes and regulations will be established and adherence required.
- All maintenance performed on the equipment will employ manufacturers recommended parts, and be inspected prior to returning to services by the SSO.

In addition to the requirements established by this HASP all heavy equipment and/or the movement of may also be bound to meet local or site-specific regulations. Control measures for these hazards are presented in Section 9.0 "Standard Work Practices".

3.4.6 Contact with Energized Sources

One of the hazards associated with the execution of this scope of work is the potential for encountering energized sources (i.e. pressurized lines, water lines, telephone lines, buried utility lines), primarily while engaged in drilling and/or excavation activities. Due to the obvious ramifications associated with this hazard, extreme caution and strict adherence to procedures to detect, identify, and take evasive action shall be followed during the completion of the scope of work. Efforts will be made through local contacts, as built drawings (where available) along with geophysical surveys to identify potential locations. Positive readings will require the relocation of a soil boring point. To further avoid hazards of this type, no drilling mast, boom, 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. Any such utilities identified shall be physically marked and avoided.

3.4.7 Noise in Excess of 85 dBA

Noise exposures exceeding the OSHA Permissible Exposure Limit could be encountered during certain phases of site operations. Personnel who are repeatedly overexposed could experience a permanent reduction in their hearing ability. Appropriate hearing protectors will be worn when in close proximity to drilling and excavating operations, as determined by the SSO. It shall also be the responsibility of the SSO to ensure the application, use, and maintenance of occupational noise protective measures shall be determined and proceed in accordance with OSHA 29 CFR 1910.95.

3.4.8 Water Hazards

As proposed in the scope of work, activities will take place near the water's edge. To avoid potential hazards associated with working near water (e.g. falling in, or sinking in the mud) the field team will use extreme caution when working within 4 feet of the water's edge, or when working in marsh/wetland areas. However, surface water bodies at the site consist only of shallow low flowing streams. Due to the obvious hazards associated with near water's edge during inclement weather, all

field activities may be temporarily suspended or terminated at the discretion and direction of the Task Leader, or Site Safety Officer representative.

3.4.9 Natural Hazards (ticks, snakes, and other indigenous creatures)

Natural hazards such as poisonous plants, bites from poisonous or disease carrying animals or insects (e.g., snakes, ticks, mosquitoes) cannot be avoided in 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 repellents. Nesting areas in and about sampling points shall be avoided and another point selected within the same vicinity. Lastly, within recent years a marked increase in Lyme Disease has been reported. For this operation, this is a significant point as ticks (which are the primary vectors of this disease) have been encountered during previous visits to this site. In an effort to control this hazard, close attention will be given during operations and decontamination with regard to personal hygiene to detect and remove ticks once they adhere to the body. A discussion on Lyme Disease (including issues of recognition, evaluation and control) has been included as Attachment A-III of this Health and Safety Plan. It should be noted the primary constituents associated with insect repellant agents may jeopardize sample integrity. Therefore, care must be taken not to contaminate samples collected in these site operations.

3.4.10 Inclement Weather

As all work will be conducted outdoors, inclement weather may be encountered. As conditions may vary, it will be at the discretion and direction of the Task Leader and the Site Safety Officer representative to temporarily suspend or terminate activities as conditions dictate. All activities will be terminated in the advent of electrical storms. Activities in areas with possible UXO will also cease in the event of thunderstorms and personnel within these areas will be required to leave the area immediately. The NSWC Explosive Safety Officer (ESO) will be notified in advance of any work in areas which may contain UXO. Arrangements will be made with the White Oak lightning detection system for notification when lighting is detected in the vicinity of the facility.

3.4.11 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 Task Leader and the Site Safety

Officer shall initiate heat stress monitoring, and effect the appropriate control measures. American Conference of Governmental Industrial Hygienists (ACGIH)-recommended control measures for this hazard are included in Attachment A-I.

3.4.12 Cold Stress

The cold stress Threshold Limit Values (TLVs) are intended to protect workers from the most severe 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 than 35°C (95°F) is 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.

For more information concerning cold stress effects and control measures see Attachment A-I.

3.4.13 Contact with UXO

Contact with UXO is a potential problem at the sites under investigation. Therefore, all of these sites will first be surficially cleared by a UXO expert (Halliburton NUS EOD personnel) prior to initiation of activity. In addition, the NSWC ESO will be notified in advance of any work in areas which may potentially contain UXO. Particular care must be given to areas of heavy vegetation owing to the fact that the ground surface may be obscured. If suspected explosive contamination or UXO is discovered at any time during operations at a site where it was not previously suspected or which has been cleared, operations will be stopped immediately in the affected area, all personnel will be excavated to a safe distance, the location will be marked, and the following phone call will be initiated:

- NSWC, Fire Department X41333 (301-394-1333).

NSWC emergency protocols will assure that appropriate contacts are notified.

The following are hazards associated with encountering UXO:

- Fire
- Blast
- Heat
- Fragmentation
- Jet
- Over-pressure
- Ejection
- Propulsion

These are all produced in varying combinations as a result of the intended or unintended functioning of a high or low explosive. The most effective protection from all hazards of explosives is a safe separation distance. The risk of exposure to these hazards by personnel conducting UXO operations must be kept to the absolute minimum necessary to perform the operation. All other personnel must be at or beyond the safe separation distance. This distance will be adjusted by the HNUS UXO specialist as the situation dictates.

3.5 UNEXPLODED ORDNANCE (UXO)

Due to the potential of encountering UXO during planned field activities, arrangements have been made to provide UXO support to all sites. These UXO operations are addressed in detail in a Standard Operating Procedure (SOP) of the HASP, attached. A copy of that SOP will be presented to all site personnel prior to the initiation of site activities, and all personnel will be required to review and sign a site-controlled copy of that document as part of their site-specific health and safety training. A summation of UXO procedures, controls, and restrictions is as follows:

a) NSWC ESO will be notified in advance of any work in areas where UXO may be present.

b) Explosive Ordnance Disposal (EOD)-qualified personnel and necessary equipment will be available for all field activities.

c) All geophysical survey locations where UXO is a potential hazard will be screened by Halliburton NUS UXO Specialists for UXO prior to the initiation of survey activities. A magnetometer will be used to conduct the screening.

If UXO is discovered at any time during site activities, operations will be stopped immediately, the location will be marked, all personnel will evacuate the area, and the following contacts will be made:

- NSWC Fire Department, X41333 (301-394-1333)
- NSWC ESO

During all UXO-related hazardous operations, a qualified UXO Specialist (who is a Master-rated EOD technician) will be mobilized to perform these services.

4.0 AIR MONITORING

This section presents requirements for the use of real-time air monitoring instruments during site activities involving potential for exposure to site contaminants. It establishes the types of instruments to be used, the frequency of which they are to be used, techniques for their use, action levels for upgrading/downgrading levels of protection, and methods for instrument maintenance and calibration.

4.1 INSTRUMENTS AND USE

4.1.1 HNu-PI101 Photoionization Detector

A HNu PI-101 photoionization detector (PID) with a 11.7 eV lamp will be used to monitor potential source areas and to screen the breathing zones of employees during soil boring, sampling, excavation of test pits, or any intrusive activities. The PID has been selected because it is capable of detecting organic gases and vapors and some inorganic gases and vapors. Detection is based on the contaminants ionization potential in comparison to the lamp energy, which has to be equal to or greater than the ionization potential of the contaminant. When calibrated with isobutylene, the PID has a one-to-one correspondence with benzene.

Prior to the commencement of any field activities, the background levels of the site must be determined and noted. Daily background readings must be taken away from areas of potential contamination to obtain accurate results. These readings, any influencing conditions (i.e., weather, temperature, humidity) and location will also be documented in the Health and Safety Logbook as a matter of reference.

Any positive instrument responses observed above background levels will be considered to indicate contaminant release. As such the following actions will be taken:

- Monitor work areas continuously, concentrating on worker breathing zones (BZ) areas (head and face regions) when positive source results are reported. If readings are observed at these areas to be at background levels, continue monitoring and work efforts.

- If sustained or repeated intermittent readings in the workers BZ are above background, workers are to retreat to an unaffected area and remain until further determinations regarding the contaminant are made or until further direction from the FOL.

- If background levels are regained, work may resume, with continuous monitoring via instrument usage.

- If background levels are not regained, the SSO shall determine what controls are necessary to permit work activities to resume (i.e. upgrading respiratory protection, additional air sampling such as colorimetric tube sampling to identify the contaminant).

4.1.2 OVA-Model 128 Flame ionization Detector

The use of an Organic Vapor Analyzer (OVA) (Flame Ionization Detector) may also be utilized to screen potential source emissions and the breathing zones of employees during the execution of the scope of work or during any intrusive activities which may release airborne emissions. The OVA has been selected because it may detect the presence of long chain hydrocarbons more efficiently than a photoionization detector (PID). The relative response for BTEX compounds range from 100-150%. Both instruments are suitable for use, and are offered here as alternative devices, based on the field technicians' knowledge and level of comfort using these instruments.

Positive readings indicated by the OVA will result in actions as discussed above for the HNu-PI101 Photoionization Detector. These devices are used as primary screening tools to detect contaminants which are readily released into the environment and that may pose an increased threat to site workers.

NOTE: A summary of air monitoring types are given in Table 4-1. It should be realized that many of the contaminants of concern are nondetectable using these types of screening instruments, therefore primary emphasis will be given to visual observation as these contaminants may present themselves as particulates or bound to particulates.

4.2 ADDITIONAL MONITORING REQUIREMENTS

In addition to the above mentioned air monitoring devices the use of a combustible gas indicator (CGI), oxygen survey meter will be required. The types of monitoring instruments specified by the hazard and the action levels to upgrade personnel protection are shown in Table 4-2. All monitoring equipment

TABLE 4-1

AIR MONITORING TYPE AND FREQUENCY

TASK(S)	ATMOSPHERIC HAZARD(S)	MONITORING TYPE & FREQUENCY
Geophysical surveys Soil borings, test pits	Flammable/Explosive Toxic Particulates UXO	**PID/OVA** - potential sources continuously, Breathing zone based on positive results at potential source areas. **LEL/O_2 meter** - continuously **Magnetometer** = per SOP direction **Visual Observation** - for dusty conditions since contaminants may be present in particulate form or bound to particulates
Sampling Subsurface soil Surface soil Sediment	This is a task driven specification. Each site has varying potentials for exposure. However, all sites may contain the following atmospheric hazards; Flammable/Explosive Toxic Particulates UXO	As these are intrusive activities, monitoring may be used to detect hot spots and respective airborne concentrations. Any such hot spots detected, will observe continuous monitoring requirements, as specified below. **PID/OVA** - during the initial opening of the well casing or area of surface water, then periodically if conditions so dictate **LEL/O_2 meter** - continuously **Magnetometer** = per SOP direction **Visual Observation** - for dusty conditions since contaminants may be present in particulate form or bound to particulates

TABLE 4-2

ACTION LEVELS FOR NSWCWODET

INSTRUMENT	ACTION LEVEL	RESULTANT ACTION
HNu PHOTOIONIZATION DETECTOR	Any sustained readings above established background levels in workers' breathing zones.	Retreat to an unaffected area and allow the work area to ventilate. Work may not resume until further determinations as to the identity of the contaminant are made.
OVA Detector	Any sustained reading greater than background	Same actions as for the HNu Photoionization detector.

shall be maintained following procedures outlined in the Halliburton NUS Standard Operating Manual for Monitoring Equipment.

4.3 MONITORING SCHEDULE

4.3.1 Air Monitoring Requirements - HNu and OVA

Air monitoring with the HNu PI-101 and OVA will be initiated at potential sources of vapor emissions. The following potential sources are anticipated.

- All intrusive activities (i.e. soil boring, test pit excavations, drill cuttings, sampling, etc.)
- Decontamination procedures
- Any time chemical odors are perceived
- All potential sources of exposure

4.3.2 Air Monitoring Frequency

All site readings (including indications of no positive readings) must recorded on the direct reading instrument response sheet provided in Table 4-3. Site readings may instead be recorded in the Health and Safety Logbook provided that the same information is recorded as that specified in Table 4-3.

The following schedule used in conjunction with Table 3-1, will be followed, but not limited to, for air monitoring activities as specified for each activity:

NOTE: The use of air purifying respirators are not suitable for protection against inhalation of vapors associated with several of the site contaminants. As a result, the presence of any concentrations in the workers breathing zone will require workers to retreat to an unaffected area. Continued work in areas in which PID readings exceed background levels will require a qualitative and semi-quantitative determination as to the chemical(s) of concern. This may be accomplished through the use of colorimetric tubes. Based on the results of this air monitoring the presence of these contaminants and the need for respiratory protection may be confirmed or dismissed.

4.4 VISUAL OBSERVATION

Based on the hazard assessment, the potential exists for contaminants to be present in the form of a particulate. Any observations of airborne dusts or particulates should be noted and attempts shall be made to minimize generation of dust emissions. Controlling particulate generation and dispersal is accomplished through work practices such as wetting down areas of potential dust generation. Any visible dust concentrations which cannot be controlled (particularly at Sites 2, 3 and 11) will require discontinuation of site activities.

4.5 INSTRUMENT MAINTENANCE AND CALIBRATION

Air monitoring instruments will be maintained and pre-field calibrated by the equipment supplier. With regard to HNu usage, field calibration will be performed daily prior to the initiation of work. An additional calibration will be performed at the end of the day to determine any significant instrument drift. All calibration efforts will be documented in the Equipment Calibration Log or the Site Health and Safety Logbook. Information provided must include the following: Calibration information shall include the following:

- Dates calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Any relevant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Any relevant comments or remarks

Field maintenance will consist of daily cleaning of the instruments using a damp towel or rag to wipe off the instrument's outer casing and overnight battery recharging.

4.6 RECORDKEEPING

All instrument readings above and including background levels must be recorded on Figure 4-3, or in the field Health and Safety Logbook. This shall indicate the date, instrument operator's name, instrument used (type, model number, I.D. No.), location of the reading (eg. borehole, breathing zone, etc.), reading(s) observed, workers potentially affected, and actions taken to reduce exposures. In addition, results of any colorimetric analysis must be recorded in the log book. The absence of

instrument responses (excursions above background levels) must also be recorded, at least on a daily basis. Lastly, information concerning influencing factors (i.e. weather, activities, interferences) which may have had an impact on the results shall also be recorded.

4.7 INSTRUMENT USE

The PID, OVA, and the LEL/O_2 meters will be used primarily as screening tools during, sampling activities which might release emissions of toxic contaminants. Their selection is based on chemicals readily released into the environment.

TABLE 4-3

DIRECT-READING INSTRUMENT RESPONSE SHEET

SITE NAME_____ PROJECT

NUMBER_____

PAGE_____ OF _____

Date and Time(s)	Instrument Operator Name	Instrument Used	Instrument Reading and Duration	Location (eg. Boreholes vs. Breathing Zone)	Operation(s) being Performed	Personnel in Vicinity at Time of Readings and Level of PPE Worn
Example: 12-12-94/ 14:30	Joe Field	HNu-PI101	15 ppm / 15 min	Breathing Zone	Installation of Well No. 12	Jim Technician / Level B George Grunt / Level B

5.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

This section presents requirements for the use of personal protective equipment for each of the activities being conducted as defined in Section 3.0 of this HASP. This section includes anticipated levels of protection for each of the activities, the criteria used for selecting various levels of protection, and criteria for modifying levels of protection based on monitoring instrument readings and personal observations.

5.1 ANTICIPATED LEVELS OF PROTECTION

Most work associated with this project is anticipated to be performed in a **modified** Level D Protection, as defined in Appendix B of OSHA Standard 29 CFR 1910.120 - "Hazardous Waste Operations and Emergency Response." Many sampling activities will require the use of chemical resistant coveralls, gloves, and boot covers as presented in the task breakdown which follows. Where activities overlap, the more protective requirements will be applied It is not anticipated that an upgrade to level C respiratory protection will be required during any field activities to be undertaken at this site. However, prior to initiation of work with exclusion zones or Level A, B or C PPE, clearance will be received from NSWC Environmental and Public Affairs Offices.

5.1.1 Minimum Requirements (All Tasks)

Minimum requirements include steel-toe and steel shank work boots, chemical resistant boot covers, with standard field dress consisting of long pants and long-sleeved shirts. Hard hats and safety glasses will be worn when overhead or eye hazards exist based on the task or if working in and around machinery. Tyvek coveralls may be worn to provide protection against contact with natural hazards such as ticks and poisonous plant-life. It will be at the discretion of the TL or the SSO based on tasks, site conditions, and other influencing factors for the use of optional equipment. This is of course providing action levels or the requirements of this plan are not compromised when additional elements of personal protection are required.

5.1.2 Mobilization/Demobilization, Geophysical Surveys and Site Reconnaissance

As mobilization, demobilization and geophysical survey activities present limited potentials for contacting the suspected hazardous materials associated with some tasks, the minimum requirements will be adhered to for these tasks. Disposable boot covers will be worn when on-site as much of the contaminants may exist on the surface.

5.1.3 Soil Borings, Test Trenches

Minimum requirements include steel-toe, steel shank work boots, chemical resistant boot covers, Tyvek coveralls, and nitrile or butyl rubber outer gloves over inner latex or nitrile (chemical resistant) gloves. In addition, hard hat and safety glasses will be worn when working in close proximity to machinery, equipment, or when the potential for eye or overhead hazards exist. If the potential for saturation of work cloths exists, the use of PVC or PE-coated Tyvek can substituted in place of Tyvek. Additional personal protective items may include hearing protection during the operation of mechanized equipment as specified in section 3.4.7.

5.1.4 Surface and Subsurface Soil Sampling

Hard hats, when necessary, safety glasses, steel-toe, steel shank work boots, disposable boot covers, Tyvek coveralls with taped ankle and wrist seams, nitrile or latex inner gloves (layered as necessary), and nitrile or butyl rubber outer gloves. Since soil within the borings has the potential to be saturated with water, the use of PVC, or PE-coated Tyvek coveralls are required whenever there is a potential for saturation of work clothes.

5.1.5 Sediment Sampling

Hard hats, when necessary, safety glasses, steel-toe, steel shank work boots, disposable boot covers, Tyvek coveralls with taped ankle and wrist seams, nitrile or latex inner gloves (layered as necessary), and nitrile or butyl rubber outer gloves. Since sampling surface water and sediment has the potential to saturate work cloth the use of PVC, or PE-coated Tyvek coveralls are to be worn whenever this potential exists. In addition, the field team shall employ lifelines, safety harnesses, and U.S. Coast Guard approved personal flotation devices when working within four feet of the waters edge or on boats.

5.1.6 Decontamination Activities

The PPE requirements for decontamination activities will include the minimum requirements for all tasks (See Section 5.1.1) and the use of PE-coated Tyvek or PVC with nitrile outer and inner gloves when the potential for saturation of work clothing exists, and splash shield as necessary or as directed by the FOL or SSO. This will be the required level of protection when performing large scale decontamination activities such as cleaning augers and drill flights. The general rule of thumb for respiratory protection will be to require the same level as, or one below, that of the field personnel who were using the equipment.

5.2 PPE SELECTION CRITERIA

Based on the site activities, the volatility, and concentrations of contaminants, that are anticipated to be encountered (based on previous sample results), and dispersion of potential vapors via natural ventilation (i.e. wind currents), vapor concentrations in worker breathing zones are not anticipated to be at levels which would warrant respiratory protection for most tasks. However, there is always the potential for vapor concentrations to be present and the potential also exists for dust emissions containing site contaminants to be generated. Dust emissions can be inhaled or ingested and result in exposure. If dust emissions are observed and cannot be controlled (i.e. via area wetting techniques), site activities must desist until a determination as to the need for respiratory protection is made. Initiation of this action will be determined by either the TL or SSO.

Nitrile or butyl rubber gloves were selected to provide protection against the potential site contaminants that could be encountered and to help reduce the amount of contaminants ingested as a result of incidental hand to mouth contact. Additionally, many of the site contaminants (PCBs, carbon tetrachloride, 1,1,2-tricloroethane, and 1,1,2,2-tetrachloroethane) are capable of being absorbed through the skin which may result in the potential for a significant contribution to the overall exposure. Nitrile or butyl rubber gloves in conjunction with latex inner gloves have been determined to provide an adequate barrier to the skin based on the low concentrations anticipated to be directly contacted. Hard hats, safety glasses, and work boots were selected to provide protection against some of the physical hazards associated with the proposed operations and disposable boot covers were selected to help minimize the spread of contamination. Tyvek coveralls were selected to minimize the potential for contamination of street clothes, and to protect against contact with natural hazards (i.e. ticks, poisonous plant-life, etc.). PVC of PE coated Tyvek coveralls were selected for use in the event that sampling activities have the potential to result in the saturation of work clothes.

5.3 PPE MODIFICATION CRITERIA

This section presents criteria for upgrading and downgrading chemical protective clothing and/or respiratory protection. Where uncertainties arise, the more protective requirement will apply.

5.3.1 Chemical Protective Clothing Modification Criteria

Tyvek coveralls and boot covers must be worn anytime there is a reasonable potential for contamination of street clothes. Polyvinyl chloride (PVC) or PE-coated Tyvek coveralls must be worn anytime there is a reasonable potential for saturation of work clothes. Nitrile or butyl rubber gloves must be worn anytime there is a reasonable potential for contact with site contaminants. The use of PVC or PE-coated Tyvek should particularly considered when performing intrusive activities at Sites 2 and 11, as these sites have been indicated as areas in which skin absorbent contaminants (PCBs, carbon tetrachloride, 1,1,2-tricloroethane, and 1,1,2,2-tetrachloroethane) are predominately present.

5.3.2 Respiratory Protection Modification Criteria

Site activities are to be discontinued in the event that visible dust concentrations or air monitoring equipment indicates the presence of volatile contaminants within the workers breathing zone (see Table 4-2). Therefore, the use of respiratory protection may only be utilized after further determinations as to the identity of the chemical contaminant. Respiratory protection will only be used following identification of the chemicals of concern and notification of the Health Sciences Department.

In the event that respiratory protection is required the following criteria shall imposed. Respirators belong to, and are only to be used and maintained by, the individual to whom they have been issued. All personnel working on-site must be trained, fit-tested, and declared medically fit to wear respiratory equipment prior to participating in field activities. Respirators shall be cleaned, sanitized, and properly stored after each day's usage by the user. The SSO will periodically inspect all respiratory equipment to ensure that use, application, storage, and maintenance are in accordance with 29 CFR 1910.134.

5.4 PPE INSPECTION

As part of donning, all personnel will be responsible for performing inspections on their items of PPE. These activities will include glove leak tests and close visual inspection of all coverall seams. Proper PPE inspection techniques will be required as part of initial site-specific safety training.

5.5 PPE TRAINING

Site-specific training will include information concerning use, proper fit, donning, doffing, and the limitations of the protective garments. In addition, as part of physical hazards, the temperature extremes as associated with PPE will be discussed.

TABLE 5-1

PROTECTIVE EQUIPMENT FOR ONSITE ACTIVITIES

Activity	Level	Protective Equipment
All site activities (Geophysical survey and sampling activities)	C[1] (not anticipated)	• Chemical-resistant (Tyvek) clothing • Outer nitrile or butyl rubber and inner latex or nitrile (chemical-resistant) gloves • Safety boots, with nitrile or butyl rubber outer boots (or rubber steel-toed boots) • Hard hat[2] • Type of respiratory protection is dependent upon identification and semi-quantitative determination of chemical contaminant.
	Modified D (anticipated level required)	• Tyvek coveralls / work clothes • Safety boots with disposable boot covers • Safety glasses/goggles • Hard hat[2] • Hearing protection (as directed) • Inner latex or nitrile and outer nitrile or butyl rubber gloves

[1] Use of Level C (respiratory protection) requires qualitative and semi-quantitative identification of site contaminants. In addition, clearance must be obtained from the Health Science Department and from NSWC Environmental and Public Affairs Offices.

[2] Halliburton NUS UXO Specialists are not required to wear hard hats or steel-toed boots, unless determined necessary by the HNUS Site Safety Officer.

6.0 DECONTAMINATION

Decontamination is the procedure to be employed to remove and/or neutralize site contaminants encountered through the execution of the scope of work. This procedure will be employed for the purpose of preventing cross contamination, protecting on-site personnel, and protecting the individuals outside this operation from the spread of contamination.

6.1 STANDARD PROCEDURES

1. As part of each site's mobilization activity the SSO and TL will establish a personnel decontamination station suitable to handle the activities, type and the amount of anticipated contamination, and the level of protection to be used. This area will be located adjacent to the exclusion zone or work area, and will consist of the stations described in section 6.2.

2. Upon leaving the contamination area (exclusion zone), all personnel shall proceed through the appropriate contamination reduction sequence.

3. All protective gear should be left on-site during any lunch break following decontamination procedures.

4. Also as part of mobilization, a central decontamination area for heavy equipment will be established. The equipment upon completing the task at hand will require that at least the wheels and tires to be cleaned prior to moving to the decontamination area. This area should be accessible to resources and emergency services.

5. All equipment will be inspected by the TL or SSO and approved prior to leaving the decontamination area within the contamination reduction corridor.

6. All discarded materials (i.e. drill cuttings, decontamination fluids) will be drummed, labeled, and staged to await sample analyses.

6.2 PERSONNEL DECONTAMINATION REQUIREMENTS

The decontamination of personnel and their protective clothing shall be performed in sequential stages. These stages shall include:

- Removing contamination from protective clothing and equipment with a detergent/water solution and soft bristle scrub brushes.
- Removal of protective clothing (disposable items shall be discarded into a container conspicuously marked "Potentially Contaminated Clothing").
- Workers washing hands and face with potable water and soap whenever they remove PPE and leave the exclusion zone.

The maximum decontamination layout is described in the following Table. Within this format the **bolded** sections represent the minimum requirements for all tasks conducted in an established exclusion zone. Should the task or scope require use of the material identified as optional, those sections will become mandatory (at the discretion of the on-site safety representative).

Maximum/Minimum Measures for Decontamination

Station 1:	**Segregated Equipment Drop**	**Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different plastic-lined containers. Segregation at the drop reduces the probability of cross contamination.**
Station 2:	**Boot Cover and Glove Wash**	**Scrub outer boot covers and gloves with detergent and water.**
Station 3:	**Boot Cover and Glove Rinse**	**Rinse off from Station 2 using as much water as necessary.**
Station 4:	Suit and Safety Boot Wash. As applicable as not all operations will require the use of protective suits.	Wash splash suit, gloves, and safety boots. Scrub with long-handled scrub brush and decon solution. If disposable suits are worn (i.e. Tyvek) skip to station 6.
Station 5:	Suit and Safety Boot Rinse	Rinse off decon solution using water. Rinse Repeat as many times as necessary.
Station 6:	Tape Removal	Remove tape around boots and gloves and deposit them in the plastic-lined container.
Station 7:	**Boot Cover Removal**	**Remove boot covers and deposit them in the plastic-lined container for decontamination and reuse.**
Station 8:	**Outer Glove Removal**	**Remove outer gloves and deposit them in a plastic-lined container for disposal.**

Station 1:	**Segregated Equipment Drop**	**Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different plastic-lined containers. Segregation at the drop reduces the probability of cross contamination.**
Station 9:	Cartridge or Mask Change (Level C usage). As applicable not all operations will require respiratory protection.	If worker leaves exclusion zone to change cartridges (or mask), this is the last step in the decontamination procedure. Worker's cartridges exchanged, new outer gloves and boot covers donned, and joints taped. Worker returns to duty.
Station 10:	Splash Suit Removal	With the helper's assistance, remove splash suit. Deposit it in the plastic-lined container.
Station 11:	Respirator Removal (if worn)[1]	Remove face piece. Deposit it in a plastic-lined container. Avoid touching face with fingers.
Station 12:	**Inner Glove Removal**	**Remove inner gloves and deposit them in the plastic-lined container.**
Station 13:	**Field Wash**	**Wash hands and face with potable water.**
Station 14:	Heat stress evaluation/Break Heat stress monitoring will be conducted on a as needed basis.	If heat stress monitoring procedures are engaged, they should be performed at the very beginning of the break periods. Break areas should consist of a shaded area with the ability to provide drinking fluids to personnel, if necessary.

(1) Respirators (if worn) will be cleaned and sanitized at a latter time following the conclusion of personnel decontamination, and are therefore not considered a part of this sequence.

6.3 MINIMAL DECONTAMINATION

Less extensive procedures for decontamination can be established when Level D protection is utilized, when the type and degree of contamination are known, or when the potential for transfer is judged to be minimal by the SSO. These procedures generally may involve one or two washdowns only, and/or progressive removal (and disposal, as appropriate) of items of PPE.

6.4 EQUIPMENT DECONTAMINATION

The drill rig and all drilling tools and hand augers will be steam cleaned between boreholes. All downhole tools, samplers, and other downhole equipment will be steam cleaned between boreholes. Under muddy conditions, the back end of the drill rig and wheels will also be steam cleaned, as needed, between boreholes. A decontamination pad at will be used for steam cleaning and decontamination operations.

6.5 DECONTAMINATION OF SAMPLING TOOLS

All sampling equipment will be cleaned between sample acquisitions in accordance with the requirements established in the sampling plan. In addition, all sampling equipment that will be leaving the site will require

a thorough decontamination, and approval by the TL or SSO to verify it has been properly decontaminated, prior to leaving the site. This can be accomplished either by steam cleaning or by a detergent wash and potable water rinse until tools are visibly clean.

6.6 EMERGENCY DECONTAMINATION PROCEDURES

Any person who becomes ill or is injured in the exclusion zone must be decontaminated to the maximum extent possible. If the injury or illness is minor, full decontamination should be completed and first aid administered prior to transport to a medical facility. If the victim's condition is serious, a partial decontamination should be performed if it does not place the injured person at greater risk. (i.e., complete disrobing of the victim and redressing in clean coveralls or wrapping in a blanket). First aid should be administered while awaiting an ambulance or paramedics. In the event of a catastrophic incident (explosion or large release) personnel should evacuate to a safe location without performing any decontamination efforts, unless it can be determined that doing so would further jeopardize the welfare of the individual.

6.7 PROTECTION REQUIRED BY DECONTAMINATION PERSONNEL

Personnel assisting with decontamination procedures will wear the same level of protection as those they are decontaminating or one level below, depending on the stage of decontamination with which they are assisting. Assistants who are stationed at the first stages of decontamination will be in the same level of protection as those being assisted. At stages where the outer garments are already removed and containerized, the decontamination assistants will wear the lower level of protection.

6.8 CLOSURE OF THE PERSONNEL DECONTAMINATION STATION

All disposable PPE, clothing, and plastic sheeting used during the operation will be washed via regular decontamination procedures and contained on-site in a Halliburton NUS dumpster to await disposal by Halliburton NUS. No materials are to be placed in any NSWCWODET dumpsters. Decontamination-generated wastes will also be contained on-site for ultimate disposal by Halliburton NUS. Reusable rubber clothing will be dried and prepared for future use. (If gross contamination has occurred, discard the item.) Cloth items will be bagged and removed from the site for final cleaning. All wash tubs, pail containers, etc., will be thoroughly washed, rinsed, and dried prior to removal from the site. The SSO will be responsible for inspecting and clearing equipment to proceed to the next location and to leave the site.

6.9 DECONTAMINATION EVALUATION

The decontamination process effectiveness will be judged in the following manner.

- Visual observation - Discoloration, stains, visible dirt, and alterations of the fabric due to chemical contact will be the primary method used to determine effectiveness.

The following methods may be used if gross contamination is encountered:

- Monitoring Instrumentation - Instruments used to detect site contaminants may be employed to scan garments and equipment for the presence of site contaminants after decontamination procedures have been employed.

- Decontamination Solution Analyses - An analyses of the solution (final rinse) and the presence of contaminants may suggest additional cleaning is required. This information may be useful in the ultimate disposal of the fluids generated.

- Sample Analyses - sample analyses may indicate the level of contamination and therefore the potential for contamination. Once again this information may be useful in the ultimate disposal.

It is suggested that a combination of methods be used to determine the effectiveness of the decontamination of the process used.

7.0 TRAINING REQUIREMENTS

This section describes the minimum requirements for initial, refresher, and site-specific training.

7.1 INTRODUCTORY AND REFRESHER TRAINING

The site-specific training form, to be signed by all onsite workers, is provided in Figure 7-1.

7.1.1 Requirements for HALLIBURTON NUS Personnel

All Halliburton NUS personnel must complete 40 hours of introductory hazardous waste site training prior to performing work at NSWCWODET. 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.

All Halliburton NUS personnel functioning in the supervisory capacity will have had Management and Supervisory training as required by 29 CFR 1910.120 (e)(4). No field personnel will function independently from a supervisor, unless they also satisfy this requirement.

Documentation of Halliburton NUS introductory, supervisory, and refresher training will be maintained at the project. Copies of certificates or other official documentation will be used to fulfill this requirement.

7.1.2 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 at the sites. All subcontractor personnel serving in the supervisory capacity will have had Management and Supervisory training as required by 29 CFR 1910.120 (e) (4). 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 7-2. Accompanying that letter (or submitted separately prior to the initiation of any on-site activities), copies of training certificates will be provided for all subcontractor personnel. Figures 7-2 and 8-2 can be combined into one letter.

FIGURE 7-1

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing sampling activities at NSWCWODET, 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

FIGURE 7-2

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. Donald Olmstead
Project Manager
Halliburton NUS Environmental Corp.
661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: Hazardous Waste Site Training - NSWC White Oak,

Dear Mr. Olmstead,

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)

NOTE: Copies of training certificates must also be attached with this letter, or otherwise provided prior to the initiation of any on-site activities.

7.1.3 Subcontractor Exceptions

Subcontractors such as surveying teams who will not perform any activities in the exclusion zone during sampling tasks or where there is no potential for exposure, will be excluded from the requirements stipulated in Section 7.1.2.

7.2 SITE-SPECIFIC TRAINING

Halliburton NUS will provide site-specific training to all Halliburton NUS employees and subcontractor personnel who will perform work on 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

7.2.1 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 7-1 will be used to document site-specific training.

7.3 OTHER TRAINING

At least one member of the field team will possess current certification in first aid and cardiopulmonary resuscitation.

8.0 MEDICAL SURVEILLANCE

8.1 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. The Halliburton NUS medical surveillance program meets the requirements specified in 29 CFR 1910.120(f).

Documentation for medical clearances will be maintained on-site and made available as necessary.

8.2 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 8-1) 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 8-1 with a letter, on company letterhead, containing all the information in the example letter presented as Figure 8-2. Figures 7-1 and 8-2 can be combined into one letter.

8.3 REQUIREMENTS FOR ALL FIELD PERSONNEL

Each field team member (including subcontractors) shall be required to complete and submit a copy of Attachment A-II (Medical Data Sheet). This shall be provided to the SSO prior to participating in site activities.

FIGURE 8-1

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 NSWCWODET, work site
   ( ) not qualified to perform work at the NSWCWODET, 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 8-1
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 or treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at the NSWCWODET, Silver Spring, Maryland 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 8-2

MEDICAL SURVEILLANCE LETTER

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. Donald Olmstead
Project Manager
Halliburton NUS Environmental Corp.
661 Andersen Drive
Pittsburgh, Pennsylvania 15220

Subject: Medical Surveillance - NSWC, White Oak, Maryland

Dear Mr. Olmstead,

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 NSWC, White Oak, Maryland.

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)

9.0 STANDARD WORK PRACTICES

The following Standard Work Practices are to be applied in addition to the Health and Safety SOPs (see Part C: Vol. 2):

* 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.

* 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 as applicable) 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 A-II).

* 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. No matches or lighters (sparking devices) are permitted on-site. Hot permits must be obtained from the base fire department.

* 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 SSO 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 SSO and obtaining a Confined Space/Limited Egress Permit from the Halliburton NUS Health and Safety Manager or his designee.

* A full-size copy of the OSHA poster included as Attachment A-IV of this HASP shall be conspicuously posted on-site.

* Any new information must be promptly conveyed to the Project SSO and the Task Leader.

* All compressed gas cylinders used (empty or full) must be stored, secured, and used properly to protect from damage.

* Material Safety Data Sheets for all chemical substances brought on-site will be collected and maintained at the Command Post (the site trailer). These documents will be reviewed with the users of the substances prior to any usage or handling.

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 by the TL shall ensure, 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 (and 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 able 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 shut down operations if the sampler must go 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.

Excavation/Trenching Operations

- All excavation and trenching operations must comply with 28 CFR 1926 Subpart P.

- No one, under any circumstances, will enter an excavation or trench until it has been deemed safe to do so by a competent person in accordance with 29 CFR 1926 Subpart P and 29 CFR 1910.146.

- Personnel must stand away from the reach of the backhoe, tires, and outriggers of excavating equipment and a minimum of 2 feet from the edge of any excavation or trench.

- To prevent cave-in, excavations and trenches must be sloped at a ratio of 1½:1 at the sides where personnel will stand or where equipment will be positioned. A lesser slope may be considered acceptable by OSHA 29 CFR Subpart P depending on the type of soil and other conditions.

- No open pits will be left unattended, under any circumstances, unless adequate precautions are taken to prevent access.

- The backhoe operator will not undermine the excavation.

- A competent person will frequently inspect the excavation/trench for slide or cave-in potential as required by 29 CFR 1926 Subpart P.

HEAVY EQUIPMENT MAINTENANCE AND OPERATION

- Heavy equipment must be operated in accordance with 29 CFR 1926 Subpart O.

- Heavy equipment will not be operated in a manner that could cause the equipment to roll over or slide into an excavation.

- Dump vehicles will be level before the bed is raised. Dump beds will be smooth to prevent loads from sticking at the front (top) of the bed. No one will stand on either side of the dump vehicle while the bed is being raised or lowered as it is always a possibility that the vehicle will roll on its side.

- A safety tire rack, cage, or equivalent protection must be used when inflating, mounting, or dismounting tires on split rims, or rims equipped with locking rings or other similar device.

- All cab glass will be kept clean and will not impair the safe operation of the equipment.

- All equipment will be operated at least 20 feet from overhead power lines and other electrical equipment unless otherwise permitted by 29 CFR 1926.550(a)(15).

- Equipment which has an obstructed view to the rear must be equipped with an audible reverse (backup) alarm.

- Haulage vehicles with cabs will be equipped with a cab shield or canopy to protect the operator from falling and shifting loads.

- All equipment must be equipped with seat belts except those which do not have roll-over protective structures. When seat belts are provided, they must be used.

- All equipment will be inspected at the beginning of each shift in accordance with 29 CFR 1926.601(b)(14).

- Equipment operators will wear hearing protection unless the owner of the equipment can demonstrate that noise exposures will not exceed the OSHA Permissible Exposure Limit.

UXO AREAS

* No souvenir hunting.

* Do not pick up or disturb unidentified items

* Report all UXO or unidentified objects.

* Do not excavate or sample any areas until they have been checked for the presence of UXO.

* Do not go outside the boundaries of the access routes or work sites.

* Do not enter uncleared areas of the site.

* Do not carry any fire or spark producing devices into the site.

* Allow the screening EOD technician to lead when surveying potential UXO areas.

10.0 EMERGENCY RESPONSE

In the event of an emergency, all site personnel will be evacuated to a predetermined location away from the work place. Emergency Response Planning will follow in accordance with 29 CFR 1910.38(a). The Contractor shall coordinate site activities with Base Fire Protection and Emergency Services in order to avoid potential emergencies. The Contractor shall utilize Base Fire Protection and Emergency Services as a first response to any emergency situation. Emergency Medical Services will be provided off-base by White Oak Rescue Squad, and will be escorted on-base by the Base Fire Department. For Police services, the Contractor shall call Base Security first. If outside Police are required, Base Security will call off-base Police and escort them on-base.

10.1 PRE-PLANNING

Upon initial arrival at the base, the Halliburton NUS TL/SSO will meet with the Base Fire Protection Department and Emergency Services and Base Security Personnel to notify coordinators of the activities to be undertaken and where. All site personnel will be required to follow base emergency procedures and will rely on base services to handle emergency situations if encountered. Medical service will be provided off-site by the White Oak Rescue Squad.

Another task in Emergency Pre-Planning efforts will be to designate appropriate emergency escape routes and safe places of refuge for the site activity areas. These designations may change on a daily basis due to factors such as wind direction, the type and extent of emergency situation warranting the need for evacuation, among others. The TL will identify any changes in escape routes and refuge points in the morning briefing.

10.2 EMERGENCY ESCAPE PROCEDURES AND ASSIGNMENTS

Upon notification of a site emergency requiring evacuation, all site personnel will proceed to predetermined locations based on emergency location and wind directions. Extent of decontamination procedures will be dependent upon extent of the emergency requiring evacuation. If personnel cannot reach those locations without endangering life or health, an alternate meeting place will be selected. Personnel will be trained to remain at the refuge until directed to resume work, or leave the site.

10.3 PROCEDURE TO ACCOUNT FOR SITE PERSONNEL

The site work force will be small enough that accounting for personnel will not be a problem. Accounting for personnel will be the Task Leader's responsibility. This will be accomplished by taking a roll call using the site logbook.

10.4 RESCUE AND MEDICAL DUTIES

Site personnel will not be authorized to participate in emergency rescue operations. During UXO survey activities the attendant or buddy will remain informed of the areas cleared in order to facilitate the rescue of UXO members.

10.5 ACTIVATION OF EMERGENCY RESPONSE PROCEDURES

Should any emergency occur which requires the support of outside services, the TL/SSO will contact:

NSWC Fire Department X4133 (301-294-1333).

Emergency numbers and directions to the nearest hospital are provided in Table 10-1.

A hand-held radio will be available on-site to provide for timely communication between the Field Team Leader and Range Control. All radio communication devices will be Hazards of Electromagnetic Radiation to Ordnance (HERO) approved prior to use.

Examples requiring outside services are as follows:

- Any field crew member involved in an accident or experiencing signs and symptoms of exposure.
- A condition discovered which suggests the activity is more hazardous than anticipated.
- Emergency services in nearby areas which directly impact operations.

Persons who observe an emergency situation must notify Base Contacts, Base Services, and Office Contacts once the situation is assessed as being out of local control.

Additional emergency response information is contained in Section 10.0 of the Standard Operating Procedure of the DVSAP (SOP No. C8M-0800-043-93). This will be reviewed with all site personnel as part of the site-specific training, and a copy will be maintained on-site.

10.6 INCIDENT FOLLOW-UP

On receiving a report of an incident (or near-incident), the FOL/SSO shall immediately investigate and make the appropriate recommendations to prevent recurrence. The CLEAN HSM shall immediately be notified by telephone. At his discretion he may wish to participate in the investigation. Details of the incident shall be documented on an Incident Report within 24 hours of its occurrence and distributed to the Project Manager and CLEAN HSM. Contractor shall fill out a White Oak Incident Report within 24 hours of occurrence, and submit it to the Base Environmental Office.

TABLE 10-1

EMERGENCY INFORMATION
(TO BE POSTED ON THE SITE)

Police	Sheriff	911
Fire	Base Fire Department	394-1333
Emergency	Base Fire Department	394-1333
Ambulance	Rescue Squad	911
Hospital	Holy Cross Hospital Emergency Room Hospital Information	 (301) 905-1225 (301) 905-0100
Poison Control	Contact Base Fire Department	394-1333
Base Contact	Environmental Office Contact: Bill Spicer	394-2439
HALLIBURTON NUS Project Manager	Don Olmstead	(412) 921-8616
HALLIBURTON NUS Health & Safety Officer	Don Westerhoff	(412)921-8457
CLEAN Health and Safety Manager	Matthew M. Soltis	(412)921-8912

Maps depicting directions from the site to the hospital shall be obtained and attached to this Health and Safety plan prior to the commencement of site activities.

Directions to Holy Cross Hospital:

Exit base, make left on New Hampshire Rd. Continue 3 miles to I-495, take East to Exit 31, Georgia Ave. Make right at first light (Forrest Glen Rd). Hospital is four blocks up on right side.

11.0 CONFINED SPACE

No Confined-Space Operations are planned to be involved as part of the field activities. Therefore, specific procedures for such efforts are not applicable and are not addressed in this section. Should any confined-space situations arise, the site health and safety officer should be notified immediately before any action is taken.

12.0 SPILL CONTAINMENT AND CONTROL

Every member of the site team will be responsible to observe and report liquid chemical releases or conditions that could lead to releases. No release or spill of contaminated liquids is anticipated in the implementation of the DVSAP. Therefore, specific procedures for such efforts for spill containment and control are not applicable and are not addressed in this section. Should any spill containment or control situations arise, the site health and safety officer should be notified immediately before any action is taken.

13.0 SITE CONTROL

This section outlines the means by which Halliburton NUS will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a three-zone approach will be used during work at this site: exclusion zones, contamination reduction zones, and support zones.

13.1 EXCLUSION ZONE

Exclusion zones will be those areas of the site with known or suspected contamination. In many cases, however, significant amounts of surface contamination will not be encountered in the proposed work areas of this site unless contaminants are brought to the surface by soil boring or some other intrusive activities. Once such activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can be reclassified as part of the contamination reduction zone. Therefore, the exclusion zones for this project will be limited to those areas of the site where active work is being performed and/or anywhere there is believed to be the potential for inhalation or ingestion exposure to site contaminants.

The zone structure for this operation will encompass the size necessary to conduct operations; this is regarded as an area of 50 feet around the point of operation. This may be altered in specific instances based on available room, site topography, or restraining circumstances. Additional circumstances may affect zone structure and operation. In addition, due to the potential for UXO, support parameters of a zone may be increased or decreased at the direction of EOD, based on the perceived hazards.

Once the work in exclusion zones is completed the area must be restored to its former condition prior to turning over access to base personnel. Once efforts are employed to clean and restore the area of all debris and work materials, cuttings, etc., the TL or SSO will be responsible for clearing the area to be released to the general base personnel and will document this approval.

13.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) will be a buffer area between the exclusion zone and any area of the site where contamination is not suspected. The personnel and equipment decontamination area

established for this project will be located in the CRZ. This area will serve both as a focal point in supporting exclusion zone activities and as the access and control point to the exclusion zone. Closure of this zone will require the same procedures as employed for the exclusion zone, as these zones are opened and closed as the operation moves about the base.

13.3 SUPPORT ZONE

The support zone for this project will include a staging area where site vehicles will be parked, equipment will be unloaded, and food and drink containers will be kept. In all cases, support zones will be established at areas of the site where exposure to site contaminants is not expected during normal working conditions or foreseeable emergencies.

13.4 SITE PREPARATION

In an effort to minimize as many foreseeable hazards as possible, site preparation in addition to UXO clearance will be performed by the TL and the SSO prior to the initiation of on-site activities in any new area. Physical hazards and potential chemical hazards which cannot be removed, identified, or barricaded to prevent possible exposure will be identified as per the safety briefing prior to the commencement of activities in that area. As part of this preparation procedure, the TL and the SSO will identify evacuation routes, assembly points, means of communication for that site, and emergency routes for medical assistance.

Staging areas for each site for investigation derived wastes will be constructed prior to the commencement of activities within that area. All resource equipment will be placed in preparation for support of all exclusion zone activities. The locations of staging areas will be approved by the NSWC Environmental Office.

13.5 SITE MAP

Once the areas of contamination, access routes, topography, and dispersion routes are determined, a site map illustrating the particulars of each site and the location of these planned activities will be generated, and will be adjusted as site conditions change. These maps will be posted in the trailer/office to illustrate up-to-date collection of contaminants and adjustment of zones and access points and be used for safety briefings to inform personnel of zone demarcations and restrictions.

13.6 BUDDY SYSTEM

Personnel engaged in on-site activities will practice the "buddy system" to ensure the safety of all personnel involved in this operation.

13.7 MATERIAL SAFETY DATA SHEET REQUIREMENTS

Halliburton NUS personnel will provide material safety data sheets (MSDSs) for all chemicals brought on site. The contents of these documents will be reviewed by the SSO with the users of the chemical substances prior to actual use or application of the substances on-site. The MSDSs will then be maintained in a central, temporary office and will be available for anyone to review upon request. The SSO will develop and maintain an inventory of all such chemical substances brought on-site, and will perform other functions necessary to comply with the OSHA Hazard Communication Standard (1910-1200.

13.8 COMMUNICATION

As personnel will not always be working near one another during field activities, a supported means of communication may be necessary. For this purpose, two-way radio communication will be used. All means of communication will have NSWCWODET and UXO approval prior to use. Radio communications for emergency services while engaged in emergency response activities on base will be curtailed, in areas identified by the base, due to the susceptibility of UXO to the hazards associated with electromagnetic radiation to ordnance.

For external communication, the locations of telephones will be identified prior to initiation of work at each site. External communication will be used primarily for the purpose of resource and emergency communications.

13.9 SITE/ZONE SECURITY

Initial lines of security for operations at each site will be established by the TL and SSO. Zone security will be maintained by all site personnel involved in this operation. Zone identification, demarcation, and zone/access control points are to be monitored by site personnel, and a list of personnel cleared to enter the area of investigation will constitute a secondary safeguard. Lastly, the TL and the SSO will be able to temporarily terminate all operations should this security be compromised. Only those

persons who have met the requirements of this plan and are approved for site clearance may enter an exclusion zone.

14.0 DOCUMENTATION AND EQUIPMENT

This section summarizes documentation and equipment required for the support of this HASP. Its purpose is a final checklist to help ensure that all the necessary resources are available to carry out the requirements of this HASP.

14.1 DOCUMENTATION

- Health and Safety Logbook
- HASP (Signed Copy)
- OSHA Poster 11 x 14
- MSDSs (if applicable)
- Medical Data Sheets
- Employee Training Certificates
- Medical Surveillance Documentation
- Incident Reports
- Respirator Fit Test Records
- Site-specific training records

14.2 HEALTH AND SAFETY EQUIPMENT

- First Aid Kit (Physician-Approved)
- ANSI-approved Eye Wash
- Class ABC Fire Extinguishers
- Nitrile Gloves
- Inner Gloves
- Tyvek
- Chemical Resistant Tyvek - Saranex, hooded with welded seams
- Barricade Tape
- Boot Covers
- Duct Tape
- Decon Kit (Alconox tube, brush, sorbants, step stool)
- Particle Monitor

- Portable Micro-R (Micro-rem) Meter
- Portable Count-Rate Meter with GM-Pancake Detector
- Hard Hats, Safety Glasses
- Splash Shield
- Steel Toe/Shank Boots
- Photoionization Detector (PID)
- Magnetometer
- Air Purifying Respirator with cartridges

ATTACHMENT A-I

HEAT/COLD STRESS

COLD STRESS

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 fibrillation
21	69.8	

Core Temperature		Clinical Signs
°C	°F	
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.

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.

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 initiated 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.

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.

* Adapted from Occupational Health & Safety Division, Saskatchewan Department of Labor.

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 temperature 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.

Note: This information has been adopted from the **1992-1993 "Threshold Limit Values** for Chemical Substances and Physical Agents and **Biological Indices"** by the American Conference of Governmental Industrial Hygienists (ACGIH).

HEAT STRESS

Heat Stress

The SSO 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 onsite may be monitored utilizing biological monitoring.

One of the following biological monitoring procedures may be utilized by the SSO to monitor heat stress concerns.

- 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. A Standard Operating Procedure for heat stress control is also included in this Appendix.

HEAT RELATED EMERGENCIES SIGNS, SYMPTOMS, AND EMERGENCY CARE

Because some physically demanding field work is expected to take place during summer months, heat stress and exhaustion are potential problems. Therefore a "Heat Related Emergency" pamphlet is attached to this safety plan.

Heat Rash

Also known as prickly heat, this condition affects the skin. It occurs in situations where the skin remains wet most of the time. The sweat ducts become plugged and a skin rash soon appears.

Signs and Symptoms

1. Skin rash will appear on affected areas of the body.
2. Tingling or prickling sensation will be felt on the affected areas.

Emergency Care

1. Shower after working in the heat
2. Dry the skin thoroughly
3. Change underwear as needed
4. Stay in cool place after work hours.
5. Avoid repeated exposure to heated environment until condition improves, when possible.

Heat Cramps

Heat cramps are muscle pains, usually in the lower extremities, the abdomen, or both, that occur after profuse sweating with accompanying salt depletion. Heat cramps most often afflict people in good physical condition, who overwork in conditions of high temperature and humidity. Untreated, heat cramps may progress to heat exhaustion.

Treatment for heat cramps is aimed at eliminating the exposure and restoring the loss of salt and water.

Signs and Symptoms

1. Cramps in the extremities and abdomen that begin suddenly during vigorous activity. Heat cramps can be mild with only slight abdominal cramping and tingling in the extremities, but more commonly present intense and incapacitating pain in the abdomen and extremities.

2. Respiration rate will increase, decreasing after the pain subsides.

3. Pulse rate will increase

4. Skin will be pale and moist.

5 Body temperature will be normal

6. Generalized weakness will be noted as the pain subsides.

7. Loss of consciousness and airway maintenance are seldom problems with this condition.

Emergency Care

1. Move the worker to a cool environment. Have him lie down if he feels faint.

2. If the person is nauseated, avoid giving him anything orally until the nausea subsides.

3. If the person is not nauseated he may be given one or two glasses of an electrolyte solution. Have the person drink slowly. The use of salt tablets is not recommended because they may cause nausea.

4. Avoid massaging the cramping muscles. This rarely helps and may actually aggravate the pain.

5. As the salt and water level is replenished, the worker's pain will subside. He may wish to return to work; however, this is NOT recommended for a period of 12 hours. Further exertion may lead to heat exhaustion or heat stroke.

Heat Exhaustion

Heat exhaustion is a more severe response to salt and water loss, as well as an initial disturbance in the body's heat-regulations system. Like heat cramps, heat exhaustion tends to occur in people working in hot environments. Heat exhaustion may progress to heat stroke. Treatment for heat exhaustion is similar in principle to that for heat cramps.

Signs and Symptoms

1. Heat exhaustion may be accompanied present by a headache, fatigue, dizziness, or nausea with occasional abdominal cramping. More severe cases of heat exhaustion may resulting partial or complete temporary loss of respiration nd circulation due to cerebral ischemia.

2. Sweating will be profuse.

3. Pulse rate will be rapid and weak.

4. Respiration rate will be rapid and shallow.

5. The skin will be pale and clammy

6. The body temperature will be normal or decreased.

7. The person could be irritable and restless.

Emergency Care

1. Monitor the person's airway and level of consciousness. If this is a true medical emergency, prompt intervention by Emergency Medical Services is recommended.

2. Move the person to a cool environment. Take off as much of his clothing as possible and place him in a supine position with his legs elevated.

3. Sponge the person with cool water. If you fan the person, avoid chilling. When the body shivers, this energy is released in the form of heat and actually can increase the body temperature.

Heat Stroke

Heat stroke is caused by a severe disturbance in the body's heat-regulating system and is a profound emergency: The mortality rate ranges from 25 to 50 percent. It is most common in men over 40, especially alcoholics. It can also occur to people of any age having too much exposure to the sun or prolonged confinement in a hot atmosphere. Heat stroke comes on suddenly. As the sweating mechanism fails, the body temperature begins to rise precipitously, reaching 106°F (41°C) or higher within 10 to 15 minutes. If the situation is not corrected rapidly, the body cells -- especially have very vulnerable cells to the brain--are literally cooked, and the central nervous system is irreversibly damaged. The treatment for heat stroke is aimed at maintaining vital functions and causing as rapid a decrease of body temperature as possible.

Signs and Symptoms

1. The person's pulse will be strong and bounding.
2. The skin will be hot, dry, and flushed.
3. The worker may experience headache, dizziness, and dryness of mouth
4. Seizures and coma can occur.
5. Loss of consciousness and airway maintenance problems can occur.

Emergency Care

1. Establish an open airway.

2. Move the person to a cool environment. Take off as much clothing as possible, and place him in a semireclining position with the head elevated.

3. Use any means to cool the worker. Improvise with whatever is available. A bathtub filled with cold water and ice cubes is effective. Remember, speed is essential; delay may result in permanent brain damage. Vigorous efforts to cool the worker must continue until the body temperature is below 102° F (38.9°C).

4. This is a true medical emergency--prompt intervention by Emergency Medical Services is recommended.

These are only guidelines for heat related emergencies. Actual training in emergency medical care or basic first aid is recommended.

Cold Stress

The cold stress TLVs are intended to protect workers from the most severe 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. For a single, occasional exposure to a cold environment, a drop in core temperature to no lower than 35°C (95°F) is 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.

For more information concerning cold stress effects and control measures see Attachment 2.

Heat Stress

As this scope of work will require the use of various types of 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 FOL and the SSO 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 attached to this HASP as Appendix 3), and the ACGIH recommended control measures, (also included in Attachment 3).

ATTACHMENT A-II

MEDICAL DATA SHEET

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 _____ work site
   ( ) not qualified to perform work at the _____ 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:

1. Results of the medical examination and tests (excluding finding or diagnoses unrelated to occupational exposure):

   _____

   _____

   _____

SUBCONTRACTOR MEDICAL APPROVAL FORM
PAGE TWO

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

ATTACHMENT A-III

TICK CONTROL

LYME DISEASE

Lyme disease has become a worldwide problem since its identification in 1976. This disease is characteristically recognized as being transmitted by ticks, which may be encountered by field personnel while working at this site. As a result, this discussion has been included with this Health and Safety Plan to provide for adequate recognition, evaluation, and control efforts to minimize the occurrence and effects of this potential hazard.

The discovery of Lyme disease is credited to Dr. Allen Steere of Yale University Medical School, and is named after the community where it was reportedly first encountered, Lyme, Connecticut. This disease can be transmitted to Man through the bite of ticks that are infected with a corkscrew-shaped microbe (spirochete). The spread of this disease has been so rapid that in 1984 it surpassed Rocky Mountain Spotted Fever as the most common tick-borne disease in the United States. In this country, most of the incidents of this disease have been recorded in the Northeast, and the tick species most commonly attributed with its spread is the deer tick.

Recognition

This potential hazard exists primarily in the spring and summer, as these are the seasons that tick populations and activity flourish. In fact, 90 percent of the reported cases occur from early June through September. Also, this concern exists primarily in heavily vegetated areas. Therefore, recognition of these factors can aid in the awareness and control of this threat.

To aid in the recognition and identification of these insects, an example illustration of the tick species common to the region where this site is located has been included with this discussion. This species (the American Dog tick) is common in the eastern half of the United States, typically in areas covered with grass or underbrush. These insects attach themselves to animals (including humans) that pass through the area and rub against them. After finding a host, the tick inserts its mouthparts and sucks blood until it is fully engorged. This requires from 3 to 12 days, after which the tick drops off. This tick has also been identified as a transmitter of Rocky Mountain Spotted Fever and the organisms of tularemia and possibly relapsing fever. The wounds left by tick bites can be painful and can also have a paralyzing effect commonly referred to as tick paralysis.

The earliest symptom of the onset of this disease is usually the occurrence of an unusual red skin rash. This is commonly the first indication, since many persons who have contracted the disease were, in fact, unaware that they had been bitten. This rash can appear at the site of the bite anywhere from several days to a few weeks after the bite. It typically starts as a small red spot, and then expands as the spirochetes expand from the bite location. The size of the rash can vary, but it most commonly is 2 or 3 inches in diameter. This rash will fade (with or without treatment) after a few weeks. Body sites where rashes frequently occur include the thigh areas, groin, and armpits. It is not uncommon for a rash to develop in more than one place. Close inspection is necessary to detect this symptom, however, as the rashes are easy to miss because they very often are faint.

Other early symptoms include profound fatigue, a stiff neck, and flu-like symptoms such as headache, chills, fever, and muscle aches. Recognition of the onset of any of these symptoms is important since tick bites do not always produce a rash.

If left untreated, the disease will progress to its second stage within weeks or months after the infection. In this stage, the heart and nervous system are affected. A common second-stage symptom is paralysis on one or both sides of the face. Others include severe headache, encephalitis, or meningitis. The third and final stage, which can occur up to a year or more after the bite, involves the development of chronic inflammatory arthritis.

Evaluation

Evaluation of this hazard potential principally involves field personnel performing careful close self-inspection, especially of their head, for the presence of ticks each time they leave the site. Personnel should be aware that when a tick attaches itself to its host, it inserts its entire head under the surface of the skin.

Control

There are several steps to be taken to control this threat. First, field personnel must be aware of the climate and area conditions which are commonly associated with tick infestation. Second, when working in or walking through potentially infested areas, personnel must ensure that they have no exposed body parts (i.e., they must at least wear long-sleeved shirts and long pants, particularly when protective coveralls are not worn). In heavily vegetated areas where infestation is likely, Tyvek coveralls will be required to minimize this hazard potential. Also, several commercial products have been demonstrated as being effective in repelling ticks. Examples of these include Permanone, Off!, and Cutter. These repellents will be used only

at the direction and discretion of the site Safety Officer, and only in accordance with the manufacturer's recommendations. In most instances, however, such repellents are typically applied to the outside surfaces of clothing (and not directly onto the skin); they should also be applied to shoe tops, socks, pants cuffs, and other areas most susceptible to ticks. Care should be taken to prevent the contamination by the repellents of any samples for chemical analysis.

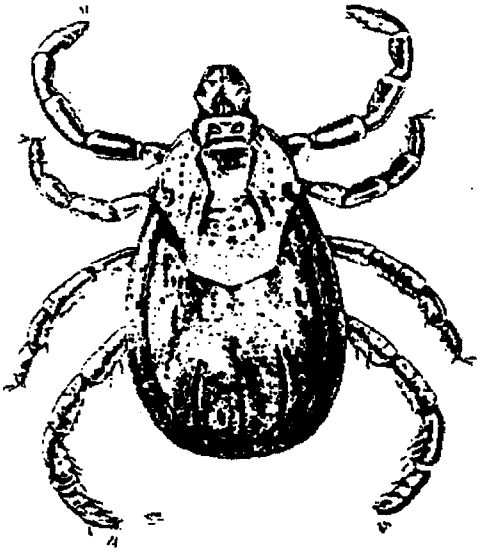
Tick Removal

In the event that a tick is discovered to be attached to a member of the field team, timely removal of the insect is critical to reducing the potential for contracting the disease. According to available information and research, at least a few hours elapse from the time of the bite until the tick transmits the microbe (spirochetes are not present in the mouth parts of the tick). However, because a tick bite is frequently unnoticed, the tick may not be discovered in time. Therefore, early removal is very important. The preferred method is to pull the tick out with tweezers or small forceps. In this method, the tick should be grasped as close to the mouth as possible and then pulled steadily upward. Care must be exercised so as not to pull in a jerking motion, as this can result in the head of the tick becoming detached. After the tick has been removed, the bite is disinfected with rubbing alcohol or povidone iodine (Betadine). The tick must not be handled, as the microbes can enter the body through any break in intact skin. The bite should be checked occasionally for at least a 2-week period to see if a rash forms. If it does, medical attention must be sought promptly.

In order to provide for proper and timely response to tick bites, the Health and Safety Officer will ensure that the site First Aid Kit is equipped with medical forceps and rubbing alcohol, in addition to the standard kit contents. Also, an adequate supply of commercial insect (tick) repellent will be maintained on-site, and all personnel will be trained in its proper application and will be required to use it, at the direction of the Health and Safety Officer.

Tick Picture

An unengorged female American dog tick, Dermacentor variabilis



ATTACHMENT A-IV

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 ma 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 fin 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 program: 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.
1985
OSHA 2203

William E. Brock, 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.

ATTACHMENT A-V

DESIGN VERIFICATION SAMPLING AND ANALYSIS PLAN
UNEXPLODED ORDNANCE SUPPORT
STANDARD OPERATING PROCEDURE

APPENDIX B

FIELD FORMS

SAMPLE LOG SHEET

Halliburton NUS CORPORATION

☐ 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

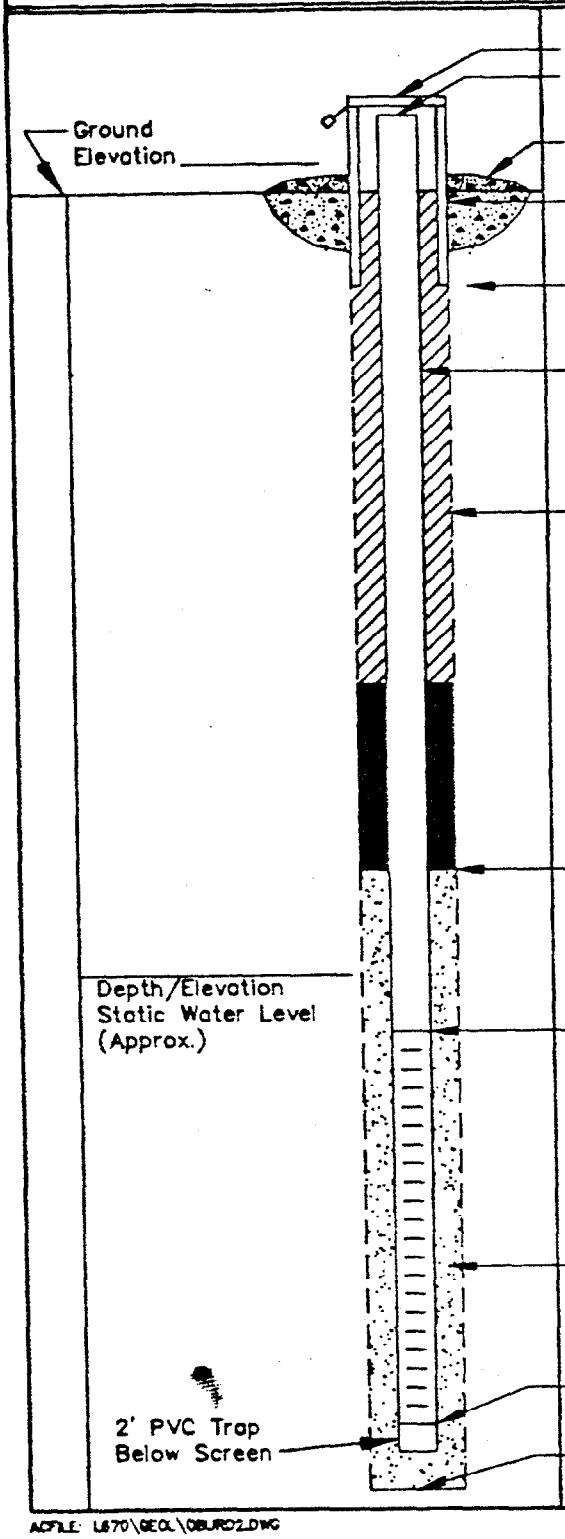
☐ Low Concentration
☐ High Concentration
☐ Grab
☐ Composite
☐ Grab - Composite

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

WELL NO.: _____

DRIVE POINT OVERBURDEN
MONITORING WELL SHEET

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



ELEVATION OF TOP OF SURFACE CASING: _____

ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

BOREHOLE DIAMETER: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

_____

DEPTH/ELEVATION TOP OF SAND: _____ / _____

DEPTH/ELEVATION TOP OF SCREEN: _____ / _____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DEPTH/ELEVATION BOTTOM OF SCREEN: _____ / _____

DEPTH/ELEVATION BOTTOM OF SAND: _____ / _____

DEPTH/ELEVATION BOTTOM OF HOLE: _____ / _____

BACKFILL MATERIAL BELOW SAND: _____

ACFILE: L670\GEOL\OBURD2.DWG

SAMPLE LOG SHEET

Halliburton NUS CORPORATION

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

Page _____ of _____

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:	Observations / Notes

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

TEST PIT LOG **HALLIBURTON NUS**

PROJECT: ..... TEST PIT NO.: .....

PROJECT NO.: ..... DATE: .....

LOCATION: .....

FIELD GEOLOGIST: .....

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

Test Pit Cross Section and / or Plan View

REMARKS .....

.....

.....

.....

PHOTO LOG ..... TEST PIT .....

.....

.....

..... PAGE.....OF.....

BORING LOG **HALLIBURTON NUS**

PROJECT: _____ BORING NO.: _____

PROJECT NO.: _____ DATE: _____ DRILLER: _____

ELEVATION: _____ FIELD GEOLOGIST: _____

WATER LEVEL DATA : _____

(Date, Time & Conditions) _____

SAMPLE NO. & TYPE	DEPTH (ft.) OR RUN NO.	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth,ft.)	MATERIAL DESCRIPTION*			ROCK BR. OR USCS	REMARKS
					SOIL DENSITY: CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		

REMARKS _____

BORING _____

PAGE ____ OF ____

* See Legend on Back

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

GROUNDWATER LEVEL MEASUREMENT SHEET

HALLIBURTON NUS

Project Name: _____ Location: _____
Project No.: _____ Weather Conditions: _____
Personnel: _____ Measuring Device: _____
Date: _____ Remarks: _____
Tidally Influenced: Yes _____ No _____

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

* ALL MEASUREMENTS TO NEAREST 0.01 FOOT

ACAD: 104L LEVEL.DWG 3/18/91 MJJ

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

D-49-3-92-16

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

PROJECT_____

SAMPLE NO._____

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 ☐	HCL ☐
_____ ☐	_____ ☐

Sampled By_____

Remarks:

CUSTODY SEAL

Date

Signature

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION

CUSTODY SEAL

Date

Signature

NUS CORPORATION

APPENDIX C

STANDARD OPERATING PROCEDURES (SOPs)

FIELD ACTIVITIES:

GH-1.2	EVALUATION OF EXISTING MONITORING WELLS
GH-1.3	SOIL AND ROCK SAMPLING
GH-1.4	SOIL AND ROCK DRILLING METHODS
GH-1.5	BOREHOLE AND SAMPLE LOGGING
GH-1.6	DECONTAMINATION OF DRILLING RIGS
GH-1.8	EXCAVATION OF EXPLORATORY TEST PITS AND TRENCHES
GH-2.5	WATER LEVEL MEASUREMENTS/CONTOUR MAPPING
GH-3.1	RESISTIVITY AND ELECTROMAGNETIC INDUCTION

USE AND CALIBRATION OF INSTRUMENTS:

ME-01	HNu PI-101 ORGANIC VAPOR METER
ME-11	GENERAL CALIBRATION REQUIREMENTS

SAMPLING METHODS

SA-1.2	SURFACE WATER AND SEDIMENT SAMPLING
SA-1.3	SOIL SAMPLING IN TEST PITS AND TRENCHES
SA-6.1	SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY
SA-6.2	SAMPLE PACKAGING AND SHIPPING
SA-6.3	SITE LOGBOOK

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.2	Page 1 of 4
		Effective Date 05/04/90	Revision 1
		Applicability EMG	
		Prepared Earth Sciences	
Subject EVALUATION OF EXISTING MONITORING WELLS		Approved D. Senovich	

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2.0 SCOPE

3.0 GLOSSARY

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 PRELIMINARY EVALUATION
- 5.2 FIELD INSPECTION

6.0 RECORDS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating existing monitoring wells, and to insure that the validity of data to be collected from these wells is usable during site investigations.

2.0 SCOPE

This procedure is applicable during stages of a site investigation. The procedures are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

The program represents a comprehensive approach to evaluating existing monitoring wells. Because of its comprehensiveness, completion of the program as specified will result in some duplication of effort. The actual level of evaluation program will depend on the data that are available (or which can be made available), the use to which that data will be put (i.e., the data quality objectives), and the effect that data will have on the time, budget and data quality for the overall program.

3.0 GLOSSARY

Data Quality Objectives (DQO) - qualitative and quantitative statements specifying data quality (i.e. measurement of uncertainty) required to support the objectives of the groundwater monitoring program.

4.0 RESPONSIBILITIES

Site Geologist - responsible for overseeing field inspections and for assessing the structural integrity of the wells and related field conditions. The geologist will carry out well evaluation procedures and assess the physical condition of the wells. These results and conclusions concerning the conditions of existing monitoring wells should be discussed with the Site Manager and Field Operation Leader, who together, will then determine which of the existing monitoring wells can be utilized.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology;
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths;
- Satisfactory methods of groundwater sampling and analysis to meet the data quality objectives (DQOs);
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 PRELIMINARY EVALUATION

A necessary first step in evaluating existing monitoring well data will be the study and review of the original work plan for monitoring well installation (if available). This will help to familiarize the geologist with specific site conditions requiring analysis, will promote an understanding of the original purpose of the monitoring wells and will help to determine if the well installation can meet the current DQOs. For example, existing wells may be sufficient for RCRA compliance but not for contaminant plume identification. Of particular interest during this phase of the project will be the rationale for the horizontal location of the wells and the vertical position and length of the monitored interval.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology and will help to establish consistency between hydraulic properties of the well to physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates the distance from prominent site features, or the location of the well on a map;
- The installation dates, drilling methods, well development methods, and contractors;
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-spoon sampling) may be used to estimate bedrock interface;
- The soil profile and stratigraphy;
- The borehole depth and diameter;
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface;
- The total depth of the well;
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval;
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size;

5.2 FIELD INSPECTION

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock;
- The condition of the cement seal surrounding the protective casing;
- The presence of depressions or standing water around the casing;
- The presence of any electrical cable and its connections.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results since the time when leakage started is unknown.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, the steps described above should be taken to rehabilitate the well. After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a PID or FID meter and combustible gas meter to determine the appropriate worker safety level. The following information should be noted:

- Cap function;
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space;
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing;
- Presence of a riser cap, method of attachment to casing, and venting of the riser;
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.
- The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. Specific field investigative activities which should be carried out include:
- This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present, the well be should be redeveloped before sampling.
- As a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

6.0 RECORDS

A record of all field procedures, tests and observations should be recorded in a field log book. Entries in the log book should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number GH-1.3	Page 1 of 13
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		Applicability EMG	
		Prepared Earth Sciences	
Subject SOIL AND ROCK SAMPLING		Approved D. Senovich	

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- 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)
- 5.4.1 Diamond Core Drilling
- 5.4.2 Rock Sample Preparation and Documentation

6.0 REFERENCES

7.0 RECORDS

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.

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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.

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.

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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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		Applicability EMG	
		Prepared Earth Sciences	
Subject BOREHOLE AND SAMPLE LOGGING		Approved D. Senovich	

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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

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 <u>Rock Classification</u>

- 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 RQD	DEPTH (ft.) OR RUN NO.	BLOWS/ 6" OR RQD (%)	SAMPLE RECOVERY /SAMPLE LENGTH	LITHOLOGY CHANGE (Depth,ft.) OR SCREENED INTERVAL	MATERIAL DESCRIPTION			BORE LOG CONSCKS	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"-Ø	CLEAN GRAVELS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel sand mixtures, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
	GRAVELS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	GM	Silty gravels, poorly graded gravel sand silt mixtures.
		Plastic fines (for identification procedures see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.
SANDS 50%(+)<¼"-Ø	CLEAN SANDS Low % fines	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.
	SANDS w/FINES High % fines	Non plastic fines (for identification procedures see ML)	SM	Silty sands, poorly graded sand-silt mixtures.
		Plastic fines (for identification procedures see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.

FINE GRAINED SOILS
More than half of material is SMALLER than No. 200 sieve size

Identification procedures on fraction smaller than No. 40 sieve size

	DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)	GROUP SYMBOL	TYPICAL NAMES
SILTS & 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
ST - 3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

ROCK SAMPLES - TYPES

X - NX (Conventional) Core (~2-1/8" O.D.
Q - NQ (Wireline) Core (~1-7/8" O.D.)
Z - Other Core Sizes, Specify in Remarks

WATER LEVELS

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

12/18
▽ 12.6' Stabilized Level ~/Date & Dept

EXHIBIT 4-2

Subject	Number	Revision	Page
BOREHOLE AND SAMPLE LOGGING	GH-1.5	2	16 of 26
		Effective Date	
		05/04/90	

D334901

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.: 619 Y — 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 DARKNESS 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
					M. HARD				ROCK
									AUGERED TO 15' W/SOLID STEM AUG.
									CUTTING MOIST @ 2.8' 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 QUARTZ PCS	VBR	SEVERAL 0 PPM Fe STAINED JOINTS ON CORE THRUOUT RUN. JOINTS AND BREAKS ARE HORIZ TO LO ∠. W/ VUGS ON LOWER PORTION 23 TO 25 OF CORE
0.9/10.0	①	0%/0	7.9/10.0						
	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 — 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 RQD	DEPTH (ft.) RUN	BLOWS 6" OR RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	MATERIAL DESCRIPTION* 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 LO ∠ 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

PAGE 2 OF 3

* 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 RQD (%)	SAMPLE RECOVERY SAMPLE LENGTH	LITHOLOGY CHANGE (Depth ft.)	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					
0/0	6	0%	1.3/10.0						68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN
									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'.

* See Legend on Back

BORING MW 3A

PAGE 3 OF 3

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 BEDROCK USCS	REMARKS (HNU) (HEAD SP)
	0.0	5 / 3	1.4/1.5		LOOSE	BLK BRN	CLAYEY SILT AND CINDERS	ML	MOIST (OPPM)
S-1		2					TR- COAL FRAGS		3/4" Φ FRAG - NEAR OLD
							TR- CC FRAG		RR. LINE.
							(FILL)		
	5.0					RED			
S-2		1 / 1	1.3/1.5	6.0	V. LOOSE	BRN TO GRAY	SANDY SILT - TR ORG TO	SM	MOIST TO WET (OPPM)
	6.5	3					SILTY SAND - TR GRAVEL		GRAY SAND @ 6'±
									INCREASING LOOSE & WETTER
									DRILLER NOTE H2O
	10.0								8-10'
S-3		11 / 23	1.2/1.5		DENSE	BRN	SILTY SAND AND S.S.	GM	WET (OPPM)
	11.5	27					FRAGS. (GRAY)		1" Φ SIZE MAX SIZE
									SUBANGULAR TO SUBROUNDED GRAVEL
	15.0								
S-4		9 / 47	1.0/1.5		V. DENSE	BRN	SILTY FINE TO C. SAND	SM	WET (OPPM)
	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 (OPPM)
							GRAVEL AND		MOIST
							S.S FRAGS		BECOMES MORE LIKE SANDY SILT AT BOTM
									OF SAMPLE

REMARKS START @ 1:15 PM - 7-1-87 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: K. 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 SCREEN INT	MATERIAL DESCRIPTION: SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	ROCK OR USCS	REMARKS (HNU)
S-6	25.0	6 / 17	1.1/1.5		DENSE	OLIVE BLUE	SILTY SAND - SOME	SM	DRY OPPM
	26.5	30				GRAY	GRAVEL - TR CLAY		C.S. IS FRIABLE FIRST SAMPLE 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	SILTY SAND - SOME GRAVEL	SM/	MOIST → WET (OPPM)
	31.5	36				GRAY	TR SS FRAG	GM	SAND SIZE IS FINE
							TR CLAY		GRAY & FRIABLE. - SUBROUNDED GRAVEL
									NOT MUCH CLAY - BUT MAY BE SEMI-CON-
	35.0								FINING.
S-8	35.9	30 / 50/.4	0.7/0.9		V. DENSE	BLUE GRAY	SILTY F. TO C. SAND -	SM/	MOIST → WET (OPPM)
							SOME GRAVEL	GM	V. SL. TR. CLAY - LESS
							TR. SS. FRAG.		THAN S-7 1" Ø FRAG. - MORE
									COARSE 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 TO- GETHER WHEN SQUEEZ'D
							CLAY		BUT NOT COHESIVE CLASS- IFICATION
									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

PAGE 2 OF 4

BORING LOG — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW 013
PROJECT NO.: 473Y — DATE: 7-8-87 — DRILLER: B. ERICSSON
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 EROSIVENESS USCS	REMARKS
	S-11	50.0	15/41	1.9/1.3		V. DENSE	MOTTLED BLUE	SILTY SAND - SOME GR.	GW	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	1.1/1.5		V. STIFF TO STIFF	GRAY ORANG BRN	SANDY CLAY / CLAYEY SAND SOME GRAVEL	SC	MOIST → WET (OPPM)
		56.5	26							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 COMPACT. 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
					68.0			TR. CLAY		MAX 3/4" D SIZE
							YELLOW BRN			COLOR CHANGE AT ≈ 68' MORE SAND PER
		70.0								DRILLER - BOTTOM OF SEAM CONF LAYER ?
7/14	S-15		39/39	1.0/1.5		V. DENSE	YELLOW BRN	CLAYEY SAND (F. TO C.) SOME	SC / GC	MOIST → WET (OPPM)
		71.5	41					GRAVEL - TR		1" MAX GRAVEL
								ROCK FRAG.		MORE GRAVEL @ 72' PER DRILLER

REMARKS USING HOLLOW STEM TO ADVANCE BORING - WASHING OUT THRU AUGERS, WHEN NEEDED, 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
PAGE 3 OF 4

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	SOIL DENSITY CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	BRKNESS ROCK OR 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	0.4/0.4		V. DENSE	GRAY ORANG. BRN	SILTY F. TO C. SAND - SOME	GW	WET (0PPM)
S-17	85.4	.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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1.0 PURPOSE

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-1.8	Page 1 of 6
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject EXCAVATION OF EXPLORATORY TEST PITS AND TRENCHES		Approved D. Senovich	

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2.0 SCOPE

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5.0 PROCEDURES
- 5.1 APPLICABILITY
- 5.2 TEST PIT AND TRENCH CONSTRUCTION
- 5.3 BACKFILLING OF TRENCHES AND TEST PITS

6.0 REFERENCES

7.0 RECORDS

1.0 PURPOSE

This procedure describes methods for proper excavation of test pits and trenches.

2.0 SCOPE

These procedures give overall technical guidance and may be modified by site-specific requirements for field exploratory test pits and trenches. Conditions which would make trench excavation technically difficult (such as shallow water table), potentially dangerous (presence of explosive materials or underground utilities) or likely to cause even greater environmental problems (such as potential rupture of buried containerized wastes) would require modifications to the methods described herein and may prevent implementation of the exploratory excavation program. Furthermore, the costs and difficulties in disposing of potentially hazardous materials removed from test pits may constrain their use to areas where contamination potential is low. Consequently, the techniques described herein may be most applicable in areas of low apparent contamination and where potentially explosive materials are not expected to be present.

3.0 GLOSSARY

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

4.0 RESPONSIBILITIES

Site Manager - is responsible for determining, in consultation with other project personnel (geologist, geochemist, engineer), the need for test pits or trenches, their approximate locations, depths and sampling objectives.

Field Operation Leader (FOL) - is responsible for finalizing the location and depth of test pits/trenches based on site conditions and the site geologist's advice. The FOL is ultimately responsible for the proper construction and backfilling of test pits and trenches, including adherence to OSHA regulations if applicable (see Section 5.0).

Health and Safety Officer - responsible for air quality monitoring during test pit construction and sampling, to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. He/She may also be required to advise the FOL on other safety-related matters and mitigative measures to address potential physical hazards from unstable trench walls, puncturing of drums, or other hazardous objects, etc.

Site Geologist/Sampler - responsible for recording all information and data pertaining to the test pit excavation. Engineers, field technicians, or other properly trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 APPLICABILITY

This subsection presents routine test pit or trench excavation techniques. Specialized techniques that are applicable only under certain conditions are not presented.

During the excavation of trenches or pits at hazardous waste sites, several health and safety concerns arise and control the method of excavation. All excavations that are deeper than 4 feet must be stabilized (before entry into the excavation) by bracing the pit sides using wooden or steel support structures. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments. In these cases, substantial air monitoring is required before entry, and appropriate respiratory gear and protective clothing is mandatory. There must be at least two persons present at the immediate site before entry by one of the investigators. The reader shall refer to OSHA regulations 29 CFR 1926, 29 CFR 1910.120, and 29 CFR 1910.134.

Excavations are generally not practical where a depth of more than about 15 feet is desired. They are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pits, providing that pumped water can be adequately stored or disposed. If data on soils at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.

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

5.2 TEST PIT AND TRENCH EXCAVATION

These procedures describe the methods for excavating and logging test pits and trenches to determine subsurface soil and rock conditions.

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

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

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

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

Fifteen feet is considered to be the economical vertical limit of excavation. However, larger and deeper excavations have been used when special problems justified the expense.

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

The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, field conditions may necessitate revisions to the initial plans. The final depth and construction method shall be determined by the field geologist. The actual layout of each test pit, temporary staging area and spoils pile will be predicated on site conditions and wind direction at the time the test pit is made. Prior to excavation, the area can be surveyed by magnetometer or metal detector to identify the presence of underground utilities or drums.

The test pits and trenches shall be excavated in compliance with applicable safety regulations as specified by the health and safety officer.

If the depth exceeds 4 feet and people will be entering the pit or trench, Occupational Safety and Health Administration (OSHA) requirements must be met: Walls must be braced with wooden or steel braces, ladders must be in the hole at all times, and a temporary guardrail must be placed along the surface of the hole before entry. It is advisable to stay out of test pits as much as possible; if possible the required data or samples shall be gathered without entering the pit. Samples of leachate, groundwater, or sidewall soils can be taken with telescoping poles, etc.

Stabilization of the sides of test pits and trenches, when required, generally is achieved by sloping the walls at a sufficiently flat angle or by using sheeting. Benching or terracing can be used for deeper holes. Shallow excavations are generally stabilized by sheeting. Test pits excavated into fill are generally much more unstable than pits dug into natural in-place soil.

Sufficient space shall be maintained between trenches or pits to place soil that will be stockpiled for cover, as well as to allow access and free movement by haul vehicles and operating equipment. Excavated soil shall be stockpiled to one side in one location, preferably downwind, away from the edge of the pit to reduce pressure on the pit walls.

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

The overland flow of water from excavated saturated soils and the erosion or sedimentation of the stockpiled soil shall be controlled. A temporary detention basin and a drainage system shall be planned to prevent the contaminated wastes from spreading, if necessary.

5.3 BACKFILLING OF TRENCHES AND TEST PITS

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

After inspection, backfill material shall be returned to the pit under the direciton of the field supervisor.

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

6.0 REFERENCES

NUS and CH_2MHill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, 1979. Excavation, Trenching and Shoring 29 CFR 1926.650-653.

7.0 RECORDS

Test pits and trenches shall be logged by the field geologist in accordance with Procedure GH-1.5.

Test pit logs shall contain a sketch of pit conditions (see Attachment A, Test Pit Log Form). In addition, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Test pit locations shall be documented by tying in the location of two or more nearby permanent landmarks (trees, house, fence, etc.) and shall be located on a site map. Surveying may also be required, depending on the requirements of each project. Other data to be recorded in the field logbook include the following:

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

ATTACHMENT A

TEST PIT LOG — *NUS CORPORATION*

PROJECT: ..... TEST PIT NO.: .....
PROJECT NO.: ..... DATE: .....
LOCATION: .....
FIELD GEOLOGIST: .....

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

Test Pit Cross Section and / or Plan View

REMARKS .....

PHOTO LOG ..... TEST PIT .....

PAGE ..... OF .....

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		Applicability EMG	
		Prepared Earth Sciences	
Subject WATER LEVEL MEASUREMENT/CONTOUR MAPPING		Approved D. Senovich	

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1.0 PURPOSE

The objective of this procedure is to provide general reference information and technical guidance on the measurement of hydraulic head levels and the determination of the direction of groundwater flow, using contour maps of the water table or the potentiometric surface of an unconfined or confined aquifer.

2.0 SCOPE

This procedure gives overall technical guidance for obtaining hydraulic head measurements in wells (frequently conducted in conjunction with groundwater sampling) and preparation of groundwater contour maps. The specific methods could be modified by requirements of project-specific plans.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

Potentiometric Surface - A surface which is defined by the levels to which water will rise in wells which are screened or open in a specified zone of an unconfined or confined aquifer.

Unconfined (water table) Aquifer - An aquifer in which the water table forms the upper boundary.

Confined Aquifer - An aquifer confined between two low permeability layers (aquitards).

Artesian Conditions - A common condition in a confined aquifer in which the water level in a well completed within the aquifer rises above the top of the aquifer.

Flow Net - A diagram of groundwater flow, showing flow lines and equipotential lines.

Flow Line - A line indicating the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Equipotential Line - A contour line on the potentiometric surface or water table showing uniform hydraulic head levels. Equipotential lines on the water table are also called water-table contour lines.

4.0 RESPONSIBILITIES

Project Hydrogeologist - has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells shall be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - must have a basic familiarity with the equipment and procedures involved in obtaining water levels, and must be aware of any project-specific requirements.

5.0 PROCEDURES

5.1 GENERAL

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well evacuation or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment A), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and bariometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. The reference point shall be noted in the field notebook. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater if required.

Water level readings shall be taken regularly, as required by the site hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due weather changes, and at least during the same day.

5.2 WATER LEVEL MEASURING TECHNIQUES

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the onsite hydrogeologist.

In most instances, preparation of accurate potentiometric surface requires that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, the Chalked Tape or Electrical Water Level Indicator methods have been found best, and thus are the most often utilized. Other, less precise methods, such as the Popper or Bell Sound or Bailer Line methods, may be appropriate for developing preliminary estimates of hydraulic conditions. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use the Float Recorder or Pressure Transducer methods. When conditions in the well limit readings (i.e., turbulence in the

water surface or limited access through small diameter tubing), less precise, but appropriate, methods such as the Air Line or Capillary Tubing methods can be used.

5.2.1 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required.

2. Record all information specified below in the geologist's field notebook or on the Groundwater Level Measurement Sheet.

   a. Well number.
   b. Record water level to the nearest 0.01 foot (0.3 cm). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing.
   c. Record the time and day of the measurement.

Water level measuring devices with permanently marked intervals shall be used when possible. If water level measuring devices marked by metal or plastic bands clamped at intervals along the measuring line are used, the spacing and accuracy of these bands shall be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points (see Section 5.2.3).

5.2.2 Water Level Measuring Devices

Chalked Steel Tape

The water level is measured by chalking a weighted steel tape and lowering it a known distance (to any convenient whole foot mark) into the well or borehole. The water level is determined by subtracting the wetted chalked mark from the total length lowered into the hole.

The tape shall be withdrawn quickly from the well because water has a tendency to rise up the chalk due to capillary action. A water finding paste may be used in place of chalk. The paste is spread on the tape the same way as the chalk, and turns red upon contacting water.

Disadvantages to this method include the following: depths are limited by the inconvenience of using heavier weights to properly tension longer tape lengths; ineffective if borehole/well wall is wet or inflow is occurring above the static water level; chalking the tape is time consuming; difficult to use during periods of precipitation.

Electric Water Level Indicators

These devices consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well. The electric tape is marked at the measuring point where contact with the water surface was indicated. The distance from the mark to the nearest tape band is measured using an engineer's folding ruler or steel tape and added to the band reading to obtain the depth to water. If band is not a permanent marking band, spacing shall be checked periodically as described in Section 5.2.3.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Float Recorder

A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole. A paper-covered recording chart drum is rotated by the up and down motion of the float via a pulley and reduction gear mechanism, while a clock drive moves a recording pen horizontally across the chart. To ensure continuous records, the recorder shall be inspected, maintained, and adjusted periodically. This type of device is useful for continuously measuring periodic water level fluctuations, such as tidal fluctuations or influences of pumping wells.

Air Line

An air line is especially useful in pumped wells where water turbulence may preclude the use of other devices. A small-diameter weighted tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air (from a compressor, bottled air, or air pump) is used to purge the water from the tube, until air begins to escape the lower end of the tube, and is seen (or heard) to be bubbling up through the water in the well. The pressure needed to purge the water from the air line multiplied by 2.307 (feet of water for 1 psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gauge can be calculated by subtracting the length of air line below the water surface from the total length of the air line.

The disadvantages to this method include the need for an air supply and lower level of accuracy (unless a very accurate air pressure gauge is used, this method cannot be used to obtain water level readings to the nearest 0.01 ft).

Capillary Tubing

In small diameter piezometer tubing, water levels are determined by using a capillary tube. Colored or clear water is placed in a small "U"-shaped loop in one end of the tube (the rest of the tube contains air). The other end of the capillary tube is lowered down the piezometer tubing until the water in the loop moves, indicating that the water level has been reached. The point is then measured from the bottom of the capillary tube or recorded if the capillary tube is calibrated. This is the best method for very small diameter tubing monitoring systems such as Barcad and other multilevel samples. Unless the capillary tube is calibrated, two people may be required to measure the length of capillary tubing used to reach the groundwater. Since the piezometer tubing and capillary tubing usually are somewhat coiled when installed, it is difficult to accurately measure absolute water level elevations using this method. However, the method is useful in accurately measuring differences or changes in water levels (i.e., during pumping tests).

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost-effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

Bailer Line Method

Water levels can be measured during a bailing test of a well by marking and measuring the bailer line from the bottom of the bailer (where water is first encountered) to the point even with the top of the well casing. This is a useful technique during bailing tests (particularly if recovery is rapid) if the bailer is heard hitting the water. However, it is not recommended for measuring static water levels because it is not usually as accurate as some of the other methods described above.

5.2.3 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.2.4 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells.

Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy periodically. A water level indicator calibration sheet shall be completed each time the measuring device is checked. A water level indicator calibration form is shown in Attachment A. The "actual reading" column on the sheet is the actual length of the interval from the end of the indicator to the appropriate marked depth interval. In many cases, these measurements are different because the water level measuring device is connected to the end of the measuring tape or line, and may extend beyond "0" feet on the measuring line.

5.3 POTENTIOMETRIC SURFACE MAPPING

5.3.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day.

Before mapping, review the recorded water levels and monitoring-well construction data, site geology and topographic setting to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this decision. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow, and many more wells will be needed to provide an accurate contour map. Generally, shallow systems require more wells than deep systems for accurate contour mapping.

5.3.2 Construction of Equipotential Lines

Plot the water elevations in the chosen wells on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is most commonly used, as it is the simplest technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful for large data sets. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted in accordance with these, utilizing the professional judgment of the hydrogeologist. Closed contours should be avoided unless a known sink exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must show in the contour plot.

5.3.3 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

5.4 HEALTH AND SAFETY CONSIDERATIONS

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a Health/Safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone

concentrations using a PID (HNU) or FID (OVA) and combustible gas meters shall be performed to determine required levels of protection.

6.0 REFERENCES

Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey, 604 pp.

Cedergren, H. R., 1977. Seepage, Drainage and Flow Nets (2nd edition). John Wiley and Sons, New York.

Fetter, C. W., 1980. Applied Hydrogeology. Me !, Columbus, Ohio, 488 pp.

7.0 ATTACHMENTS

Attachment A - Groundwater Level Measurem neet

Attachment B - Water Level Indicator Calibration Sheet.

ATTACHMENT A

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.

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7.0 RECORDS

1.0 PURPOSE

The purpose of this guideline is to provide a general description of, and technical management guidance on, the use of Resistivity and Electromagnetic Induction (Ground Conductivity) surveys during hazardous waste site investigations.

2.0 SCOPE

This guideline provides a description of the principles of operation, instrumentation, applicability, and implementability of geophysical methods used during hazardous waste site investigations to determine subsurface resistivity or conductivity. Measurements of subsurface conductivity or resistivity can be used to determine the presence and approximate extent of subsurface contaminants, buried drums and metal containers. In addition, the depth to the water table, and structural characteristics of the subsurface environment can be determined.

The document is intended to help develop an understanding of each method sufficient to permit work planning and scheduling, resource planning, subcontractor procurement and evaluation, and manipulation and use of the technical data during remedial investigations and feasibility studies. This guidance is not intended to provide a detailed description of methodology and operation. The highly specialized nature of the methods requires inclusion of project-specific, site-specific, and subcontractor-specific information prior to development of detailed operating procedures. Specialized expertise during both planning and execution of these geophysical methods is also required.

The description focuses on methods and equipment that are readily available and typically applied; it is not intended to provide a complete discussion of the state-of-the art.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Resistivity - Intrinsic property of a substance, equal to the resistance of a body multiplied by its cross-sectional area and divided by its length.

Resistivity Survey - A geophysical exploration method whereby an electrical current is transmitted into the ground and the resultant potential field is measured to deduce the apparent subsurface resistivity.

Potential - Intrinsic property of electrical fields, equating to the ability to do work. A potential field can induce a potential difference (voltage) between two electrodes.

Current - The quantity of charge transmitted per unit time.

Conductivity - Intrinsic property of a substance, equal to the reciprocal of resistivity.

Apparent Resistivity - The quantity actually deduced during a resistivity survey; proportional to the actual resistivities of subsurface materials.

Apparent Conductivity - The quantity measured during an electromagnetic induction survey; proportional to the actual conductivities of subsurface materials.

4.0 RESPONSIBILITIES

Site Manager - responsible for the scoping of geophysical surveys during development of the Work Plan, with the help of the RI leader, site geologist, and site geophysicist.

Site Geophysicist - as a specialist in this field, the site geophysicist plays a central role in determining the appropriateness of these techniques for providing necessary data. Field work for these surveys is supervised by the site geophysicist.

5.0 PROCEDURES

5.1 ELECTROMAGNETICS

The electromagnetic induction (EM) method provides a means of measuring the electrical conductivity of subsurface soil, rock, and groundwater. Electrical conductivity is a function of the type of soil and rock, its porosity, its permeability, and the fluid composition and saturation. In most cases the conductivity of the pore fluids will be responsible for the measurement. Accordingly, the EM method applies both to assessment of natural geohydrologic conditions and to mapping of many types of contaminant plumes. In addition, trench boundaries, buried wastes, drums, and utility lines can be located with EM techniques.

5.1.1 Applicability

Although EM is not a definitive technique, it is useful for several reasons. First, an EM survey can be conducted over an entire site very quickly. In addition, EM methods are generally inexpensive, even for coverage of large areas. Often, 100 acres or more may be surveyed in just a few days time (depending on desired detail). More importantly, EM data can be used to direct the more expensive phases of an investigative project, potentially resulting in a large cost savings. For example, rather than drilling several dozen monitoring wells while searching for groundwater contamination, an EM conductivity unit may be used to survey for a conductive (or resistive) plume. Several EM survey lines may be run to provide definition of the plume and an indication of its source area, reducing the number of exploratory wells required. This approach could potentially result in better well placement at a cost savings. Another reason why EM should be considered is to fill in data gaps and to reduce the risk of missing a facet of the investigation, such as the presence of undetected refuse trenches, buried drums, or changing hydrologic conditions.

Electromagnetic methods may be used in many situations for a variety of purposes. The following list includes major uses related to investigations of hazardous waste sites:

- Defining the location of a contaminant plume (This could lead to the identification of downgradient receptors, source areas, and flow directions if the conductivity of the plume (target) is distinct in comparison to the host (background), hydrogeologic setting.)

- Locating buried metal objects (e.g., drums, tanks, pipelines, cables, monitoring wells).

- Addressing the presence or location of bedrock fault/fracture systems (This is important for identification of preferential pathways of water flow in bedrock.)
- Mapping grain size distributions in unconsolidated sediments.
- Mapping buried trenches.
- Defining lithological (unit) boundaries.
- Determining the rate of plume movements by conducting multiple surveys over time.

The above list is only partial; in fact, EM methods may be used wherever a significant change in conductance can be measured. EM should be considered for use when a suspected target is anticipated to have a conductivity significantly different from background values. Factors such as cost, site-specific conditions, and equipment availability should also be evaluated before deciding to proceed with an EM survey.

5.1.2 General

Objectives

The geophysicist should evaluate the objectives of the site investigation in light of EM capabilities. If the purpose of the site study is to confirm the presence of contaminants with minimal effort, EM methods may provide too much detail and no direct evidence; direct methods, such as installing monitoring wells with limited sampling, may be more suitable. If a site is to be characterized in detail and if assessment of geohydrologic conditions and identification of all source areas, plumes, and receptors are a priority, then EM (and other geophysical methods) may be a cost-effective way of selecting strategic locations for monitoring wells, directing test pit operations, efficiently selecting sampling points, and providing information between site sampling points.

Existing Data

If EM equipment is identified as capable of providing the type of information desired, the user should further evaluate the equipment to determine whether it is appropriate for use under the conditions found at a particular site. Evaluation of existing data can identify problems that may be encountered in the field:

- Variations in geohydrologic conditions (e.g., varied water table conditions or changes in rock or sediment) can result in a conductivity range that envelopes the response of the target (e.g., plume) and effectively masks or blocks out any signals.
- Scattered, near-surface metal may mask buried targets such as drums or trenches.
- Near-surface layers of extreme conductivity (high or low) such as a clay lens or surficial frost zone may mask the signal from a deeper target.

An analysis of the site history might more closely define a survey area, thereby cutting survey costs by reducing the size of the survey. Deep targets may be out of the penetration range of many EM units, and specialized equipment may be required. It is difficult for EM systems to detect a groundwater contaminant plume through 100 feet of unsaturated overburden. A site reconnaissance should be conducted to identify other site conditions that may affect the data. Drastic topography changes can

affect the quality of EM data obtained with some systems, and this possibility should be considered at each site.

5.1.3 Survey Design

Once the EM survey objectives have been defined, existing information has been reviewed, and reconnaissance of the site has been conducted, attention should be given to the design of the geophysical survey. The detail required of an EM survey is a primary factor in designing and planning fieldwork. If the purpose of performing EM work onsite is to define a large geologic feature, then a grid using a wide (100- to 1,000-foot) line spacing may be needed. Some instruments are capable of providing a continuous data profile, which makes it less likely to miss small conductors than the typical discrete measurement EM instruments. The importance of designing and implementing a grid system tied into existing "permanent" features (such as roads and buildings) cannot be overstated. This permanent feature will allow the grid to be reoccupied in the field to place drill holes and monitoring wells. Furthermore, additional surveys may be conducted on the site using other geophysical techniques or the same technique to provide an indication of plume movement. These surveys will help in orienting maps and diagrams that are produced later and in defining targets.

Background Noise

Background noise can be a significant factor in the success of an EM survey. Evaluation of existing data and a site reconnaissance will help to identify the probable background noise level. A high noise level can make interpretation difficult and may actually cause an anomaly to be overlooked. It is difficult to delineate a conductive contaminant plume contained in overburden that has a wide natural variation in conductivity.

Noise sources can be divided into two groups: (1) natural, such as changing grain size distributions, steeply dipping strata, undetected mafic dikes, Karstic topography, unexpected fault zones; and (2) cultural, such as power lines, houses, railroads, surface metal debris, cars, and radio transmission towers. Some instruments are more sensitive to certain types of noise sources than others. Because there is little published information on this subject, experience is important.

Limitations

All EM instruments have varying limitations with regard to sensitivity and penetration. Published references, operator's manuals, and field experience should be used to evaluate instrumentation versus capability. Table GH-3.1-1 lists several commercially available instruments along with factors that control their productivity.

Instrumentation

Table GH-3.1-2 provides guidance for EM equipment selection. These instruments may not be suitable to specific site conditions and investigation objectives. The decision to use a specific instrument is dependent upon site factors.

Electromagnetic techniques have also been adapted for downhole applications. These techniques can be useful in defining the vertical extent of a contaminant zone. Some systems work inside polyvinyl chloride (PVC) or Teflon monitoring well casings. Table GH-3.1-3 compares some of the more common EM systems.

TABLE GH-3.1-1

FACTORS CONTROLLING PRODUCTIVITY OF SOME COMMONN EM UNITS

Instrument	Manufacturer	No. Operators	Typical Daily Line Miles (50-ft readings)	Notes
EM-16-R	Geonics	2	2	2
EM-16	Geonics	1	3-4	2
EM-31-D	Geonics	1 or 2	3	2
EM-34-3	Geonics	2	2	2
VLF-3	Scintrex	1	3	2
Genie (SE-88)	Scintrex	2	N/A	1
Radem-VLF	Crone	1	3-4	2
CEM	Crone	2	2	1
Max Min II	Apex	2	3	1
EM-38	Geonics	1	3	2

Notes:

(1) Primarily useful for geologic features only.
(2) Useful for geological and cultural features.

Designations such as ME-16 or EM-13 are the manufacturer's model numbers and do not imply equipment complexity or capability.

TABLE GH-3.1-2

APPLICATION GUIDELINES FOR EQUIPMENT USE

Equipment Use	EM-16	EM-16R	EM-31	EM-34
Locate single shallow buried drum	3	3	1	3
Locate many shallow buried drums	2	3	1	2
Locate single deep buried drum	3	3	3	3
Locate many deep buried drums	2	3	2	2
Define shallow fault zone	1	2	2	2
Define deep fault zone	1	3	3	2
Delineate shallow contaminant plume	3	1	1	1
Delineate deep contaminant plume	3	1	2	1
Locate shallow pipeline	1	3	1	2

1. Good success rate.
2. Moderate success rate.
3. Poor success rate-not applicable.

Shallow is only several meters.
deep is several tens of meters.

Note: This table is based primarily on field experience. Designations such as EM-16 or EM-31 are the manufacturer's model numbers and do not imply equipment complexity or capability.

TABLE GH-3.1-3

COMPARISON OF COMMON EM SYSTEMS

	VLF-3	EM-16	EM-31	EM-34	EM-38
Operators	1	1 or 2	2	2	1
Typical penetration in saturated sands (meters)	20-30	20-30	less than 5	see below	Less than 2
Source (Tx)	Navigational signals continuously broadcast by U.S. Navy		self-contained coil	self-contained coil	Self-contained coil
Receiver (Rx)	Entire is RX (2-anetennae)		self-contained coil	self-contained coil	Self-contained coil
Frequency	Interchangeable Rx crystals 15-25 KHz		9.8 Khz	10 meter 6.4 kHz 20 meter 1.6 kHz 40 meter 0.4 kHz	13.2 kHz
Tx-Rx spacing	Unlimited		3.6 meters	10,20,40 meters	1 meter
Notes	Receives only specified frequencies Will not read most noise. Penetration depends on formation resistivity. Maximum penetration is over 100 meters.		Continuous reading with a strip chart recorder. Can be used as a horizontal or vertical dipole for control of penetration.	Penetration varies with coil separation and with orientation. Maximum penetration is 50 meters.	Lightweight.

5.2 ELECTRICAL RESISTIVITY

Electrical resistivity surveys provide information about the subsurface distribution of the ground resistivity. The information can be used to infer groundwater quality, lithologic, and geologic information. Both horizontal and vertical changes in ground resistivity can be mapped by resistivity surveys. In practice, resistivity surveys are mostly used to determine the vertical resistivity changes. Lateral resistivity changes are more easily mapped by electromagnetic surveys.

5.2.1 Applicability

Electrical resistivity (ER) data are subject to interpretation; therefore, ER field results should be checked periodically and confirmed by direct methods, such as sampling or drilling.

Although ER is not a definitive technique, the data are useful for several reasons. Typical productivity with conventional resistivity equipment is several thousand line-feet per day. This high productivity rate allows a large amount of useful data to be collected in a relatively short period of time. For example, rather than drilling several dozen monitoring wells or test borings to develop a complete picture of the site stratigraphy and structure, a few wells can be drilled (for control) and information about the rest of the site can be obtained by using resistivity methods. Method integration such as this can reduce the amount of time and the costs required for a project.

Resistivity methods may be used in a wide array of situations and for a variety of purposes. The following is a partial list of major uses related to investigations of hazardous waste sites:

- Definition of a contaminant plume. (This could lead to the identification of downgradient receptors and source areas.)
- Waste pit delineation.
- Definition of bedrock fault/fracture systems.
- Water table mapping (for contour maps).
- Stratigraphic mapping of soil layers (particularly useful in overburden, discriminating clays from sands and establishing their thicknesses).
- Defining bedrock topography (valleys).

Resistivity methods may be used whenever the feature to be mapped has a contrasting resistivity with the background material.

5.2.2 General

Electrodes are typically arranged in one of several patterns, called electrode arrays, depending on the desired information. Electrical resistivity techniques can determine the vertical subsurface resistivity distribution beneath a point. In this type of survey, called vertical electrical soundings, the electrode array is expanded systematically and symmetrically about a point. For each set of electrode spacings, apparent resistivity is determined from measurements of potential and input current. The resultant plot of apparent resistivity versus electrode spacing is interpreted to provide the subsurface resistivity with depth distribution at that one particular point. Examples of three common arrays are given in Figure GH-3.1. The Wenner and Schlumberger arrays are somewhat more common than the Dipole-Dipole and other arrays. These arrays (Wenner, Schlumberger) start with a small electrode spacing that is increased to permit deeper penetration for sounding.

The manner in which the apparent resistivity changes with the electrode separation can be used to determine formation conductivity and layer thickness. To increase accuracy, the user should evaluate the interpretation of resistivity data against the existing subsurface information. With any set of apparent resistivity readings, a number of solutions are possible, so existing data must be used to select the one that fits best. A formation resistivity may be assigned, but without geological control the material is not known. Resistivity electrode arrays can also be used with constant inner-electrode spacing to develop a lateral picture of the site through profiles. Stratigraphic control is even more important when mapping lateral changes with constant electrode spacings, because layer thickness changes alone can cause changes in apparent resistivity. The desired resolution is a major factor in deciding how closely to space measurements for a given survey.

In practical application, a resistivity survey target (such as a plume or clay lens) should have a resistivity contrast (positive or negative) 20 percent from background. This change in resistivity should be 50 percent or more to provide proper detection and delineation. For example, if a resistivity survey were being conducted to delineate a groundwater contaminant plume (in overburden) with a resistivity of 200 ohm-meters, a background, saturated overburden resistivity of over 400 ohm-meters (for a conductive plume) or under 100 ohm-meters (for a resistive plume) would probably be detected, providing other factors (such as depth) are not detrimental.

When depth sounding, resolution of individual layers has an accuracy generally around 20 percent; accuracy can be substantially more or less depending on the site conditions and operator expertise. Vertical resistivity sounding is usually less accurate than seismic refraction work, which is often conducted within a 10 percent error tolerance. However, geologic units may be distinguishable (by geophysics) only with the use of resistivity methods at some sites.

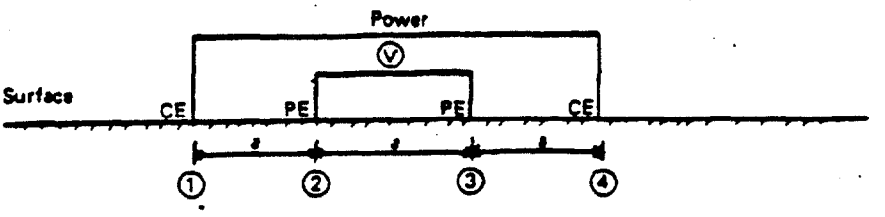
5.2.3 Survey Design

Data can be collected at randomly located stations or along survey lines. If vertical electrical soundings are performed to obtain resistivity changes with depth, then the soundings are positioned where the information is most useful. If measurements are made to map lateral resistivity changes, then the soundings are positioned where the information is most useful. If measurements are made to map lateral resistivity changes, then the survey is best performed on a grid or on survey lines. The station spacing will be determined form the target size.

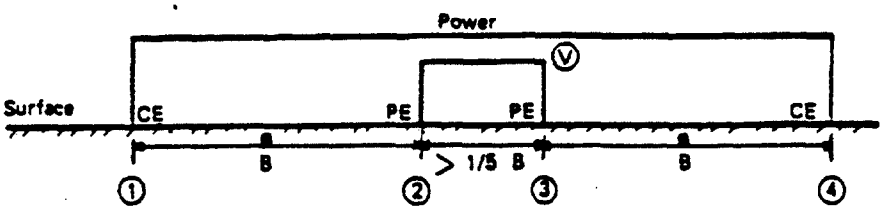
FIGURE GH-3.1

EXAMPLES OF COMMON ER ARRAYS

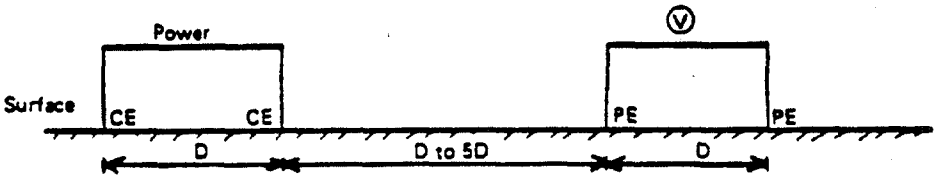
WENNER ARRAY



SCHLUMBERGER ARRAY



DIPOLE-DIPOLE ARRAY



1 Electode Number
PE Potential Electrode
CE Current Electrode
V Voltmeter

SOURCE: Based in part on W. M. Telford et al., Applied Geophysics, 1976, and R. E. Sheriff, Encyclopedic Dictionary of Exploration Geophysics, 1984.

Background Noise

Evaluation of existing data and a site reconnaissance will help to identify the possible background noise level. A high noise level can make interpretation difficult and may mask an anomaly. It would be difficult to delineate a slightly conductive contaminant plume contained in overburden that has wide natural variations in conductivity. Noise sources can be divided into two groups: natural, such as discontinuous clay layers, undetected mafic dikes, Karstic topography, unexpected fault zones, variable water table, and lightning; and cultural, such as power lines, railroad tracks, and radio transmission towers. Since there is little published information on instrument noise sensitivity, experience is important.

Depth of Investigation

As a rule of thumb when lateral resistivity is being conducted , the array should be spaced four or five times the distance from the ground surface down to the desired target. For vertical sounding, this suggested spacing should be about ten times the anticipated target depth. These suggestions should be used only as general guidance.

5.2.4 Miscellaneous Considerations

Instrumentation

For most shallow work at hazardous waste sites, most resistivity systems will suffice. Generally, equipment capability becomes important only when the desired investigative depth exceeds 70 to 100 feet. Larger power sources are needed to provide a measurable electrical potential with a wider electrode spacing. Some newer resistivity units are capable of electronic data storage, and other features. Often, the peripheral capabilities of an ER system may be the deciding factor when purchase is considered.

Borehole resistivity equipment has been used (in uncased boreholes) to determine relative formation porosity and other factors. For more information on this equipment, the reader should refer to the borehole geophysics subsection of this compendium.

Calibration

ER equipment requires calibration, either in the field or in the laboratory; dated records of this calibration should be kept in the equipment management file and in the appropriate project file. Calibration is used to establish the reliability and accuracy of the equipment; calibration typically includes an internal circuit check or actual field trials (e.g., tests over a known target). Equipment that historically exhibits fluctuations in calibration should not be used. The equipment serial number should be recorded on the calibration records. If the manufacturer recalls equipment, this fact should be explained and documented for instrument maintenance in the proper file. The current source and potentiometer must be calibrated on any type of resistivity equipment. The instrument's current source may be calibrated by placing a reference ammeter in series with the electrode cables. The reading obtained on the reference ammeter is compared with the value read from the instrument's current source ammeter. The current source ammeter is then adjusted accordingly.

The potentiometer is calibrated by either of two methods. The preferred field method, which is similar to the calibration of the current source, is done by comparing the instrument's indicated potential to that potential measured with an independent voltmeter. An alternative means of calibration,which can be performed in the laboratory, involves placing a precision resistor of a known

value in series with the current load. A potentiometer is then placed across the resistor. The potential measured should be equal to the product of the known resistance and indicated current.

Data Reduction

The raw data are the measured potential produced by a known current. To calculate the P (apparent resistivity), these known quantities are used. The electrode configuration is also used in the determination of apparent resistivity, which is defined by:

$$Papp = (2\pi \times V/I) / (1/r_1 - 1/r_2 - 1/R_1 + 1/R_2)$$

where:

V = The circuit potential (voltage)
I = Applied current (amperage)
r_1 = Distance between electrode #1 and #2 (meters)
r_2 = Distance between electrode #2 and #4 (meters)
R_1 = Distance between electrode #1 and #3 (meters)
R_2 = Distance between electrode #3 and #4 (meters)
Papp = Apparent resistivity

Apparent resistivity is the resistivity measured at the ground surface and usually has units of ohm-meters or ohm-feet. The apparent resistivity is a function of the distribution of actual ground resistivities and the electrode geometry. Interpretation and reduction of the resistivity sounding are very specialized and are beyond the scope of this guideline; interpretation and reduction often involve curve matching or computer analysis. For further information, the reader should refer to the references listed in Section 6, particularly Zohdy (1975).

6.0 REFERENCES

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Grant, F. S., and G. F. West. Interpretation Theory in Applied Geophysics. McGraw-Hill Book Company. 1955.

Griffiths, D. H., and R. F. King. Applied Geophysics for Geologists and Engineers. Pergamon Press. 1981.

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Rudy, R. J., and J. A. Caoile. "Utilization of Shallow Geophysical Sensing at Two Abandoned Municipal/Industrial Waste Landfills on the Missouri River Floodplain." Ground Water Monitoring Review. Fall issue, 1984.

Slaine, D. D., and J. P. Greenhouse. "Case Studies of Geophysical Contaminant Mapping at Several Waste Disposal Sites." Presented at the NWWA Second National Symposium on Aquifer Restoration and Ground Water Monitoring. Columbus, Ohio. 1982.

Steward, M. T. "Evaluation of Electromagnetic Methods for Rapid Mapping of Salt-Water Interfaces in Coastal Aquifers." Groundwater, Vol. 20. September-October 1982.

6.1.3 Manufacturers

Aerodat Limited
3883 Nashua Drive
Mississauga, Ontario L$V 1R3
416/671-2446 (airborne EM systems)

Crone Geophysics Limited
3607 Wolfedale Road
Mississauga, Ontario L5C 1V8
416/270-0096 (surface EM systems)

Geonics Limited
1745 Meyerside Drive
Mississauga, Ontario L5T 1C5
416/676-9580 (borehole and surface EM systems)

Phoenix Geophysics Limited
200 Yorkland Boulevard
Willowdale, Ontario M2J 1R5
416/493-6350 (surface EM systems)

Scintrex
222 Snidercroft Road
Concord, Ontario L4K 1B5
416/669-2280 (surface EM systems)

6.2 ELECTRICAL RESISTIVITY

6.2.1 Electrical Resistivity (ER) Theory and Interpretation Textbooks

Griffith, D. H., and R. F. King. Applied Geophysics for Geologists and Engineers. Pergamon Press. 1981.

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Evans, R. B., and G .E. Schweitzer. "Assessing Hazardous Waste Problems." Environmental Science Technology, Vol. 18, No. 11. 1984.

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Underwood, J. W., K. J. Laudon, and T. S. Laudon. "Seismic and Resistivity Investigations near Norway, Michigan." Ground Water Monitoring Review. Fall 1984.

6.2.5 Manufacturers

ABEM-Atlas Copco
Distributed by Geotronic Corp.
10317 McKalla Place
Austin, Texas 78758

Bison Instruments, Inc.
570-8 West 36th Street
Minneapolis, Minnesota 55416

BRGM-Syscal
Distributed by EDA Instruments
5151 Ward Road
Wheat Ridge, Colorado 80033

Phoenix Geophysics Limited
200 Yorkland Boulevard
Willowdale, Ontario M2J 1R5

Scintrex Limited
222 Snidercroft Road
Concord (Toronto), Ontario L4K 1B5

7.0 RECORDS

The following information will be recorded in the field log book.

- Date
- Equipment operators
- Name and project number of site
- Position and instrument readings
- Position specific information

NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number ME-01	Page 1 of 12
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Health and Safety	
Subject HNU PI-101 ORGANIC VAPOR METER		Approved D. Senovich	

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1.0 PURPOSE

To establish procedures for the use, maintenance, and calibration of the HNU PI-101 Organic Vapor Meter.

2.0 SCOPE

Applies to each usage of the HNU PI-101 photoionization detector by NUS/EMG personnel.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Office Health and Safety Supervisor (OHSS) - The OHSS shall insure that the user has been appropriately trained and certified in the usage of the HNU instrument. He/she shall also insure that the instrument is properly maintained and calibrated prior to its release for field service.

Instrument User - The user should be personally secure that he/she has been adequately trained and understands the operation and limitations of the instrument. He/she is further responsible to insure that the appropriate probe(s) have been selected for compounds to be found on site and that the instrument has been calibrated and is working properly.

5.0 PROCEDURES

5.1 PRINCIPLE OF OPERATION

The HNU System portable photoionizer detects the concentration of many organic gases as well as a few inorganic gases. The basis for detection is the ionization of gaseous species. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many gaseous compounds. The molecule is transformed into charged-ion pairs, creating a current between two electrodes. Each molecule has a characteristic ionization potential, which is the energy required to remove an electron from the molecule, yielding a positively-charged ion and the free electron. The instrument measures this energy level.

5.2 INSTRUMENT CONFIGURATION

Three probes, each containing a different UV light source, are available for use with the HNU. Probe energies are 9.5, 10.2, and 11.7eV. All three detect many aromatic and large-molecule hydrocarbons. The 10.2 and 11.7eV probes, in addition, detect some smaller organic molecules and some halogenated hydrocarbons. The 10.2eV probe is the most useful for environmental response work, since it is more durable than the 11.7eV probe and detects more compounds than the 9.5eV probe.

5.3 CALIBRATION

The primary HNU calibration gas is benzene (or isobutylene, a benzene equivalent). The span potentiometer knob is adjusted for benzene calibration. A knob setting of zero increases the sensitivity to benzene approximately ten-fold. The instrument's response can be adjusted to give more accurate readings for specific gases and eliminate the necessity for calibration charts. Daily calibration is to be performed in accordance with Attachment G.

5.4 SPECIALIZED USES

While the HNU is used primarily as a qualitative instrument, it can also be used to detect certain contaminants or at least to narrow the range of possibilities. Noting instrument response to a contaminant source with different probes can eliminate some contaminants from consideration. For instance, a compound's ionizing potential may be such that the 9.5eV probe produces no response, but the 10.2 and 11.7eV probes do elicit a response. Also, HNU does not detect methane or hydrogen cyanide.

5.5 INSTRUMENT ADVANTAGES

The HNU is easy to use in comparison to many other types of monitoring instrumentation. Its range detection limit is also in the low parts per million range. Response time is rapid; the meter needle reaches 90 percent of the indicated concentration in 3 seconds for benzene. HNU can be zeroed in a contaminated atmosphere.

5.6 CAUTIONS

The instrument can monitor only certain vapors and gases in air. Nonvolatile liquids, toxic solids, particulates, and many other toxic gases and vapors cannot be detected. Because the types of compounds that the HNU can detect is only a fraction of the chemicals possibly present at a field site, a zero reading does not necessarily signify the absence of air contaminants.

The instrument is nonspecific, and its response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower then the true concentration. These discrepancies can be especially serious problems when monitoring for total contaminant concentrations, if several different compounds are being detected at once. In addition, the response of this instrument is not linear over the entire detection range. Care must, therefore, be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by more precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer of the gas-select-knob setting.

The instrument cannot be used as an indicator for combustible gases or oxygen deficiency.

6.0 REFERENCES

HNU Systems, Inc. Instruction Manual for Model PI 101 Photoionization Analyzer, 1975.

E. & E. FIT Operation and Field Manual: HNU Systems PI 101 Photoionization Detector and Century Systems (Foxboro) Model OVA-128 Organic Vapor Analyzer.

Personal Communication with Fran Connel, HNU Systems, Inc., January 4, 1984.

7.0 ATTACHMENTS

Attachment A - Start-up and Shutdown Procedures
Attachment B - Maintenance and Calibration Schedule
Attachment C - Calibration Procedure
Attachment D - Cleaning the UV Light Source Window
Attachment E - Cleaning the Ionization Chamber
Attachment F - Troubleshooting
Attachment G - Daily Calibration

ATTACHMENT A

START-UP AND SHUTDOWN PROCEDURES

Start-up

1. Attach the probe to the readout unit. Match the alignment key, then twist the connector clockwise until a distinct locking is felt.

2. Turn the FUNCTION switch to the battery check position. Check to ensure that the indicator reads within or beyond the green battery arc on the scale plate. If the indicator is below the green arc, or if the red LED comes on, the battery must be charged prior to using.

3. To zero the instrument, turn the FUNCTION switch to the STANDBY position and rotate the ZERO POTENTIOMETER until the meter reads zero. Wait 15-20 seconds to ensure that the zero adjustment is stable. If not, then readjust.

4. Check to see that the SPAN POTENTIOMETER is set at the appropriate setting for the probe being used. Follow procedures in Attachment G in the performance of daily calibrations.

5. Set the FUNCTION switch to the desired ppm range.

6. Listen for the fan operation to verify fan function.

7. Check instrument with an organic point source (such as a magic marker) prior to usage to verify instrument function.

Shut Down

1. Turn FUNCTION switch to OFF.

2. Place the instrument on the charger.

ATTACHMENT B

MAINTENANCE AND CALIBRATION SCHEDULE

Function	Frequency
• Routine Calibration	Prior to each use*
• Factory Check-out and Calibration	Yearly or when malfunctioning
• Wipe Down Read-Out Unit	After each use
• Clean UV Light Source Window	Every month or as use and site conditions dictate
• Clean the Ionization Chamber	Monthly
• Recharge Battery	After each use

* In accordance with the specifications identified in Attachment G.

ATTACHMENT G

DAILY CALIBRATION OF HNU PI-101

HNU PI-101 organic vapor meters are to be field calibrated at the beginning of each work day, prior to actual on site usage.

In order to accomplish this, HNUs assigned to jobs shall be accompanied with a calibration gas cylinder, an appropriate fitting, and a flexible connecting hose. The procedure for performing field calibration is as follows:

1. Connect the probe to the instrument and turn it on.
2. Attach the eight-inch extension to the probe.
3. Set the Span Potentiometer to the setting specified on the calibration cylinder.
4. Connect the cylinder fitting to the cylinder.
5. Connect the cylinder and the instrument together with the flexible tubing.
6. Open the cylinder valve and wait 15 seconds.
7. Instrument reading should coincide with the designed reading stated on the calibration cylinder label.
8. If item number 7 does not coincide, adjust the Span Potentiometer until the desired reading is achieved. Any such adjustments must be within the following limits:

Probe	Initial Span Pot. Setting	Maximum Acceptable Span Pot. Adjustment
9.5 eV	5.0	1.0
10.2 eV	9.8	8.5
11.7 eV	5.0	2.0

If these limits are exceeded, the sensitivity and accuracy of the instrument is hindered. At these points, the instruments are to be returned to the NUS Equipment Manager for inspection, necessary cleaning and maintenance, and recalibration.

The manufacturer also recommends that the lamp inside of the probe be checked twice per week (16 hours of use) and cleaned at least weekly. This involves removing any noticeable obstructions or contamination from the lamp by wiping it off with a clean, soft cloth being careful not to scratch the circular window.

ATTACHMENT G
DAILY CALIBRATION OF HNU PI-101
PAGE TWO

In using this instrument to protect NUS employees and subcontractors, it is imperative that it is accurately responding to airborne substances present at the work site. By implementing these procedures, this end will be better achieved.

Additionally, all calibration activities must be documented in field log books, instrument calibration log sheets, or equivalent. This information must include the date inspected, the person calibrating the instrument, the instrument serial or identification number, the probe lamp eV (9.5 , 10.2, or 11.7), identification of calibration gas (gas source stated on the cylinder label), the initial and final Span Potentiometer settings, and the instrument resultant reading. This information must be submitted to the Site Safety officer at the completion of the job.

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1.0 PURPOSE

To establish a procedure delineating minimum requirements for equipment and instrument calibration.

2.0 SCOPE

This procedure is applicable to all instruments used on NUS projects or by NUS staff to acquire data used for health, safety, or training purposes; used to fulfill project objectives; or which require calibration as per manufacturer's specifications.

3.0 GLOSSARY

Instrument - Any data-gathering device.

Calibration - An operational check of a monitoring or detecting device, which yield, an expected response when operated with a known standard.

Equipment Manager - Person assigned responsibility for equipment storage and use. All calibration functions shall be documented and maintained by the Equipment Manager responsible for the instruments involved.

4.0 RESPONSIBILITIES

It is the responsibility of each NUS office manager to ensure the implementation and maintenance of this procedure. Other responsibilities involved with this procedure shall be addressed by personnel function.

5.0 PROCEDURES

Calibration Responsibilities - Instruments requiring calibration shall be calibrated according to their respective manufacturer's specifications, be given an operational check, and be calibrated prior to assignment to a project. Only qualified individuals, knowledgeable (or certified, if applicable) in the proper procedures, are permitted to perform instrument calibration. It is unacceptable (and shall not be permitted) to use any instrument which requires calibration before it is successfully calibrated. It is the responsibility of the equipment operator/user to ensure that all instruments in his/her control have been calibrated and are given an operational check prior to field use.

Procedures and Schedules - Calibration frequencies and procedures shall follow: (1) NUS Operating Procedures or (2) manufacturer's specifications.

Recordkeeping - All calibration activities must and shall be documented to ensure compliance with both applicable regulatory standards and with the requirements of this program. Proper and timely documentation is the responsibility of the person(s) performing the calibration. These records shall be updated and maintained for at least the life of the instrument. All equipment calibration efforts shall be documented, using calibration cards (see Attachment A). Items that must be included on these documents shall include either the manufacturer's recommendations or those items specified in the Standard Operating Procedures. Any equipment maintenance efforts also shall be documented using the Maintenance Service record (see Attachment A). It shall be the responsibility of the Equipment Manager in each office to maintain these records.

Upon use and task completion, the user/operator is required to document any problems or malfunctions noted throughout the use. This information shall be accompanied by the user/operator's name, identification of the instrument involved, and identification of the job/project involved. This information shall be used to inspect, repair, and/or maintain instruments. Any such activities shall be conducted in accordance with Equipment Tagging Procedures.

Equipment calibration is an auditable function. Therefore, accurate recordkeeping shall be maintained to ensure compliance with this program as well as to monitor that all persons are fulfilling their respective responsibilities.

6.0 REFERENCES

None.

7.0 ATTACHMENTS

Attachment A – Calibration and Maintenance Service Cards

ATTACHMENT A

CALIBRATION (EXAMPLE 1) AND MAINTENANCE SERVICE (EXAMPLE 2) CARDS

EXAMPLE 1

ITEM		I.D.	INV #	REQUIREMENTS
DATE	PERSON	REMARKS		

EXAMPLE 2

ITEM	MOD #	COST	INV #
	SER #	RENTAL	ID#
	MFR #	MONTH	
DATE	MAINTENANCE SERVICE/REMARKS		

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6.0 REFERENCES

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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

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7.0 ATTACHMENTS

None.

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1.0 PURPOSE

This procedure describes the method for logging and sampling of test pits and trenches to determine subsurface soil and rock conditions and recover small-volume or bulk samples. The methods apply only to data collection and do not apply to the construction of excavations.

2.0 SCOPE

The procedure is applicable to the collection of bulk and small-volume samples of subsurface soils for laboratory testing which are exposed through excavating at hazardous substance sites.

3.0 GLOSSARY

Test pit or trench - A pit or trench, either machine or manually excavated, from which large quantities of soil may be removed.

4.0 RESPONSIBILITIES

Site Manager - responsible for determining, in consultation with other project personnel (geologist, geochemist), the need for test pits or trenches, their approximate locations, depths and sampling objectives.

Field Operations Leader (FOL) - responsible for finalizing the location, orientation and depth of test pits/trenches based on on-site conditions and the site geologist's advice. The FOL is ultimately responsible for the proper construction, sampling and backfilling of test pits and trenches, including adherence to OSHA regulations.

Health and Safety Officer (HSO) - responsible for air quality monitoring during test pit construction and sampling, to ensure that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The HSO may also be required to advise the FOL on other safety-related matters regarding the test pit or trench excavation and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Site Geologist/Sampler - responsible for recording all information and data on test pit/trench construction and for the proper collection and logging of samples according to this procedure.

5.0 PROCEDURES

5.1 DATA COLLECTION AND SAMPLING

5.1.1 General

Test pits and trenches are usually logged as they are excavated. Records of each test pit/trench will be made on prepared forms or in a field notebook. If the log is made in a field notebook, it will be transcribed to the prepared forms. These records include plan and profile sketches of the test

pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records will also include safety and sample screening information.

Requirements for sampling shall be determined by the Site Manager, and shall be documented in the Project Operation Plan (POP). A copy of this plan shall be maintained by the Field Operations Leader. To expedite sampling, the crew shall have sufficient tools and equipment to sample each pit. The tools and equipment must be properly decontaminated prior to use.

Entry of test pits by personnel is extremely dangerous and shall be avoided unless absolutely necessary. Pits more than 4 feet deep must be shored prior to entry, the "buddy" system must be used, and all applicable H&S and OSHA requirements followed.

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

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

5.1.2 Sampling Equipment

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

- Backhoe or other excavating machinery.
- Shovels, picks and hand augers, stainless steel trowels.
- Sample container - bucket with locking lid for large samples and glass bottles for chemical or geotechnical analysis samples.
- Polyethylene bags for enclosing sample; buckets.
- Remote sampler consisting of 10-foot sections of steel conduit (1-inch diameter), hose clamps and right angle adapter for conduit (see Attachment A).

5.1.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 5.1.4.

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

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

- Any fluid phase or groundwater seepage is encountered in the test pit.
- Any drums, other potential waste containers, obstructions or utility lines are encountered.
- Distinct changes of material are encountered.

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

- Remove loose material to the greatest extent possible with backhoe.
- Secure walls of pit if necessary. (There is seldom any need to enter a pit or trench which would justify the expense of shoring the walls. All observations and samples can generally be taken from the ground surface.)
- Samples of the test pit material will be obtained either directly from the backhoe bucket or from the material once it has been deposited on the ground. The sampler or Field Operations Leader directs the backhoe operator to remove material from the selected depth or location within the test pit/trench. The bucket is brought to the surface and moved away from the pit. The sampler and/or HSO then approaches the bucket and monitors its contents with a photoionization (HNU) or OVA meter. The sample is collected from the center of the bucket or pile and placed in sample jars using a clean stainless steel trowel or spatula.
- If a composite sample is desired, several depths or locations within the pit/trench are selected and a bucket is filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample bottle shall be emptied into a mixing container (e.g., stainless steel bucket) and thoroughly stirred prior to being placed into the sample jars. Composite sampling is not appropriate for samples which will undergo analysis for volatile organic compounds.

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

- Prepare shipping papers, labels, and chain-of-custody records, as described in SA-6.2, Sample Packaging and Shipping.

5.1.4 In-Pit Sampling

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

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

- The project will benefit significantly from the improved quality of the logging and sampling data obtained if personnel enter a pit or trench rather than conduct such operations from the ground surface.

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

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

- An experienced geotechnical professional determines that the pit/trench is stable or is made stable prior to entrance of any personnel (by grading the sidewalls or using shoring). OSHA requirements (Reference 1) must be strictly implemented.

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

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

operations. In the event of a cave-in they can either be lifted clear in the bucket, or at least climb up on the backhoe arm to reach safety.

5.1.5 Geotechnical Sampling

In addition to the equipment described in Section 5.1.2, the following equipment is needed for geotechnical sampling:

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

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

Relatively undisturbed samples are usually extracted in cohesive soils using open tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than a drill rig. Also, the sampler may be extracted from the test pit by excavation around the sampler when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit the requirements described in Section 5.1.4 must be followed. The open tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate, because the sample will not have the correct orientation.

A sledge hammer or the backhoe may be used to drive or push the sampler or tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, to minimize disturbance to the sample. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hand excavation to remove the soil from around the sides of the sampler and slice off the sample at its bottom may be required. If this requires entry of the test pit, the requirements in Section 5.1.4 must be followed. Prepare, label, pack and transport the sample in the required manner, as described in SA-6.2, Sample Packaging and Shipping.

Hand-carved block samples are extracted in a similar manner to open tube samples, except that the sampling container (usually a large tube or box with no top or bottom) is not used to cut the sample. Instead, the surrounding sections of the test pit floor are carved away by hand to leave a sample slightly smaller in plan dimensions than the container, with the sample remaining connected to the test pit floor at its bottom. The container is slipped over the sample, and the annular space and top of the sample is covered with melted wax. The bottom of the sample is then sliced away from the test pit floor, the container is inverted, about 1/2 inch of soil removed, and the space filled with melted wax. Caps are then installed, taped, and dipped in hot wax for each end of the container, and the block sample is labeled and shipped in the same manner as a tube sample.

5.2 RECORDS

The following information will be recorded on the test pit/trench log form and in the field notebook:

- Name, work assignment number, and location of job.
- Date of digging or trenching.
- Surface elevation.
- Depth, surface area and orientation of pit or trench.
- Sample numbers.
- Method of taking samples, type and size of samples.
- Approximate water levels after stabilization (if below the water table), and location and depth of any seeps.
- Description of soil.
- Other pertinent information, such as HNU or OVA readings, weather conditions, etc.
- List of photographs.
- Name of contractor, backhoe (or other equipment) operator and sampler.
- Date and type of backfill.

6.0 REFERENCES

OSHA, 1979. Excavation Trenching and Shoring, 29 CFR 1926.650-653.

7.0 ATTACHMENTS

Attachment A - Remote Sampling/Sample Holder for Test Pit/Trench

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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 w[illegible]e, 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]atory 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

SAMPLERS: *(Signature)*

STA. 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:	

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

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6.0 REFERENCES

7.0 ATTACHMENTS

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	D O T. PROPER SHIPPING NAME	HAZARD CLASS	CODE	L P	CONTAINER NUMBERS	PLC	BULK
1	55 gal	200 lbs.	x	Nitric Acid, Fuming	Oxidizer	55-BN	C	1	✓	
1	55 gal	450 lbs	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-ABF	—	2		✓
1	55 gal	250 lbs	x	Flammable Liquid, n.o.s.	Flammable Liquid	55-BN	B	3	✓	
1	15-A	12 lbs.	x	Bromine	Corrosive Material	55-BN	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 _____

Disposal Work Order _____

Service Order No _____

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NUS CORPORATION ENVIRONMENTAL MANAGEMENT GROUP	STANDARD OPERATING PROCEDURES	Number SA-6.3	Page 1 of 4
		Effective Date 05/04/90	Revision 2
		Applicability EMG	
		Prepared Earth Sciences	
Subject SITE LOGBOOK		Approved D. Senovich	

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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

APPENDIX D

QUALITY ASSURANCE/QUALITY CONTROL PLAN (QA/QC)

Appendix D
Quality Assurance/Quality Control Plan (QA/QC)

for

Remedial Actions at Sites 2, 3, 4, 8, 9, and 11 Naval Surface Warfare Center White Oak

Silver Spring, Maryland

Engineering Field Activity Chesapeake
Naval Facilities Engineering Command

Northern Division Contract Number N62472-90-D-1298
Contract Task Order 0180

January 1995

R-12-94-10

APPENDIX D
QUALITY ASSURANCE/QUALITY CONTROL PLAN (QA/QC)
FOR
REMEDIAL ACTIONS AT
SITES 2, 3, 4, 8, 9, AND 11
NAVAL SURFACE WARFARE CENTER
WHITE OAK
SILVER SPRING, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Chesapeake
Design Branch Code 04
Naval Facilities Engineering Command
Washington Navy Yard, Building 212
Washington, D.C. 20374-2121

Submitted by:
Halliburton NUS Corporation
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0180

JANUARY 1995

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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 field work to be performed to support the implementation of an Design Verification Sampling and Analysis Plan (DVSAP) for NSWC White Oak. The DVSAP is being prepared for six sites, including Site 2, 3, 4, 8, 9 and 11.

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 data obtained pertaining to operations of 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. It should be noted that this QA/QC document is provided for samples which will be sent to a fixed base laboratory for analysis. Samples will also be analyzed at the same laboratory for quick turn analysis.

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 subcontracted fixed base laboratory. The laboratory will have prior NEESA approval. QA/QC procedures for the chemical analyses will satisfy NEESA requirements for Level C and Level E QC, as defined in the guidelines document "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program" (NEESA 20.2-047B; June, 1988). 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 performance of the fieldwork.

2.0 SCOPE OF WORK

The field activities will be performed to determine the extent of soil contamination prior to beginning a source remediation at the NSWC White Oak facility. These data will be used to determine the remedial options for each site and to determine the amount and types of contamination which might be present at each of the six sites. Details of the field activities, such as the technical approach, selection of drilling locations, and sample collection activities are found in Sections 3.0 and 4.0 of the DVSAP. Descriptions of physical features and site history can be found in Section 5.0 through Section 10.0 of the DVSAP.

3.0 SAMPLE PARAMETERS AND COLLECTION

As part of the field activities, environmental samples of soil and sediment will be collected for analysis. A listing of the sample matrices, parameters, and frequency of collection is found on Table 4-1 of the DVSAP. Table 4-2 of the DVSAP presents the sample containers, preservatives, and maximum allowable holding times for the analyses requested for the site. Sampling protocols to be used in this study are provided in Section 6.0 of this QA/QC Plan. As required by NEESA, a sampling rationale is included in Section 3.0 and Section 4.0 of the DVSAP.

All samples submitted for fixed laboratory analysis will be analyzed for VOA, SVOC, metals and Method 8330 analytes, and TKN and soil engineering parameters. Some samples submitted for analysis will be analyzed for a subset of the TAL/TCL scan depending on site conditions and the results of previous sampling at each site.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Halliburton NUS 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 Halliburton NUS in a number of areas.

4.1 PROJECT ORGANIZATION

The key firms and personnel involved in the field work, as well as the chain-of-communication and responsibility of the project personnel, are as follows:

Chesapeake Division
Naval Facilities Engineering Command
901 M St. S.E., Building 212
Washington, D.C. 20374-5018
(202) 433-3760

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EFACHES NFEC
901 M St. S.E.
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(202) 433-3760 Secretary
(202) 433-6193 Fax

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(412) 921-7090

Debra Wroblewski
Deputy Program Manager

Debra Scheib
Quality Assurance/Quality Control Manager

Matt Soltis
Health and Safety Manager

Don Olmstead
Project Manager

The Project Manager has the primary responsibility for project and technical management. 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 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 QA/QC manager (as applicable) will identify the appropriate corrective action.

4.2 FIELD ORGANIZATION

The Halliburton NUS 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/EOD Specialist
- Sampling technicians

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 adherence to all sample acquisition and handling protocols and the availability and maintenance of all sampling materials/equipment. The FOL will be responsible for the completion and quality assurance review of all sampling, well construction, and chain-of-custody

documentation, and will assume custody of all samples and ensure the proper handling and shipping of samples. The FOL will interface with the QA/QC manager as deemed appropriate.

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 in Appendix B.

The site Health and Safety Manager 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. The FOL or his or her designee, will function in this capacity and interface with the Health and Safety Manager on an as-needed basis.

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, field quality control 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 field activities. The sampling rationale provided in the DVSAP explains the choice of sample locations and media which will supply information needed for the source removal action of the Design Verification Plan.

5.2 PARCC PARAMETERS

The quality of a data set is measured by certain characteristics of the data, such as precision, accuracy, representativeness, comparability, and completeness (the PARCC parameters). Some of these parameters are expressed quantitatively, while others are expressed qualitatively. The objectives of the field activities 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 the analytical method as referenced by NEESA. Field duplicates for analysis by the fixed base laboratory will be collected for 10 percent of all environmental samples obtained for analysis by the onsite laboratory.

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:

$$\% R = E/T \times 100\%$$

where: E = experimental result

T = true value (theoretical result)

and

$$T = \frac{(\text{Sample Aliquot})\ (\text{Sample Conc.}) + (\text{Spike Aliquot})\ (\text{Spike Conc.})}{\text{Sample Aliquot} + \text{Spike Aliquot}}$$

Control limits for accuracy are set at the mean plus or minus three times the standard deviation of a series of %R values.

Accuracy for soil samples will be evaluated by use of surrogate and matrix spikes. Matrix spikes are analyzed with a frequency of 20 percent. Surrogate spikes are added to every environmental sample, field

quality control sample, laboratory standard and laboratory quality control sample analyzed. Additionally, as required by NEESA, blank spikes are analyzed with a frequency of 20 percent for pesticide/PCB fraction analyses.

Out-of-criteria results will be reviewed for data applicability as a part of data validation. Data validation procedures are discussed in Section 10.0 of this QA/QC plan.

5.2.3 Representativeness

All data obtained should be representative of actual conditions at the sampling location. The DVSAP is designed so that the samples taken will present an accurate representation of actual site conditions. The rationales discussed in the DVSAP 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 NEESA 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 new data with 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 of data collected. For relatively clean, homogeneous matrices, 100-percent completeness is expected. However, as matrix complexity and heterogeneity 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 TRIP BLANKS

Trip blanks are samples which originate from analyte free water taken from the laboratory to the sampling site and returned to the laboratory with the Volatile Organic Compound (VOC) samples sent for analysis at the fixed base laboratory. One trip blank is assigned to each cooler containing VOCs. Trip blanks are only analyzed for volatile organic compounds.

5.4 FIELD DUPLICATES

Field duplicates are two samples collected from 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. Five percent of samples collected from screening samples (soil borings from Sites 2, 3, 4, and 8) will be sent as duplicates. Ten percent of samples collected from leaching well samples (at Sites 9 and 11) will be sent as duplicates. Duplicate samples will be split during the sampling procedure and will be sent to the fixed base laboratory. Results for the two samples will be compared to determine the accuracy of the laboratory.

5.5 BOTTLEWARE

NEESA requires specific bottleware cleaning procedures. Precleaned bottles will be used at the White Oak site; the required certification will be provided.

5.6 QUANTITATION AND DETECTION LIMITS

Quantitation limits are those required as Contract Required Quantitation Limits (CRQLS; organic analyses), and Contract Required Detection Limits (CRDLs; metals analyses), as defined in the current Contract Laboratory Program (CLP) analytical Statements of Work (SOWs). Allowances are made for dilutions and dry-weight conversions.

As required by NEESA, organic method detection limits (MDLs) and inorganic instrument detection limits (IDLs), will also be reported. MDLs and IDLs must be less than or equal to the contract required limits of quantitation.

6.0 SAMPLING PROCEDURES

A complete description of sampling procedures for all media are included in Sections 3.0 and 4.0 of the DVSAP. All aspects of sample collection, including sampling location, sampling methods, bottle requirements, holding times, preservatives and numbers of samples to be analyzed are included in these sections.

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 B of the DVSAP.

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 following procedures will be followed for handling samples in the field:

- 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 appended form).

  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 and preparation procedures. Copies of all logs used are provided in Appendix D.

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 on 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 fixed base 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 of samples to the fixed laboratory 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 by the onsite or fixed base laboratory:

- 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.

- 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.

The following procedures will be followed when shipping samples for laboratory analysis by the fixed base laboratory:

- 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.

- Only shipping containers that meet all applicable state and Federal standards for safe shipment will be used.

- Shipment will be made by a public courier. After samples have been taken, they will be sent to the laboratory within 24 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. A sample instrument calibration log is provided in Appendix B.

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 4.0 (Tables 4-1 and 4-2) of the DVSAP 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. Note that data from this site laboratory will be used to screen samples, and therefore will not be validated.

The final Design Verification report will include a data summary. The summary of analytical data will exclude non-detected compounds. No subtraction of blank contaminant concentrations 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 blanks and duplicates marked. The format recommended by the Navy will be used. Field logs and forms will be included in a separate appendix.

11.0 INTERNAL QUALITY CONTROL CHECKS

Quality control samples generated by Halliburton NUS will include the collection of field duplicates and the preparation of field and equipment/rinsate blanks. Prepared trip blanks will be provided by the laboratory. Approximately a 5 percent duplication (1 per 20 samples of like matrix or 1 per sample matrix if less than 20 samples are collected) will be obtained (see Table 4-1).

Trip blanks are prepared by the laboratory and accompany the samples during field activities to ensure the integrity of sample handling. Rinsates, prepared by running distilled de-ionized 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 detailed in the Section 6.0 of this QA/QC Plan.

Two types of quality assurance mechanisms are used to ensure the production of analytical data of known and documented quality. One mechanism relates to the use of standardized sample acquisition, handling, and shipping procedures. The second mechanism relates to the internal quality control procedures used by the laboratory which are stipulated in the laboratory's QA/QC plan and referenced by the NEESA guidelines and analytical methods indicated in Table 3-1. 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 the subcontract 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 sample not in compliance with the QC criteria will be identified and reanalyzed by the laboratory, as applicable. The following procedures will be employed for the White Oak 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 defined by the analytical method.

12.0 PERFORMANCE AND SYSTEM AUDITS

System audits will be performed on a semi-continuous basis, as appropriate, to assure that the work is being implemented in accordance with the approved project QAPP and SOPs, and in an overall satisfactory manner.

- The FOL will supervise and check on a daily basis that the field measurements are made accurately, equipment is thoroughly decontaminated, samples are collected and handled properly, and the field work is accurately and neatly documented.

- For samples sent to the laboratory, 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 in accordance with the laboratory's QA/QC plan and are integral to NEESA 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 auditor will check that sample collection, sample handling, decontamination protocols, and instrument calibration and use are in accordance with the approved project SOPs. The auditor 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 NEESA, be eligible to perform the required analysis under the specified 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 and field blanks.

The representativeness of the data will be assessed by determining whether 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.

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 QA/QC manager, 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 manager (or designee) 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.

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, September 1991. Contract Laboratory Program Statement of Work for Inorganics Analysis. CLP SOW ILM02.1

U.S. EPA, October 1992. Contract Laboratory Program Statement of Work for Organics Analysis. CLP SOW OLM01.8.

U.S. EPA, April 1993. Region III Modifications to National Functional Guidelines for Inorganic Data Review.

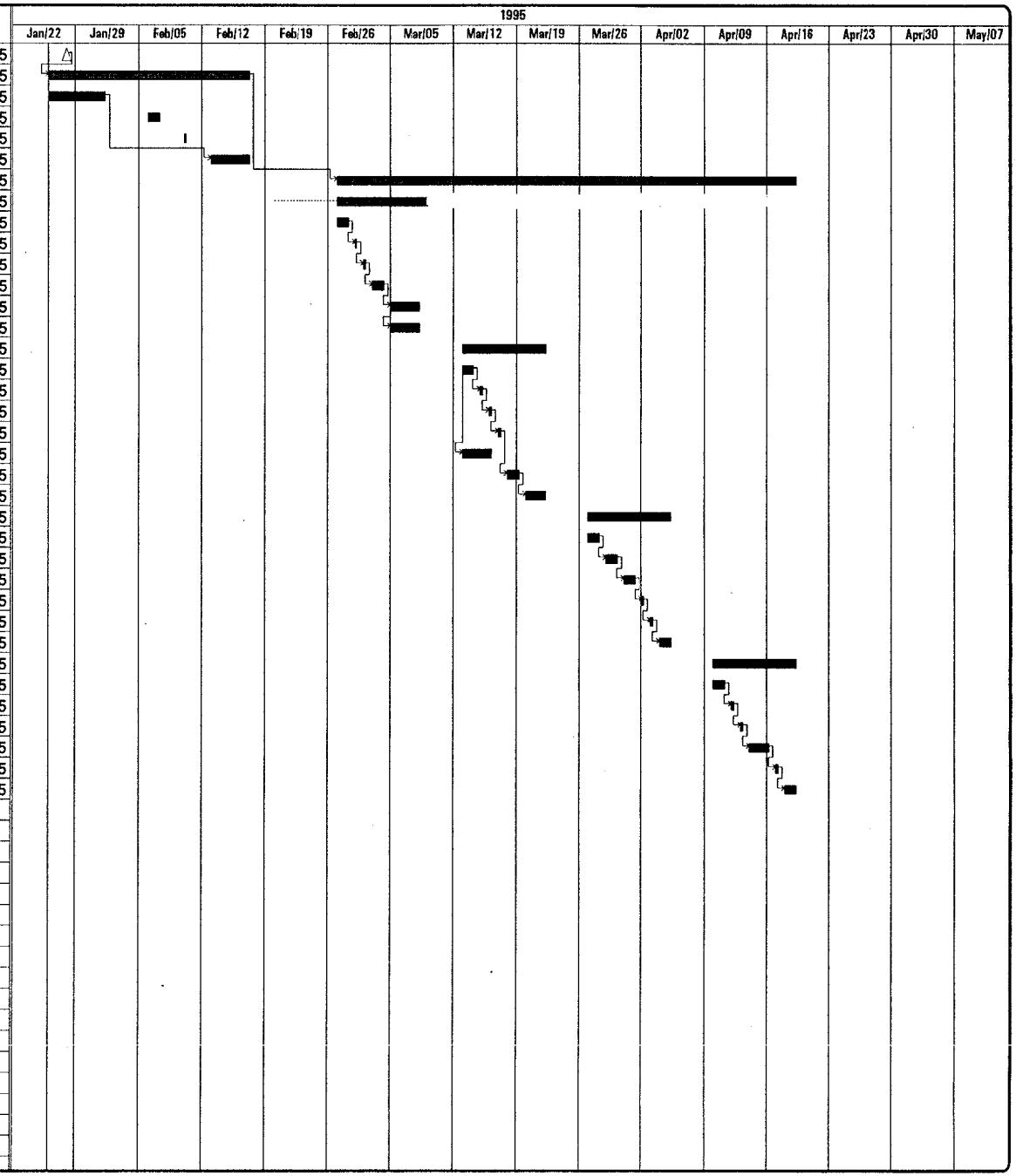
U.S. EPA, May 1993. Region III Modifications to National Functional Guidelines for Organic Data Review.

APPENDIX E

FIELD OPERATIONS SCHEDULE

Proposed DVSAP Schedule

Task Name	Duration	Start	End
DVSAP Submittal	0.00 d	Jan/28/95	Jan/28/95
Field Investigation Planning	17.00 d	Jan/26/95	Feb/17/95
Prepare and Issue RFP	5.00 d	Jan/26/95	Feb/01/95
Pre-bid meeting at White Oak	2.00 d	Feb/06/95	Feb/07/95
Recieve RFP's	1.00 d	Feb/10/95	Feb/10/95
Review proposals and award subcontracts	5.00 d	Feb/13/95	Feb/17/95
Design Verification Field Investigation	42.00 d	Feb/27/95	Apr/19/95
First 10 day shift	.00 d	Feb/27/95	Apr/19/95
Site Mobilization	2.00 d	Feb/27/95	Feb/28/95
EM Survey Site 9	1.00 d	Mar/01/95	Mar/01/95
EM Survey Site 11	1.00 d	Mar/02/95	Mar/02/95
Locate/Uncover leaching wells - Sites 9, 11	2.00 d	Mar/03/95	Mar/04/95
Sample leaching wells - Sites 9, 11	4.00 d	Mar/05/95	Mar/08/95
Analyze leaching well samples	4.00 d	Mar/05/95	Mar/08/95
Second 10 day shift	10.00 d	Mar/13/95	Mar/22/95
EM Survey Site 2	2.00 d	Mar/13/95	Mar/14/95
EM Survey Site 3	1.00 d	Mar/15/95	Mar/15/95
EM Survey Site 4	1.00 d	Mar/16/95	Mar/16/95
EM Survey Site 8	1.00 d	Mar/17/95	Mar/17/95
EM Data Evaluation	4.00 d	Mar/13/95	Mar/16/95
Test trenches, Site 2 and 3	2.00 d	Mar/18/95	Mar/19/95
Soil Boring (hand augers), Site 4 and 8	3.00 d	Mar/20/95	Mar/22/95
Third 10 day shift	10.00 d	Mar/27/95	Apr/05/95
Soil Borings, Site 11	2.00 d	Mar/27/95	Mar/28/95
Soil Borings, Site 9	2.00 d	Mar/29/95	Mar/30/95
Soil Borings, Site 4	2.00 d	Mar/31/95	Apr/01/95
Soil Borings, Site 8	1.00 d	Apr/02/95	Apr/02/95
Soil Borings, Thermal Unit Location	1.00 d	Apr/03/95	Apr/03/95
Additional Borings if needed	2.00 d	Apr/04/95	Apr/05/95
Fourth 10 day shift	10.00 d	Apr/10/95	Apr/19/95
Sediment / soil sampling, Site 2	2.00 d	Apr/10/95	Apr/11/95
Landfill borings, Site 3 / Background soils	1.00 d	Apr/12/95	Apr/12/95
Water level measurement	1.00 d	Apr/13/95	Apr/13/95
Revise site maps	3.00 d	Apr/14/95	Apr/16/95
Sample IDW / Arrange for removal	1.00 d	Apr/17/95	Apr/17/95
Demobilize	2.00 d	Apr/18/95	Apr/19/95



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Page 1

Milestone △ Summary ▬ Fixed Delay ····

Proposed DVSAP Schedule

January 1995

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1 New Year's	2 New Year's (Obs.)	3	4	5	6	7
8	9	10	11	12	13	14
15	16 M. L. King Day	17	18	19 Robt. E. Lee Day	20 Inaug. Day	21
22	23	24	25	26	27	28 DVSAP Submitta
29	30	31				

Prepare and Issue RFP

Prepare and Issue RFP

Proposed DVSAP Schedule

February 1995

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
			Prepare and Issu			
5	6	7	8	9	10	11
	Pre-bid meeting at White Oak				Recieve RFP's	
12 Lincoln's B. Day	13	14	15	16	17	18
	Review proposals and award subcontracts					
19	20 Presidents' Day	21	22	23	24	25
26	27	28				
	Site Mobilization					

Proposed DVSAP Schedule

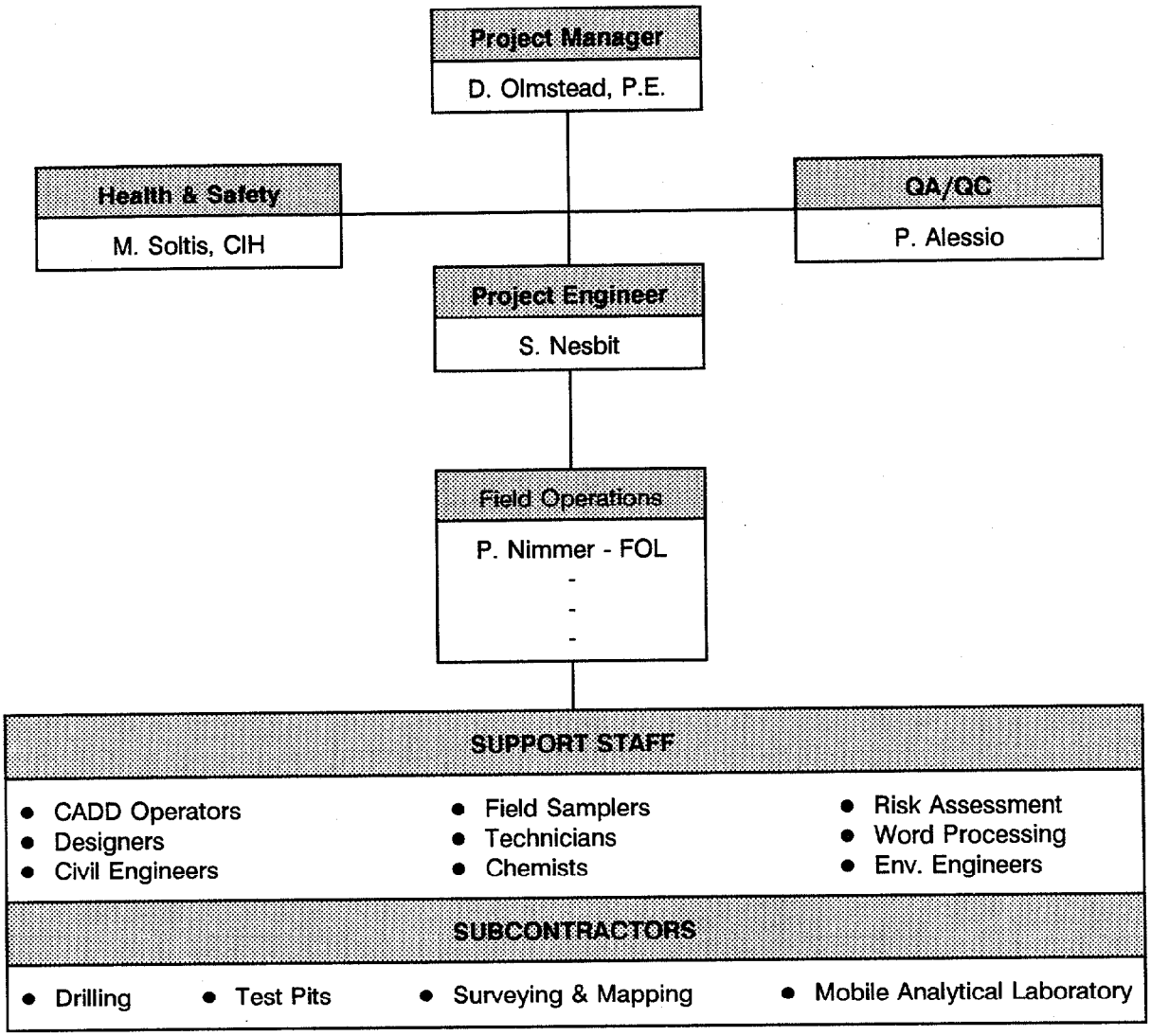
March 1995

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1 EM Survey Site 9	2 EM Survey Site 11	3 Locate/Uncover leaching wells - Sites	4
5 Analyze leaching well samples Sample leaching wells - Sites 9, 11	6	7	8	9	10	11
12	13 EM Survey Site 2,3 EM Data Evaluation Second 10 day shift	14	15 EM Survey Site 4	16 M Survey Site 8	17 M Survey Site	18 Test trenches, Si
19 Test trenches, Si	20 Soil Boring (hand augers), Site 4 and 8 Second 10 day shift	21	22	23	24	25
26	27 Soil Borings, Site 11 Third 10 day shift	28	29 Soil Borings, Site 9	30	31 Soil Borings, Site	

Proposed DVSAP Schedule

April 1995

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1 Soil Borings, Site Third 10 day shift
2 Soil Borings, Site Third 10 day shift	3 Soil Borings, The	4 Additional Borings if needed	5	6	7	8
9	10 Sediment / soil sampling, Site 2 Fourth 10 day shift	11	12 Landfill borings,	13 Jefferson's B. Day Water level mea	14 Good Friday Revise site maps	15
16 Easter Revise site maps Fourth 10 day shift	17 Patriot's Day Sample IDW / Ar	18 Demobilize	19	20	21	22
23	24	25	26	27	28	29
30						

FIGURE E-2

PROJECT ORGANIZATION CHART