M67001.AR.004602
MCB CAMP LEJEUNE
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D-33-11-90-12/20

# FINAL
# SAMPLING AND ANALYSIS PLAN

## VOLUME I OF II

## FIELD SAMPLING PLAN
## AND
## QUALITY ASSURANCE PROJECT PLAN
## FOR SITE INSPECTIONS
## AT
## SITES 3, 7, 43, 44, 54, 63, 65, 80, AND 82

## CAMP LEJEUNE MILITARY RESERVATION
## JACKSONVILLE, NORTH CAROLINA

AUGUST 1991

HALLIBURTON NUS
*Environmental Corporation*

01.06-08/01/91-00694

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CAMP LEJEUNE MILITARY RESERVATION
JACKSONVILLE, NORTH CAROLINA

AUGUST 1991


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# 1.0 INTRODUCTION

## 1.1 PURPOSE

This Sampling and Analysis Plan (SAP) is being issued as part of a site inspection for the Department of the Navy, Atlantic Division, for the Marine Corps Base (MCB), Camp Lejeune. Initial Assessment Study Sites 7, 63, 54, 3, 43, 44, 65 and new sites 82 and 80 are being addressed in response to a request by the Department of the Navy. This SAP was prepared under contract N62470-90-R-7629, as specified in the Draft Work Plan (NUS, December 1990), which outlines the technical scope and schedule for the site inspection.

The SAP for this work includes sampling and analytical objectives; the number, type, and location of all samples to be collected during the field investigation; site-specific quality assurance requirements; and detailed procedures for field activities. The field activities specified in the SAP are based upon data gaps identified from evaluating the results of previous sampling activities (discussed in Section 1.2) and on the need for preliminary data on the new sites mentioned above. The sampling and analytical procedures outlined in this SAP will provide data needed to define present and future risks to human health and the environment, associated with contamination at MCB Camp Lejeune.

The Sampling and Analysis Plan is presented in two volumes. Volume I is the Field Sampling Plan and the Quality Assurance Project Plan. Volume II is the laboratory QA/QC plan. Both volumes comply with the Navy's Quality Assurance Program.

The Field Sampling Plan is divided into 13 sections. This Introduction is Section 1.0. Section 2.0, General Site Location and Description, presents an overview of Camp Lejeune Military Reservation. Sections 3.0 through 11.0 provide the detailed field investigation activities to be performed at each site. Specifically, this includes the Site Description, Work Plan Rationale, Drilling Operations, Media Sampling Operations, and Surveying Operations. Section 12.0 contains field activities for performing background samples. Section 13.0, Sampling Procedures and Field Investigation Operations, defines and discusses sampling operations and procedures.

## 1.2 BACKGROUND

An Initial Assessment Study (IAS) was conducted by Water and Air Research, Inc. of Gainesville, Florida, in 1983. The purpose of the study was to identify and assess sites posing a potential threat to human health or the environment due to contamination from past hazardous materials operations. Based on information from historical records, aerial photographs, field operations, and personnel interviews, a total of 76 potentially contaminated sites (areas of concern or AOCs) were identified. The initial assessment evaluated each site with regard to contamination characteristics, migration pathways, and potential receptors. The results of the study indicated that while none of the sites posed an immediate threat to human health or the environment, 21 areas warranted further investigation to assess long-term impacts. During the initial investigation at the 21 AOCs, an additional AOC (Site A at MCAS New River) was identified and included in the ongoing investigations, for a total of 22 sites.

Based on the recommendations of the Initial Assessment Study, an RI/FS at MCB, Camp Lejeune was initiated in 1984 to study the 22 sites. The first round of sample collection and analysis was conducted by Environmental Science and Engineering, Inc. (ES&E), beginning in July 1984. During the investigation, 55 shallow groundwater monitoring wells were installed and a total of 75 groundwater samples were collected for analyses. In addition to the groundwater samples, 56 soil samples, 7 surface water samples, 8 sediment samples, and 2 fish tissue samples were collected and chemically analyzed. An Evaluation Report presenting the data generated by this round of sample collection was prepared in January 1985. The report recommended additional monitoring for all of the

investigated sites. An additional round of sample collection and analysis was conducted by ES&E in 1986/87. In this sampling episode, 29 additional monitoring wells were installed and a total of 113 new and existing monitoring wells were sampled. In addition, 54 soil samples, 44 surface water, and 41 sediment samples were collected and analyzed. An Evaluation Report was submitted to The Department of the Navy, Atlantic Division (LANTDIV) in July 1987 which documented the data generated during the second round of sampling.

In 1988, O'Brien and Gere Engineers was retained by LANTDIV under its Underground Storage Tank Program, to provide necessary hydrogeologic services. Such services included investigating the hydrogeology and evaluating the extent of fuel leakage from the underground storage tanks and associated transfer lines at the Hadnot Point Fuel Farm (Site 22).

ES&E was retained by LANTDIV to prepare an Interim RI report consolidating all documents produced to date concerning the 22 potentially contaminated sites identified by Air Research, Inc. The report describes the contamination assessments performed at the areas of concern, indicates potential migration pathways, summarizes all rounds of analytical data collected, and provides recommendations for further action. The Final Draft Report was issued in June 1990.

There have been two additional sites identified as potentially contaminated. These sites (80 and 82) will be evaluated for the first time as part of the proposed site inspections discussed in this Work Plan.

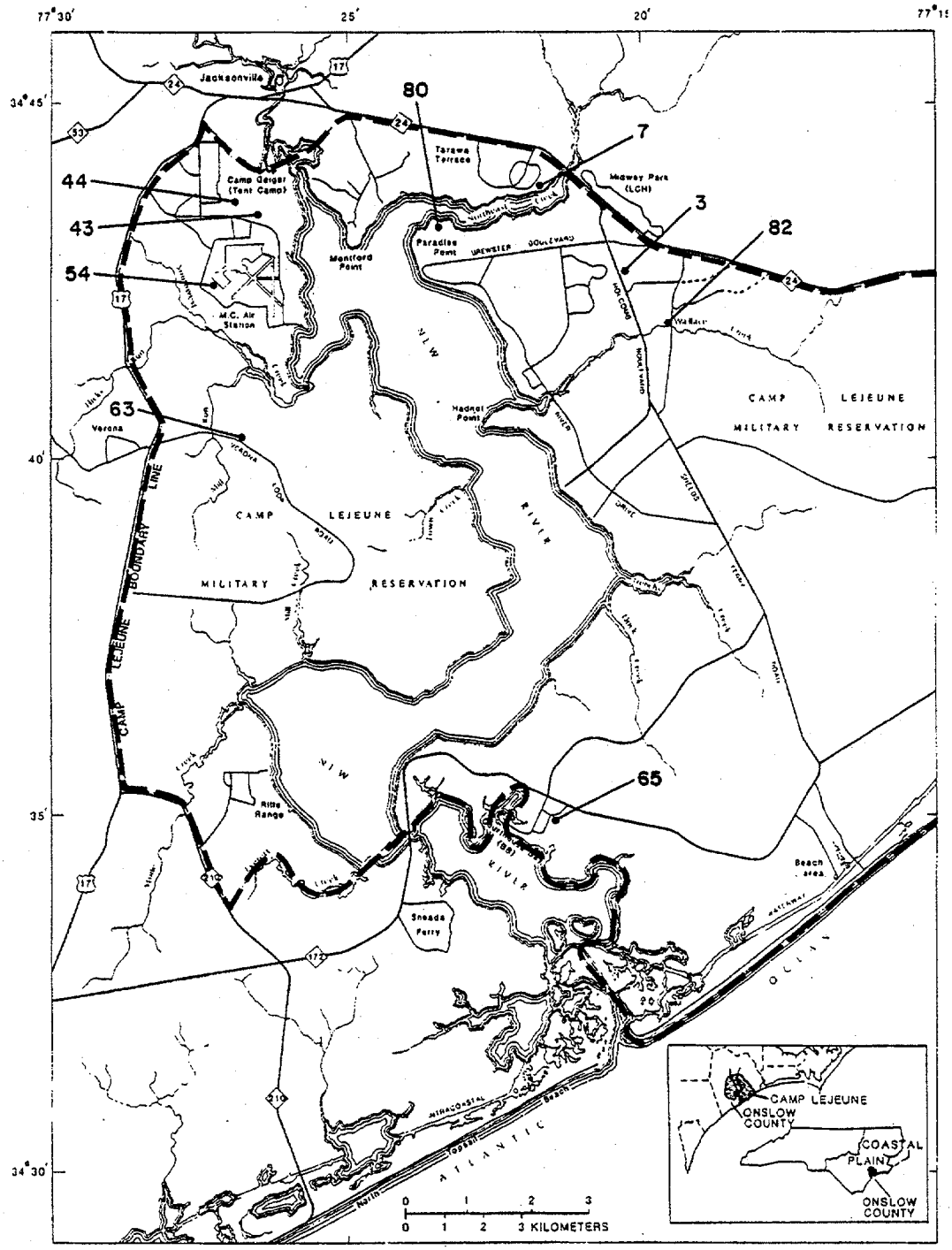
One of the sites covered in this Work Plan, Site 54: Crew Burn Pit, was part of the 22 sites originally identified as requiring confirmation of contamination and is included in ES&E's 1990 report. In this Work Plan, NUS proposes additional data gathering required to perform a risk assessment and determine whether the contaminants present pose a risk to human health or the environment.

The remaining six sites (Sites 7, 63, 3, 43, 44, and 65) were originally identified as requiring no further action in the 1983 Water and Air Research, Inc., report. This Work Plan proposes investigations to further characterize these sites and provide recommendations as to their dispensation.

# 2.0 GENERAL SITE LOCATION AND DESCRIPTION

The Marine Corps Base (MCB), Camp Lejeune, is a military installation located in Onslow County, North Carolina, just south of Jacksonville. The site is located on a 170-square-mile tract of land which is bisected by the New River estuary. The roughly triangular-shaped base is bordered by Route 24 to the north, Route 17 to the west, and the Atlantic Ocean Intracoastal Waterway to the south. Refer to the vicinity map shown in Figure 2-1, which also identifies outlying parts of the military installation. In addition, the map shows approximate locations of the sites covered in this document. Summaries of the site history, environmental setting, and existing contaminant data are included in the Work Plan (NUS, November 1990), more detailed site information can be found in the following documents:

- Continuous Seismic Reflection Profiling of Hydrogeologic Features Beneath New River, Camp Lejeune, North Carolina (USGS, 1990)
- IAS Report (Water and Air Research, 1983).
- Hydrogeologic Framework of U.S. Marine Corps Base, Camp Lejeune, North Carolina (Department of the Navy, 1990).




Base taken from, Defense Mapping Agency Hydrographic Center, Camp Lejeune Special Map, 1:50,000

**FIGURE 2-1**
**LOCATION MAP**
**CAMP LEJEUNE MILITARY RESERVATION**
**(Numbers shown identify approximate location of sites covered in this report.)**

NUS CORPORATION
A Halliburton Company

# 3.0 SITE 7: TARAWA TERRACE DUMP FIELD INVESTIGATION ACTIVITIES

## 3.1 SITE DESCRIPTION

Tarawa Terrace Dump is a landfill located east of the sewage treatment plant between Tarawa Terrace Boulevard and Northeast Creek (PDWM coordinates 3, F4). Its size is estimated to be 5 acres. As far as is known, no hazardous materials were disposed of in this facility. Only construction debris, sewage treatment plant filter media, and household trash are known to have been disposed here. The landfill was closed in 1972, but years of operation are not known. The location of the site is shown in Figure 3-1, with the boundaries being approximated pending further investigation.

## 3.2 WORK PLAN RATIONALE

The field investigation for this site is intended to determine whether the potential for an environmental contamination problem exists. Figure 3-2 provides approximate drilling and sampling locations. Final sample locations will be determined in the field by the project hydrogeologist. The hydrogeologist will locate samples in suspected areas of contamination to maximize detection of target analytes, if present. Wells will be installed so that two are located downgradient and one upgradient of the site. This will maximize detection of groundwater contamination, if present.

## 3.3 DRILLING OPERATIONS

A surface geophysical survey will be performed at all the suggested drilling locations to more readily locate the proposed wells and soil borings in areas that are least likely to contain buried metallic. The survey will consist of using an electromagnetometer (Heliflux), which can locate metallic objects, such as buried drums, near the ground surface. The drilling operations for Site 7 are discussed in detail below.

### 3.3.1 Soil Boring Installation

A total of five 15-foot soil borings will be installed at Site 7. The preliminary locations of the soil borings are shown in Figure 3-2. Final locations will be determined in the field after the geophysical survey. Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). None of the five soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 07SB01 through 07SB05 as shown on Figure 3-2. Split-spoon sampling details for the borings are given in Section 3.4.2.

### 3.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 7. Although the groundwater flow direction is not known, it is assumed that the water flows toward Northeast Creek; therefore, two downgradient wells are proposed for the southern side of the site, and one upgradient well is proposed for the northern side of the site. The preliminary locations of the monitoring wells are shown in Figure 3-2. Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 07MW01 through 07MW03, as shown on Figure 3-2. Wells shall be screened so that the

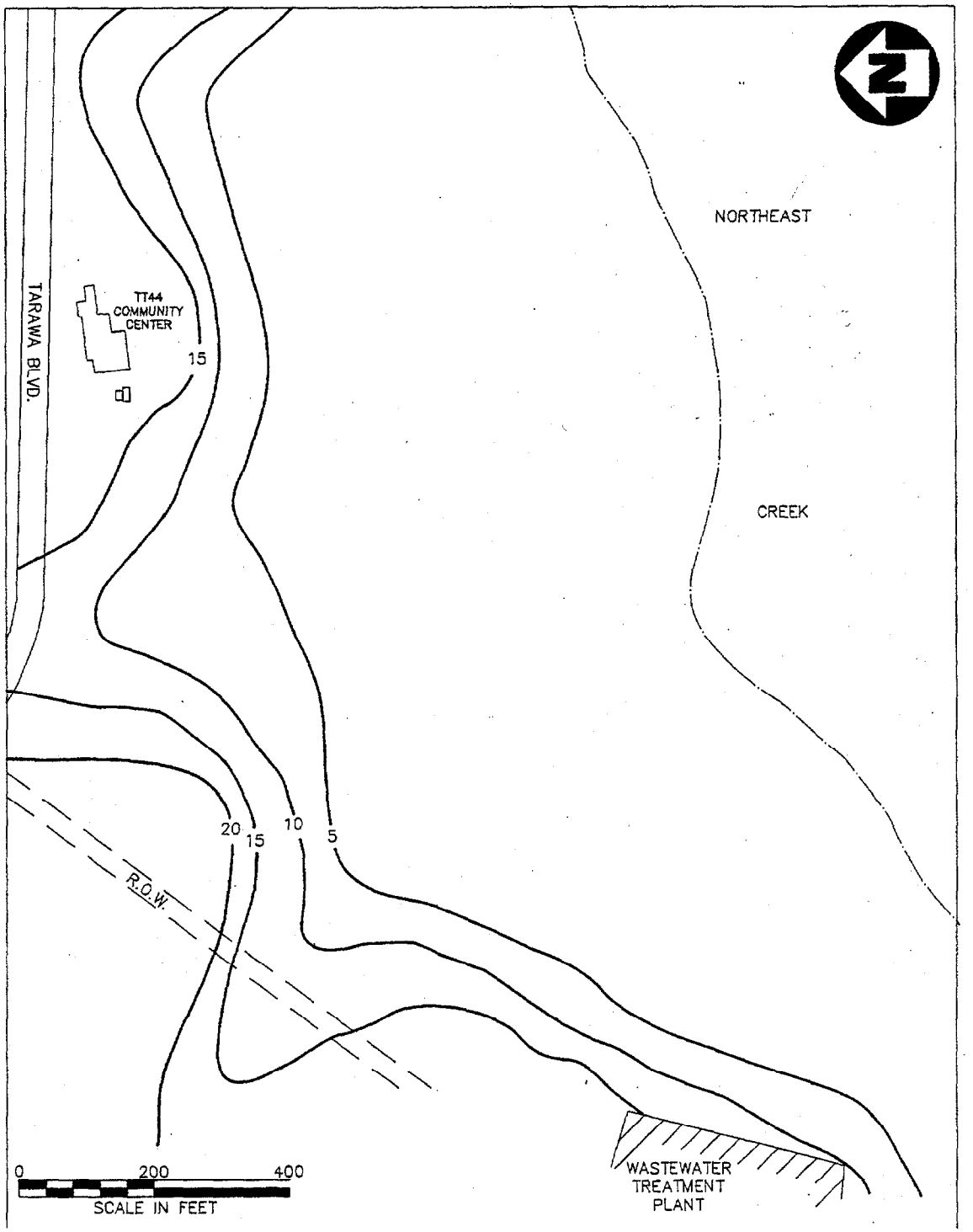



**FIGURE 3-1**
**SITE 7: TARAWA TERRACE DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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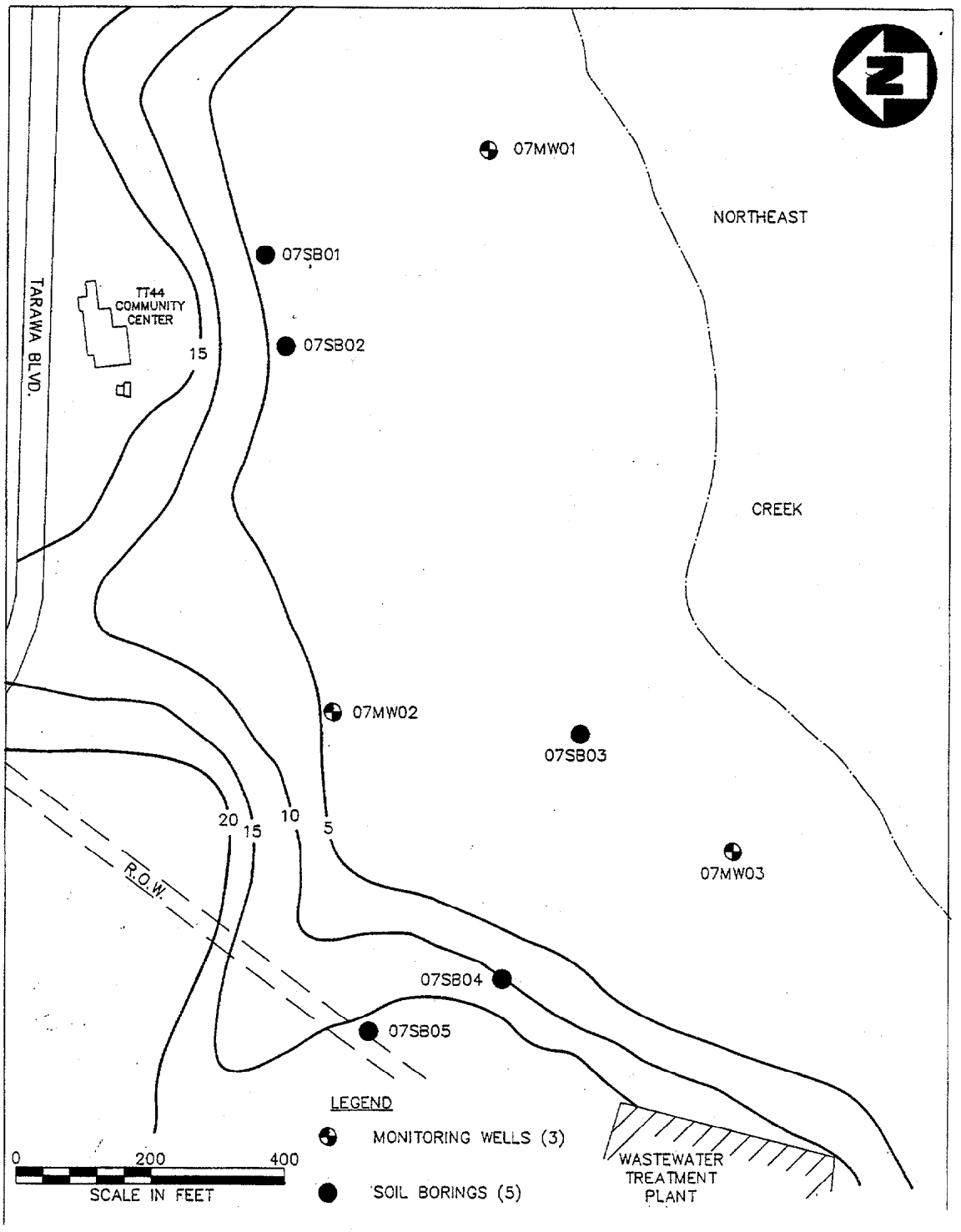


**FIGURE 3-2**
**SAMPLE LOCATIONS**
**SITE 07: TARAWA TERRACE DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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top of the screen is 2 to 3 feet above the static water level. Well development will be performed on each new well as described in Section 13.3.5. One round of samples will be collected from the new wells for chemical analysis as described in Section 3.4.1. One round of synoptic water-level measurements will be obtained from all wells (7MW01-7MW03) within a 4-hour period, as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 7 is given below:

- Install three shallow monitoring wells (7MW01-7MW03).
- Obtain synoptic water-level measurements from all new wells within a 4-hour period.

## 3.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 7:

- Groundwater
- Subsurface soil

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 3-1 provides a sampling and analysis program summary for Site 7. Table 3-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 3.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (7MW01, 7MW02, and 7MW03). Groundwater sampling locations are shown in Figure 3-2. The laboratory analysis of groundwater samples is summarized in Table 3-3. All of the monitoring wells will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 3.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 3-4 for the five soil borings drilled at Site 7. Soil sampling locations are shown in Figures 3-2. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Tables 3-3 and 3-4, laboratory analyses will be conducted on two subsurface soil samples per boring and two subsurface soil samples per well. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SITE 7: TARAWA TERRACE DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 0 | 0 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 0 | 0 |
| | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 1 | 0 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 1 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 16 | 2 | 1 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 7: [illegible]WA TERRACE DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

TABLE 3-2

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 7: TARAWA TERRACE DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | 5 | 3 | 40 ml VOA vials | HCl to pH < 2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 5 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | Cyanide | 5 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 3 | NA | NA | NA | NA |
| Soil | TCL VOAs | 20 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 19 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 19 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

**TABLE 3-3**

**MONITORING WELL INSTALLATION AND SAMPLING DETAILS**
**SITE 7: TARAWA TERRACE DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Soil Sampling Inverval (feet) | Soil Sample Type | Soil Analysis (per sample) |
|---|---|---|---|---|---|---|---|---|
| 07MW01, 07MW02, 07MW03 | 25 | 25(1) | 17 | 10 | TCL Organics<br>TCL Inorganics, Cyanide | 0.0 - 2.0 | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(2) | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |

(1) Wells will be screened from approximately 7 feet below to 3 feet above watch table.
(2) Sample to be taken directly above water table.

TABLE 3-4

SUBSURFACE SOIL SAMPLING DETAILS
SITE 7: TARAWA TERRACE DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Soil Boring Number | Soil Sampling Interval (feet) | Soil Sample Type | Soil Analysis (per sample) |
|---|---|---|---|
| 07SB01, 07SB02, 07SB03, 07SB04, 07SB05 | 0.0 - 2.0 | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |

(1) Sample to be taken directly above water table.

## 3.5 SURVEYING OPERATIONS

The locations of all soil borings and monitoring wells will be surveyed following their installation. A total of five soil borings (7SB01-7SB05) and three monitoring wells (7MW01-7MW03) will be surveyed. The locations of the proposed monitoring wells and soil borings are shown in Figure 3-2.

# 4.0 SITE 63: VERONA LOOP DUMP FIELD INVESTIGATION ACTIVITIES

## 4.1 SITE DESCRIPTION

The Verona Loop Dump is located at PWDM coordinates 14, H5. Its size is estimated to be between 3 and 4 acres. It is believed that bivouac wastes were disposed of at this site, but years of operation are unknown. It is not believed that hazardous waste was disposed of here. The location of the site is shown in Figure 4-1, with the boundaries being approximated pending further investigation.

## 4.2 WORK PLAN RATIONALE

Because no work has been conducted at this site, the field investigation for this site is intended to provide a general indication of whether the potential for an environmental contamination problem exists. The number and placement of wells and soil borings is designed to maximize the chances for detecting hazardous materials if they are present. Wells will be installed so that two are located downgradient and one upgradient of the site. This will maximize detection of groundwater contamination, if present. The proposed analyses are more comprehensive than for several other sites where the site history is better defined.

## 4.3 DRILLING OPERATIONS

A surface geophysical survey will be performed at all the suggested drilling locations to more readily locate the proposed wells and soil borings in areas that are least likely to contain buried metallic objects. The survey will consist of using an electromagmetometer (Heliflux), which can locate metallic objects such, as buried drums, near the ground surface. The drilling operations for Site 63 are discussed in detail below.

### 4.3.1 Soil Boring Installation

A total of six 15-foot soil borings will be installed at Site 63. The preliminary locations of the soil borings are shown in Figure 4-2. Final locations will be determined in the field after the geophysical survey. The locations were chosen to maximize coverage of the site. Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). None of the six soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 63SB01 through 63SB06, as shown on Figure 4-2. Split-spoon sampling intervals for the borings are given in Section 4.4.2.

### 4.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 63. Although the groundwater flow direction is not known at the time, it is thought that the water flow will be in a northeastward direction toward the New River. Therefore, two wells are proposed for the assumed downgradient direction and one for the upgradient direction as shown on Figure 4-2. Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 63MW01 through 63MW03, as shown on Figure 4-2. Wells shall be screened so that the top of the screen is 2 to 3 feet above the static water level. Well development will be performed on each new well as described in Section 13.3.5. One round of samples will be collected from the new wells for chemical analysis, as described

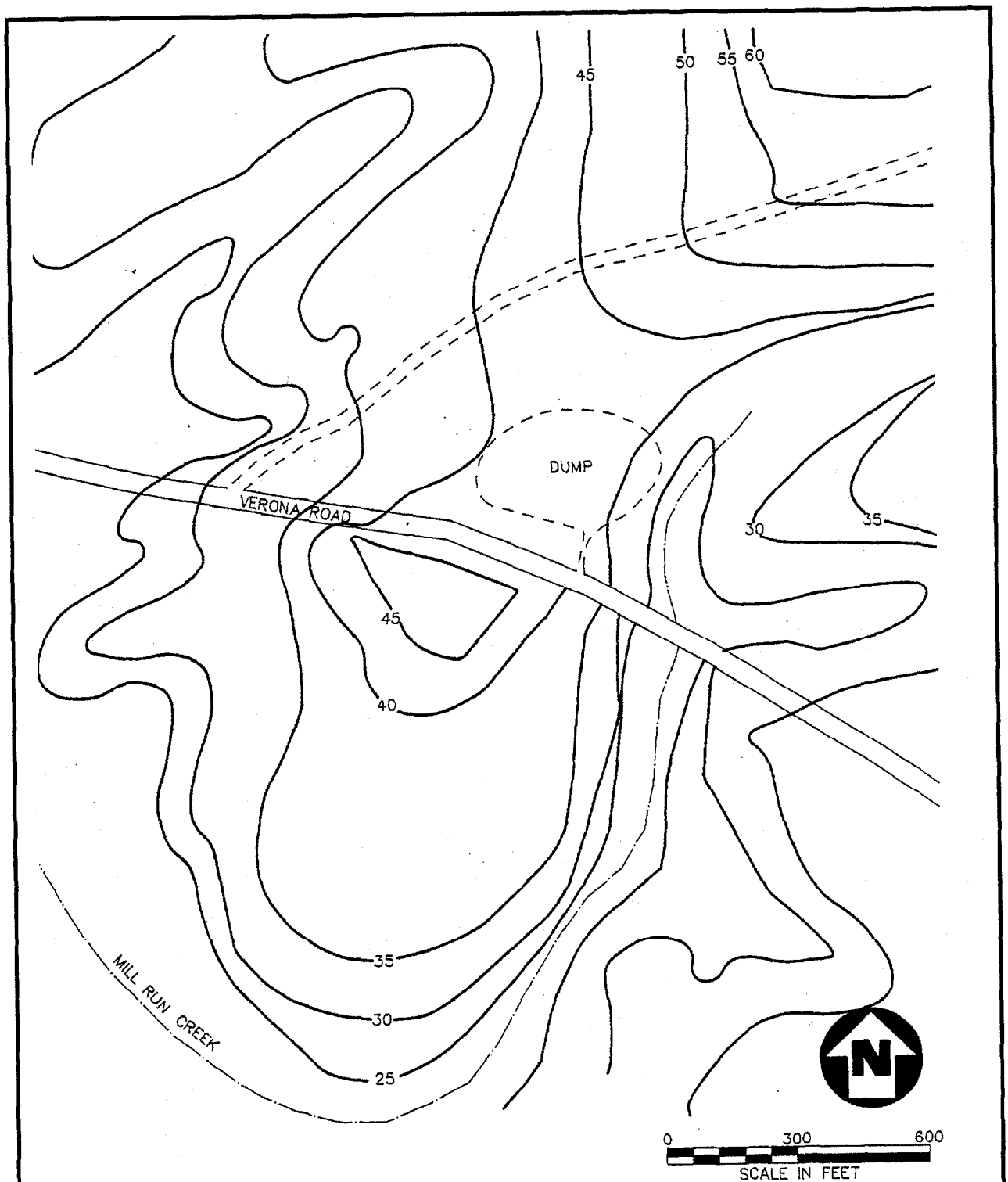


**FIGURE 4-1**
**SITE 63: VERONA LOOP DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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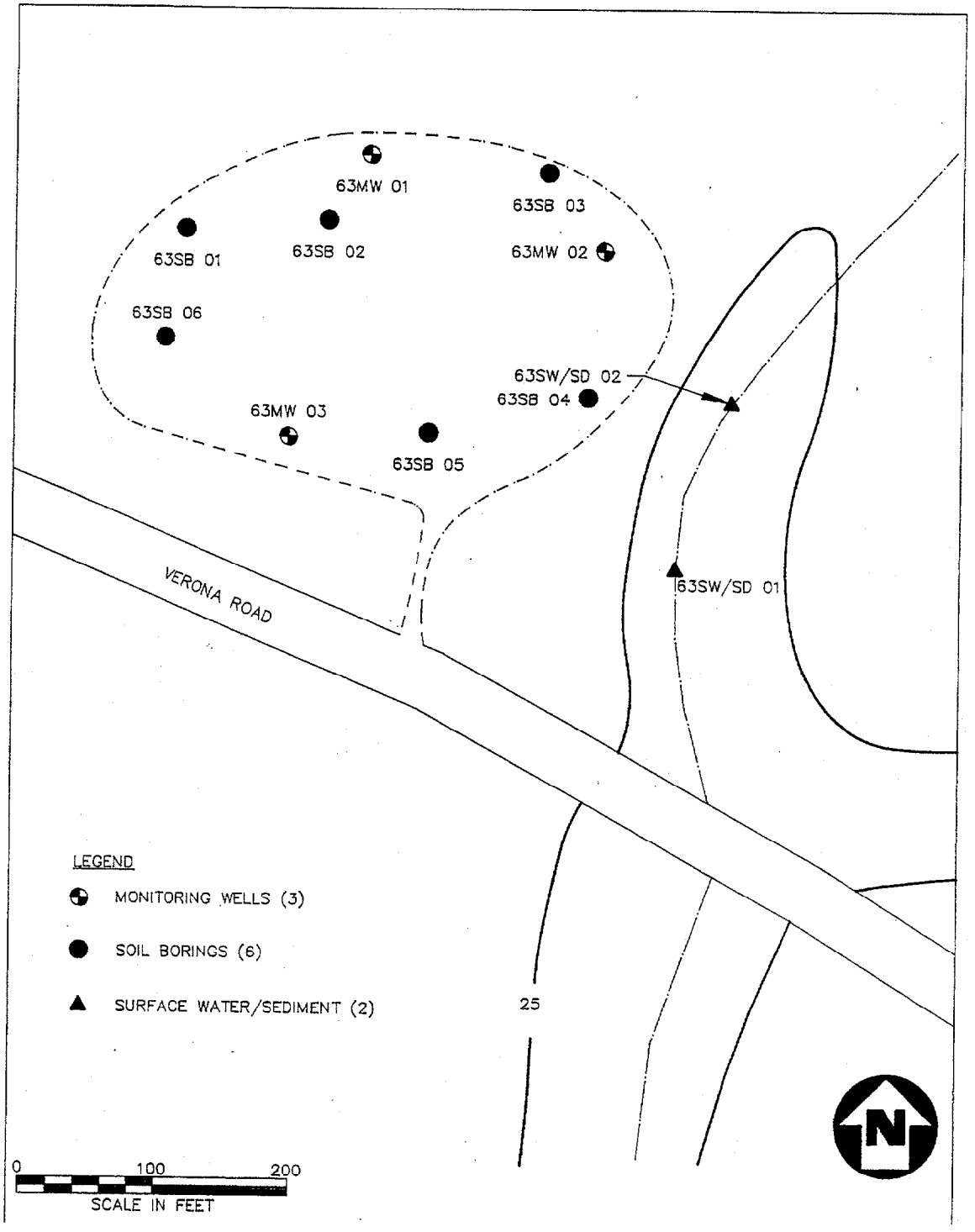


**FIGURE 4-2**
**SAMPLE LOCATIONS**
**SITE 63: VERONA LOOP DUMP**
**CAMP LEJEUENE MILITARY RESERVATION**

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in Section 4.4.1. One round of synoptic water-level measurements will be obtained from all wells (63MW01-63MW03) within a 4-hour period, as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 63 is given below:

- Install three shallow monitoring wells (63MW01-63MW03).
- Obtain synoptic water-level measurements from all new wells within a 4-hour period.

## 4.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 63:

- Groundwater
- Subsurface soil
- Surface water
- Sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 4-1 provides a sampling and analysis program summary for Site 63. Table 4-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 4.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (63MW01, 63MW02, and 63MW03). Groundwater sampling locations are shown in Figure 4-2. The laboratory analysis of groundwater samples is summarized in Table 4-3. All of the monitoring wells will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 4.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 4-4 for the six soil borings drilled at Site 63. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Tables 4-3 and 4-4, laboratory analyses will be conducted on two subsurface soil samples per boring and two subsurface soil samples per well. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description in order to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

TABLE 4-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SITE 63: VERONA LOOP DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 1 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 1 | 0 |
| | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 2 | 1 | 0 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 1 | 0 | 0 | 0 |

**TABLE 4-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 63: VERONA LOOP DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Surface Water (Continued) | Temperature | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 2 | 0 | 0 | 0 | 0 |
| Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 1 | 0 | 0 | 0 |
| Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 18 | 2 | 1 | 0 | 0 |

**TABLE 4-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 63: VERONA LOOP DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE THREE**

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

TABLE 4-2

***SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES***
**SITE 63: VERONA LOOP DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | 7 | 3 | 40 ml VOA vials | HCl to pH< 2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 6 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | Cyanide | 6 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| Surface Water | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 2 | N/A | N/A | N/A | N/A |
| Sediment | TCL VOAs | 3 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 3 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |



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TABLE 4-2
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 63: VERONA LOOP DUMP
CAMP LEJEUNE, NORTH CAROLINA
PAGE TWO

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Soil | TCL VOAs | 21 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 21 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 21 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

**TABLE 4-3**

**MONITORING WELL INSTALLATION AND SAMPLING DETAILS**
**SITE 63: VERONA LOOP DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|---|---|---|---|---|
| 63MW01, 63MW02, 63MW03 | 25 | 25(1) | 17 | 10 | TCL Organics TCL Inorganics, Cyanide | 0.0 - 2.0 | Split spoon | TCL Organics TCL Inorganics, Cyanide |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(2) | Split spoon | TCL Organics TCL Inorganics, Cyanide |

(1) Wells will be screened from approximately 7 feet below to 3 feet above water table.
(2) Sample to be taken directly above water table.

**TABLE 4-4**

**SUBSURFACE SOIL SAMPLING DETAILS**
**SITE NO. 63: VERONA LOOP DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Soil Boring Number | Sampling Interval (feet) | Sample Type | Analysis (per sample) |
|---|---|---|---|
| 63SB01, 63SB02, 63SB03, 63SB04, 63SB05, 63SB06 | 0.0 - 2.0 | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |

(1) Sample to be taken directly above water table.

### 4.4.3 Surface Water Sampling

Surface water samples will be collected from a total of two locations from a creek that runs along the eastern side of the site, as shown in Figure 4-2. The laboratory analysis program for surface water is summarized in Table 4-5. Both surface water samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 4.4.4 Sediment Sampling

Two sediment samples will be collected at the same locations as the surface water samples as shown in Figure 4-2. The laboratory analysis program is summarized in Table 4-5. Both sediment samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

## 4.5 SURVEYING OPERATIONS

The locations of all soil borings and monitoring wells will be surveyed following their installation. A total of six soil borings (63SB01-63SB06), three monitoring wells (63MW01-63MW03), and two surface water/sediment sample locations (63SW/SD01-63SW/SD02) will be surveyed. The locations of the proposed monitoring wells, soil borings, and surface water/sediment samples are shown in Figure 4-2.

**TABLE 4-5**

**SURFACE WATER/SEDIMENT SAMPLING DETAILS**
**SITE 63: VERONA LOOP DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Surface Water | 63SW01, 63SW02 | TCL Organics<br>TCL Inorganics, Cyanide |
| Sediment | 63SD01, 63SD02 | TCL Organics<br>TCL Inorganics, Cyanide |

# 5.0 SITE 54: CRASH CREW BURN PIT FIELD INVESTIGATION ACTIVITIES

## 5.1 SITE DESCRIPTION

The Crash Crew Burn Pit is a 1.5-acre site within the boundaries of MCAS New River. It is located adjacent to the southwest end of Runway 5-23 near Structure 3614 (PWDM coordinates 23, O24-25/P24-25). A map of the site, which includes the locations of samples collected by previous contractors, is presented in Figure 5-1.

An underground storage tank has been installed at this site within the last few years. It is located approximately 100 feet to the northwest of the burn pit. The area of concern is believed to have been used in the mid-1950s for crash crew training. Contaminated fuels (principally JP-type and possibly leaded fuels) and waste oils were burned during the training exercises. Originally the training was conducted on the ground surface, and the area was surrounded by a berm. Later, a burn pit was constructed, which was lined in or around 1975.

Figures 5-2 and 5-3 present geological cross-sections that were prepared by ES&E (June 1990). The sections show that the site is underlain by silty sand and silty gravelly sand, with discontinuous layers of coarse sand at depths of up to 10 feet. The groundwater contour map, Figure 5-4 (ES&E, June 1990) shows that the shallow groundwater flows toward the drainage ditch along the southwest side of the site, with a gradient of approximately 0.037 ft/ft.

## 5.2 WORK PLAN RATIONALE

The intent of this investigation is to collect sufficient data to support a risk assessment to determine whether the site presents a risk to either human health or the environment. To meet this objective, it is necessary to better characterize the site as it exists today.

The scope of work for the previous investigation was limited. Although it is known that fuels and possibly miscellaneous wastes were burned at the site, no fuel constituents were detected in the groundwater. This may be due either to the high detection limits in the laboratory or to the locations of the wells. In addition, no soil samples were ever collected for chemical analysis.

Metals were detected in the groundwater samples, but they may not actually have been transported downward from the surface. Because these samples were unfiltered, the metals observed are more likely to be associated with the soil matrix itself rather than with contamination originating at the ground surface.

It is possible that waste oils containing polychlorinated biphenyls (PCBs) could also have been burned at this facility; therefore, PCBs could be a concern. PCBs are relatively immobile in the environment due to their high organic carbon partition coefficients.

## 5.3 DRILLING OPERATIONS

### 5.3.1 Soil Boring Installation

A total of two 15-foot soil borings will be installed at Site 54. The locations of the soil borings were selected to provide some definition of the lateral and vertical extent of contamination around the burn pit. The locations of the soil borings are shown in Figure 5-5. Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). Neither of the two soil borings at this site will be converted to monitoring

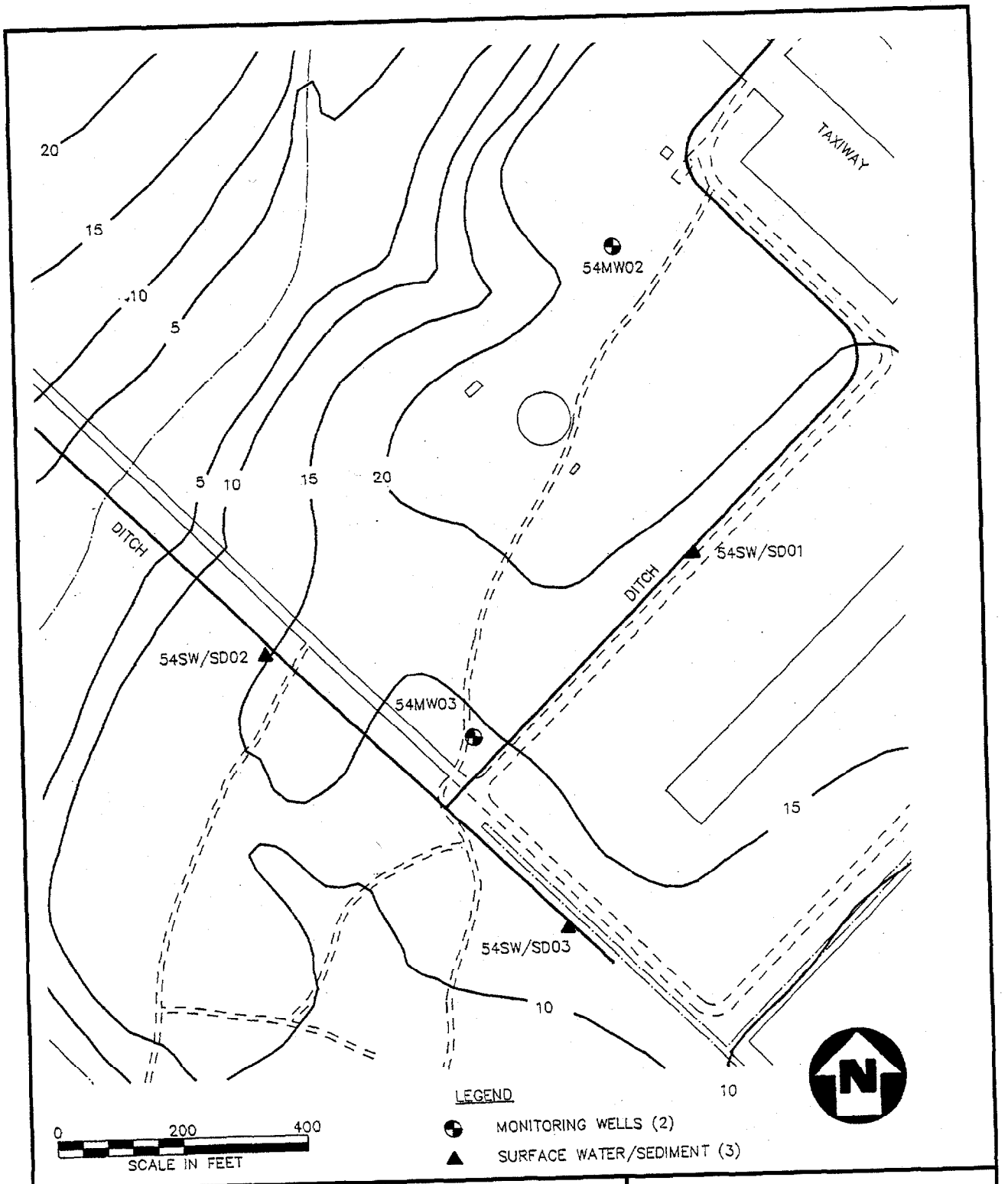


**FIGURE 5-1**
**SITE 54: CRASH CREW BURN PIT**
**CAMP LEJEUNE MILITARY RESERVATION**

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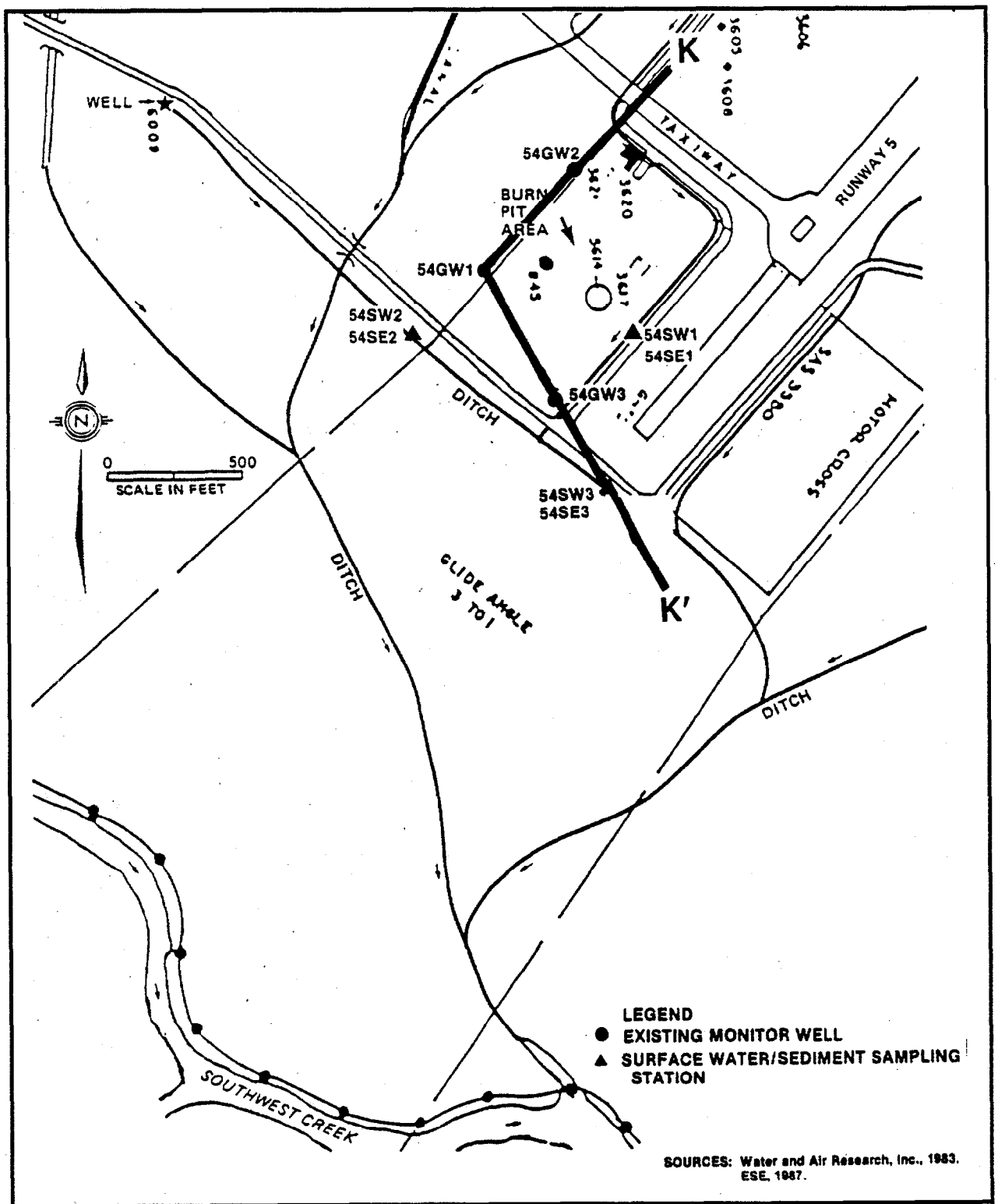


FIGURE 5-2*
GEOLOGIC CROSS SECTION LOCATION
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE MILITARY RESERVATION
SOURCE: ES&E, 1990
*54GW1 no longer exists

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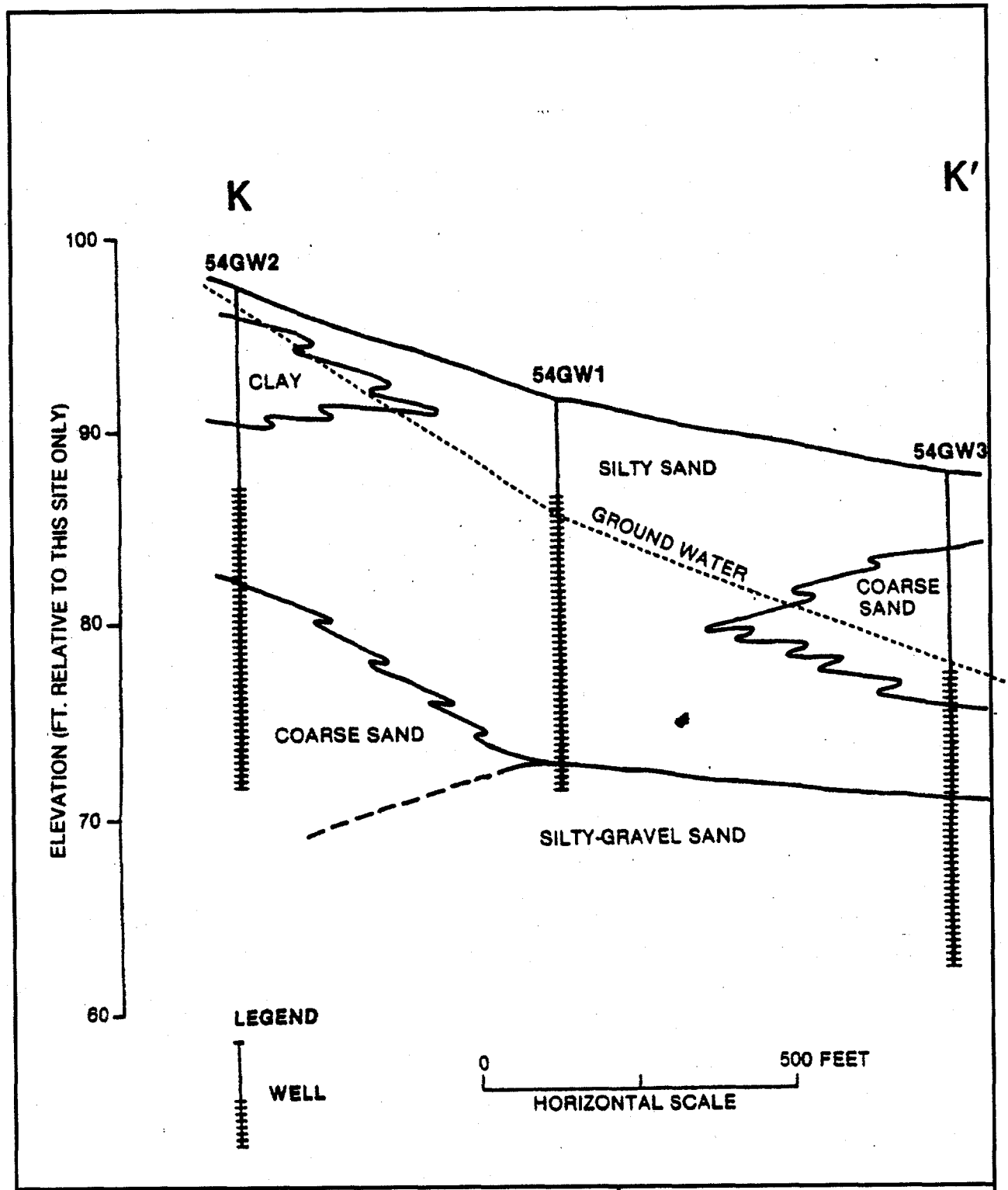


FIGURE 5-3*
GEOLOGIC CROSS SECTION
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE MILITARY RESERVATION
SOURCE: ES&E, 1990
*54GW1 no longer esists

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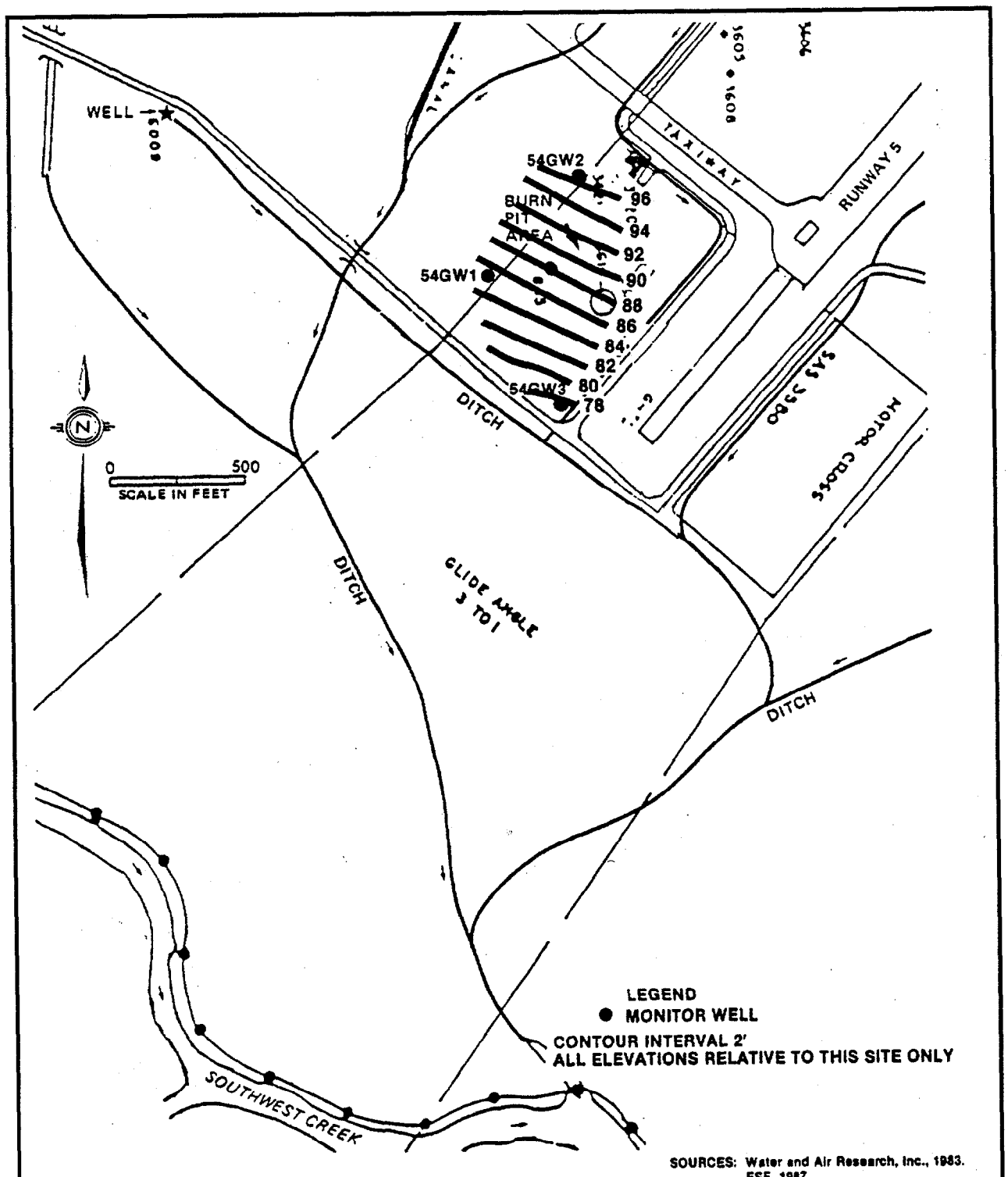


SOURCES: Water and Air Research, Inc., 1983.
ESE, 1987.

FIGURE 5-4*
GROUNDWATER CONTOUR MAP, SHALLOW AQUIFER
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE MILITARY RESERVATION
SOURCE: ES&E, 1990
*54GW1 no longer exists

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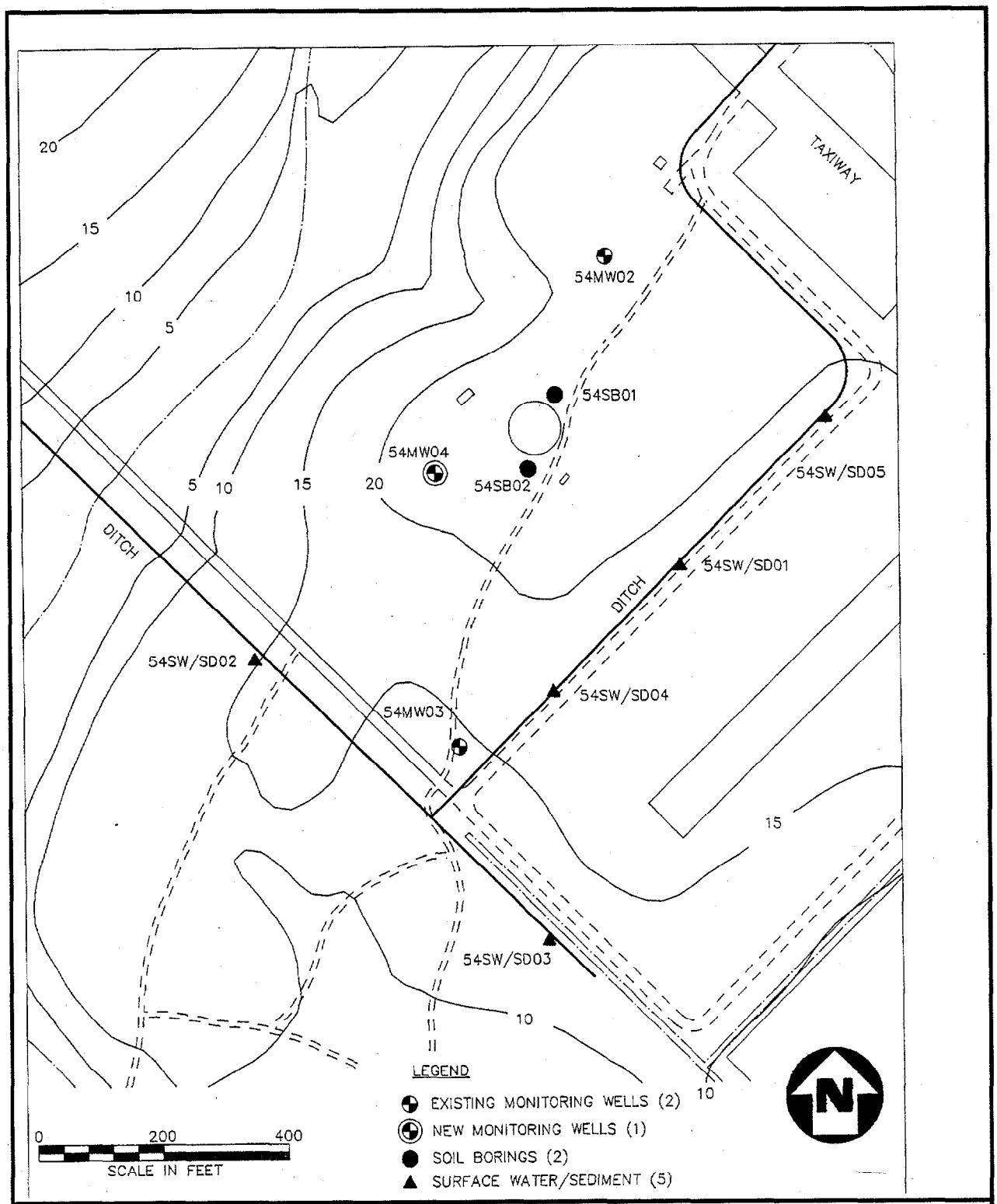


**FIGURE 5-5**
**GEOLOGIC CROSS SECTION LOCATIONS**
**SITE 54: CRASH CREW BURN PIT**
**CAMP LEJEUNE MILITARY RESERVATION**

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wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 54SB01 and 54SB02, as shown on Figure 5-5. Split-spoon sampling intervals for the borings are given in Section 5.4.2.

### 5.3.2 Monitoring Well Installation

One 25-foot monitoring well will be installed southwest of the burn pit. It is intended that this will serve the purpose of replacing the well that was removed during runway construction. The proposed location of the monitoring well is shown in Figure 5-5.

Two split-spoon soil samples will be taken during installation of the well boring for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. The monitoring well shall be numbered 54MW04 as shown on Figure 5-5. Wells shall be screened so that the top of the screen is 2 to 3 feet above the static water level. Well development will be performed on the new well as described in Section 13.3.5. One round of samples will be collected from the new well for chemical analysis as described in Section 5.4.1. One round of synoptic water-level measurements will be obtained from the new well (54MW04) and existing wells (54MW02 and 54MW03) within a 4-hour period as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 54 is given below:

- Install one shallow monitoring wells (54MW04).
- Obtain synoptic water-level measuremens from the new well and the two existing wells within a 4-hour period.

## 5.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 54:

- Groundwater
- Subsurface soil
- Surface water
- Sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 5-1 provides a sampling and analysis program summary for Site 54. Table 5-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 5.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the two existing wells (54MW02 and 54MW03) and from the newly installed well (54MW04). The groundwater sampling locations are shown in Figure 5-2. The laboratory analysis of groundwater samples is summarized in Table 5-3. The monitoring wells will be analyzed for the following parameters:

TABLE 5-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE, NORTH CAROLINA

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 1 | 0 |
| | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 1 | 0 |
| | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 3 | 0 | 0 | 0 | 0 |
| | BTEX | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 1 |
| | Hexavalent Chromium | 10 µg/L | EPA 218.4 | 3 | 1 | 1 | 1 | 0 |
| | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Surface Water | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 1 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 1 | 0 | 0 |
| | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 5 | 0 | 0 | 0 | 0 |

**TABLE 5-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 54: CRASH CREW BURN PIT**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Surface Water (Continued) | BTEX | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 1 |
| | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 0 |
| | Hexavalent Chromium | 10 µg/L | EPA 218.4 | 5 | 1 | 1 | 0 | 0 |
| | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |
| Sediment | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 1 | 0 | 0 |
| | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 0 |
| | Total Petroleum Hydrocarbons | 0.5 mg/kg | EPA 418.1 | 5 | 0 | 0 | 0 | 0 |
| | BTEX | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 0 |
| | Hexavalent Chromium | 10 µg/L | EPA 218.4 | 5 | 1 | 1 | 0 | 0 |

**TABLE 5-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 54: CRASH CREW BURN PIT**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE THREE**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Soil | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 6 | 1 | 1 | 0 | 0 |
| | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| | Total Petroleum Hydrocarbons | 1 mg/kg | EPA 418.1 | 6 | 1 | 0 | 0 | 0 |
| | BTEX | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 1 |
| | Hexavalent Chromium | 100 µg/L | EPA 218.4 | 6 | 1 | 1 | 0 | 0 |

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

TABLE 5-2

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE, NORTH CAROLINA

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL Metals | 4 | 4 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | TCL PCBs | 6 | 1 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Total Petroleum Hydrocarbons | 3 | 1 | 1 liter glass bottle | HCl to pH<2; | 28 days |
| | BTEX | 7 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | Hexavalent Chromium | 6 | 1 | 500 ml polyethylene bottle | Cool to 4°C | 24 hours |
| | Cyanide | 4 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 3 | N/A | N/A | N/A | N/A |

**TABLE 5-2**
**SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES**
**SITE 54: CRASH CREW BURN PIT**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Surface Water | TCL Metals | 7 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | TCL PCBs | 7 | 2 | 1 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Total Petroleum Hydrocarbons | 5 | 1 | 1 liter glass bottle | HCl to pH<2 | 28 days |
| | BTEX | 8 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | Hexavalent Chromium | 7 | 1 | 500 ml polyethylene bottle | Cool to 4°C | 24 hours |
| | Cyanide | 7 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 5 | N/A | N/A | N/A | N/A |
| Sediment | TCL Metals and Cyanide | 7 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| | PCBs | 7 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Total Petroleum Hydrocarbons | 5 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | BTEX | 7 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | Hexavalent Chromium | 7 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 24 hours |

TABLE 5-2
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE, NORTH CAROLINA
PAGE THREE

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Soil | TCL Metals and Cyanide | 8 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| | TCL PCBs | 8 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Total Petroleum Hydrocarbons | 7 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | BTEX | 9 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | Hexavalent Chromium | 8 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 24 hours |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

**TABLE 5-3**

**MONITORING WELL INSTALLATION AND SAMPLING DETAILS**
**SITE 54: CRASH CREW BURN PIT**
**CAMP LEJEUNE, NORTH CAROLINA**

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Sampling Interval (feet) | Sample Type | Analysis (per sample) |
|---|---|---|---|---|---|---|---|---|
| 54MW04 | 25 | 25(1) | 17 | 10 | Benzene<br>Toluene<br>Ethylbenzene<br>Xylenes<br>Total Petroleum Hydrocarbons (TPC)<br>TCL PCBs<br>TCL, Inorganics, Cyanide<br>Hexavalent Chromium | 0.0 - 2.0 | Split spoon | Benzene<br>Toluene<br>Ethylbenzene<br>Xylenes<br>Total Petroleum Hydrocarbons (TPC)<br>TCL PCBs<br>TCL, Inorganics, Cyanide<br>Hexavalent Chromium |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(1)(2) | Split spoon | Benzene<br>Toluene<br>Ethylbenzene<br>Xylenes<br>Total Petroleum Hydrocarbons (TPC)<br>TCL PCBs<br>TCL, Inorganics, Cyanide<br>Hexavalent Chromium |

(1) Wells will be screened from approximately 7 feet below to 3 feet water table.
(2) Sample to be taken directly above water table.

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- Total petroleum hydrocarbons
- TCL PCBs
- TCL inorganics, cyanide
- Hexavalent chromium

### 5.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 5-4 for the two soil borings drilled at Site 54. Laboratory analyses of the subsurface samples are also outlined in Table 5-4. Soil sampling locations are shown in Figure 5-5. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Tables 5-3 and 5-4, laboratory analyses will be conducted on two subsurface soil samples per boring and two subsurface soil samples per well. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description in order to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- Total petroleum hydrocarbons (TPH)
- TCL PCBs
- TCL inorganics, cyanide
- Hexavalent chromium

### 5.4.3 Surface Water Sampling

Surface water samples will be collected from three previous locations (54SW/SE01, 54SW/SE02, and 54SW/SE03) and from two new locations (54SW/SD04 and 54SW/SD05) as shown on Figure 5-5. The samples will be taken from a drainage ditch on the southeastern and southwestern sides of the burn pit. The laboratory analysis program for surface water is summarized in Table 5-5. All five surface water samples will be analyzed for the following parameters:

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- Total petroleum hydrocarbons
- TCL PCBs
- TCL inorganics, cyanide
- Hexavalent chromium

TABLE 5-4

SUBSURFACE SOIL SAMPLING DETAILS
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE, NORTH CAROLINA

| Soil Boring Number | Sampling Interval (feet) | Sample Type | Analysis (per sample) |
|---|---|---|---|
| 54SB01, 54SB02 | 0.0 - 2.0 | Split spoon | Benzene<br>Toluene<br>Ethylbenzene<br>Xylenes<br>Total Petroleum Hydrocarbons (TPH)<br>TCL PCBs<br>TCL Inorganic, Cyanide<br>Hexavalent Chromium |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | Benzene<br>Toluene<br>Ethylbenzene<br>Xylenes<br>Total Petroleum Hydrocarbons (TPH)<br>TCL PCBs<br>TCL Inorganic, Cyanide<br>Hexavalent Chromium |

(1) Sample to be taken directly above water table.

TABLE 5-5

SURFACE WATER/SEDIMENT SAMPLING DETAILS
SITE 54: CRASH CREW BURN PIT
CAMP LEJEUNE, NORTH CAROLINA

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Surface Water | 54SW01<br>54SW02<br>54SW03<br>54SW04<br>54SW05 | Benzene<br>Toluene<br>Ethylbenzene<br>Xylenes<br>Total Petroleum Hydrocarbons (TPH)<br>TCL PCBs<br>TCL Inorganics, Cyanide<br>Hexavalent Chromium |
| Sediment | 54SD01<br>54SD02<br>54SD03<br>54SD04<br>54SD05 | Benzene<br>Toluene<br>Ethylbenzene<br>Xylenes<br>Total Petroleum Hydrocarbons (TPH)<br>TCL PCBs<br>TCL Inorganics, Cyanide<br>Hexavalent Chromium |

### 5.4.4 Sediment Sampling

Five sediment samples will be collected at the same locations as the surface water samples, as shown in Figure 5-5. The laboratory analysis program is summarized in Table 5-5. All five sediment samples will be analyzed for the following parameters:

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- Total petroleum hydrocarbons
- TCL PCBs
- TCL inorganics, cyanide
- Hexavalent chromium

## 5.5 SURVEYING OPERATIONS

The locations of all soil borings, monitoring wells, and surface water/sediment sample locations will be surveyed following their installation. A total of two soil borings (54SB01 and 54SB02), three monitoring wells (54MW02, 54MW03, and 54MW04), and five surface water/sediment locations (54SW/SD01-54SW/SD05) will be surveyed. All sample locations are shown in Figure 5-5.

# 6.0 SITE 82: PINEY GREEN ROAD VOC AREA FIELD INVESTIGATION ACTIVITIES

## 6.1 SITE DESCRIPTION

The Piney Green Road VOC Area is a forested area between Lot 203 and Wallace Creek and appears to have been used as a disposal area at some point in the past. It is estimated to be 30 acres in size. There is visual evidence of debris piles and small depressions, as identified by ES&E in the Site Summary Report, June 1990. This area is bounded on the northwest by Wallace Creek and is therefore a reasonable source of the observed VOCs in Wallace Creek. The area of investigation is shown in Figure 6-1.

## 6.2 WORK PLAN RATIONALE

In 1986, ES&E conducted a field investigation of IAS Site 6, which contains Storage Lots 201 and 203. During this same time period, the supply wells on the base were sampled. Trace levels of TCE and other volatiles were detected in supply wells 651, 652, and 653. Supply well 652 is located further south and is not shown on Figure 6-1.

In 1986, a soil gas survey was also performed in the vicinity of Site 6 along Piney Green Road. There was one isolated case of TCE detection southwest of Supply Well 652. Shallow monitoring wells were installed adjacent to the supply wells and the one isolated soil gas hit to determine whether there was a surface source of contamination. No contamination was found in any of the shallow wells; therefore, the source of contamination in the supply wells may be from outside the Wallace Creek area.

Figures 6-2 and 6-3 present a geological cross section that was performed by ES&E, Site Summary Report (June 1990), for the Site 6 area. The section shows the site to be underlain by silty sand, sand, and coarse sand. The surface of the shallow groundwater at this site lies within the silty sand at depths ranging from 2 to 15 feet below land surface. The groundwater contour map, Figure 6-4, indicates the groundwater flows toward Wallace Creek and Bearhead Creek at a gradient of approximately 0.009 ft/ft.

The intent of the proposed field investigation is to identify potential source(s) of contamination in Wallace Creek. Although minimal contamination was discovered in Lot 203 in the previous investigation, and no obvious sources were identified during the soil-gas survey, the area between Lot 203 and Wallace Creek may be an area of concern. The area appears to have been disturbed, and no other potential source areas were identified during an extensive site reconnaissance.

The investigation will focus on the types of contaminants identified earlier, namely TCL volatile organics, pesticides, and PCBs. Although Lot 203 has been evaluated in the past, the area known as the Piney Green Road VOC Area itself is new.

Figure 6-5 provides approximate drilling and sampling locations. Final sample locations will be determined in the field by the project hydrogeologist. The hydrogeologist will locate samples in suspected areas of contamination to maximize detection of target analytes, if present.

The most upgradient well is located near the bridge on Piney Green Road, which is the area of the creek found to contain volatile organics in 1986. One well will be located downstream toward Holcomb Boulevard. The third well is proposed for the approximate center of the site. These well locations, in conjunction with the existing wells, will provide an overall assessment of groundwater quality.

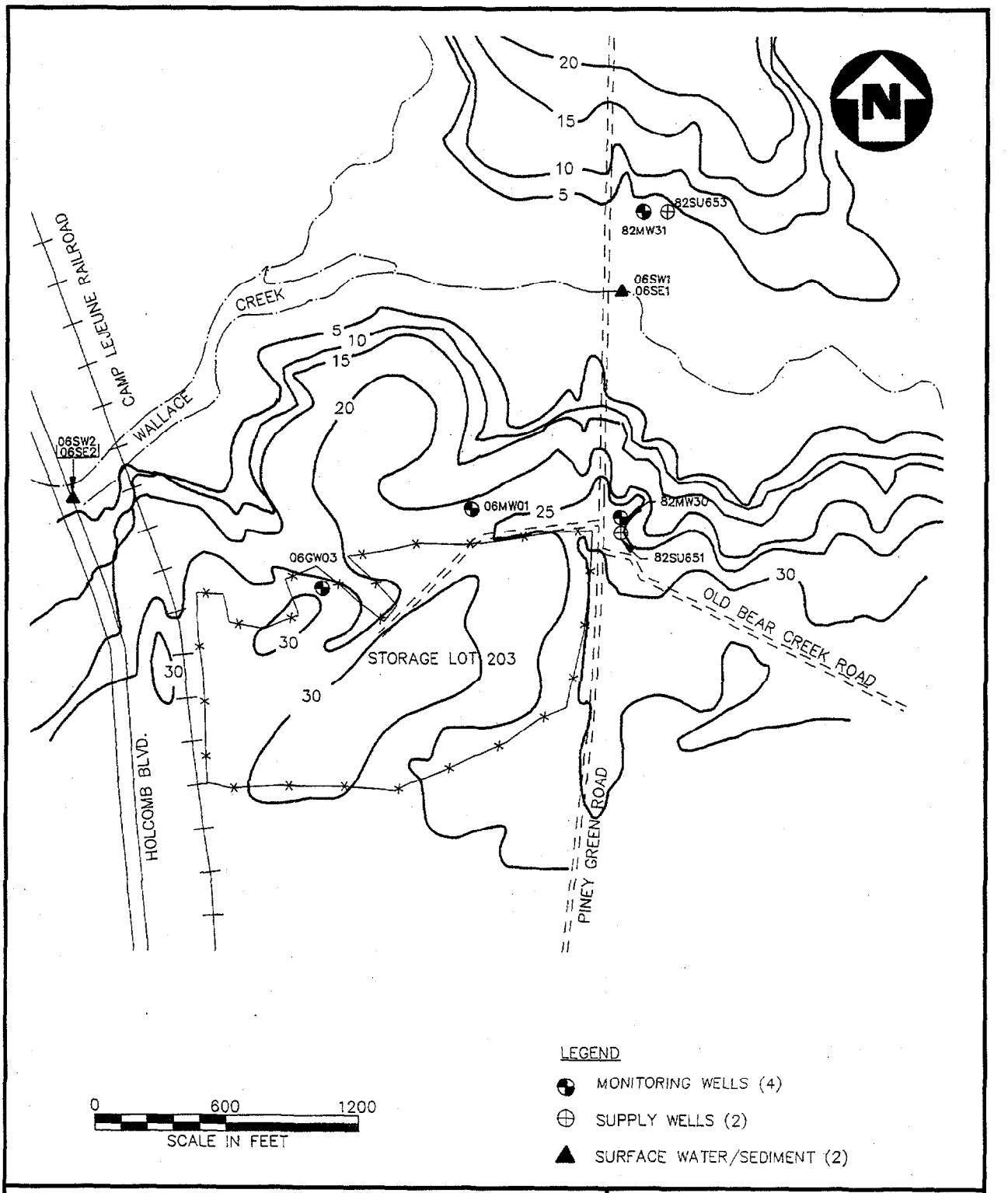


**FIGURE 6-1**
**SITE 82: PINEY GREEN ROAD VOC AREA**
**CAMP LEJEUNE MILITARY RESERVATION**

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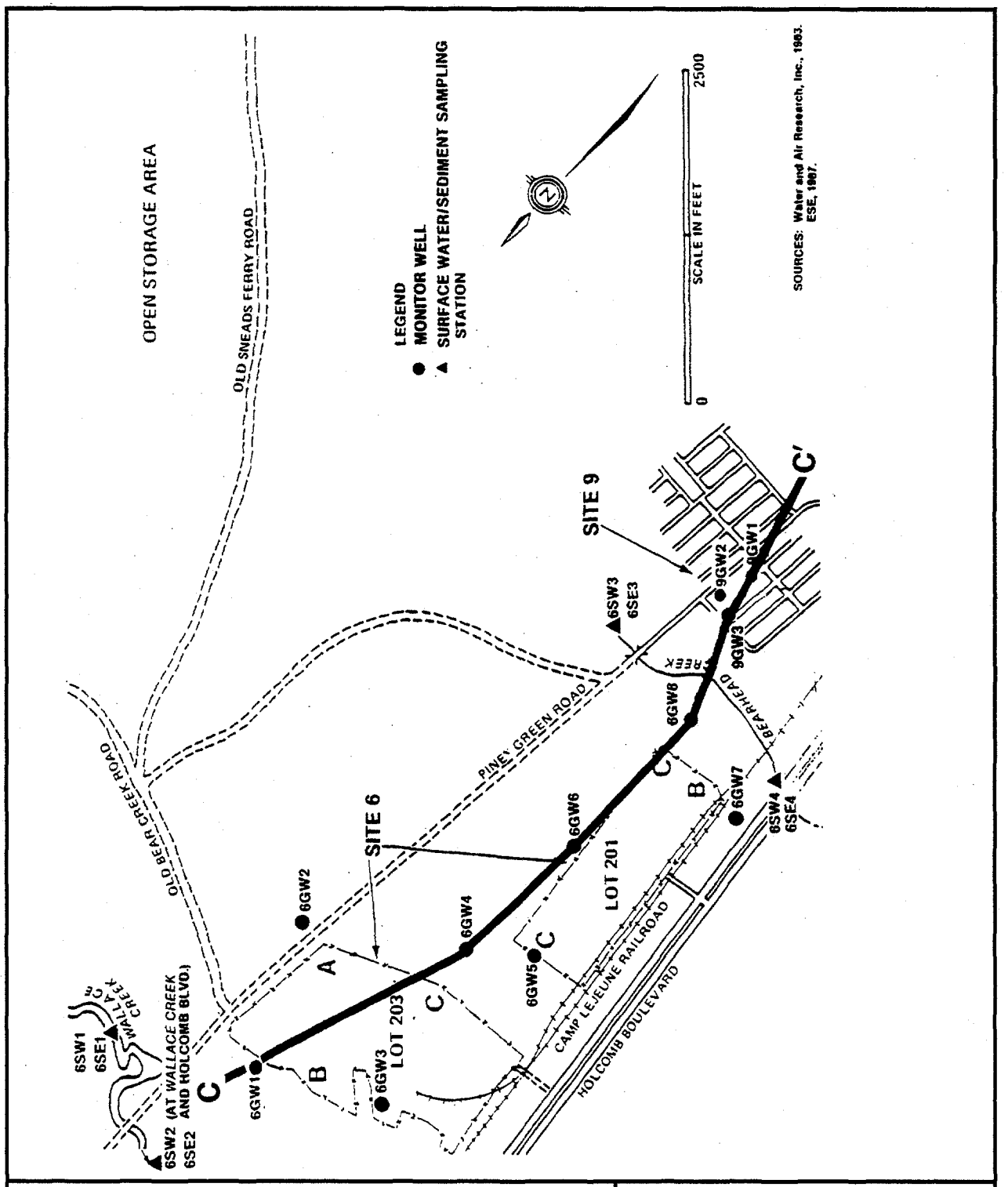


FIGURE 6-2
GEOLOGIC CROSS SECTION LOCATIONS, SITES 6 AND 9
STORAGE LOTS 201 AND 203 AND FIRE FIGHTING
TRAINING PIT
SITE 82: PINEY GREEN ROAD VOC AREA
CAMP LEJEUNE MILITARY RESERVATION
SOURCE: ES&E, 1990

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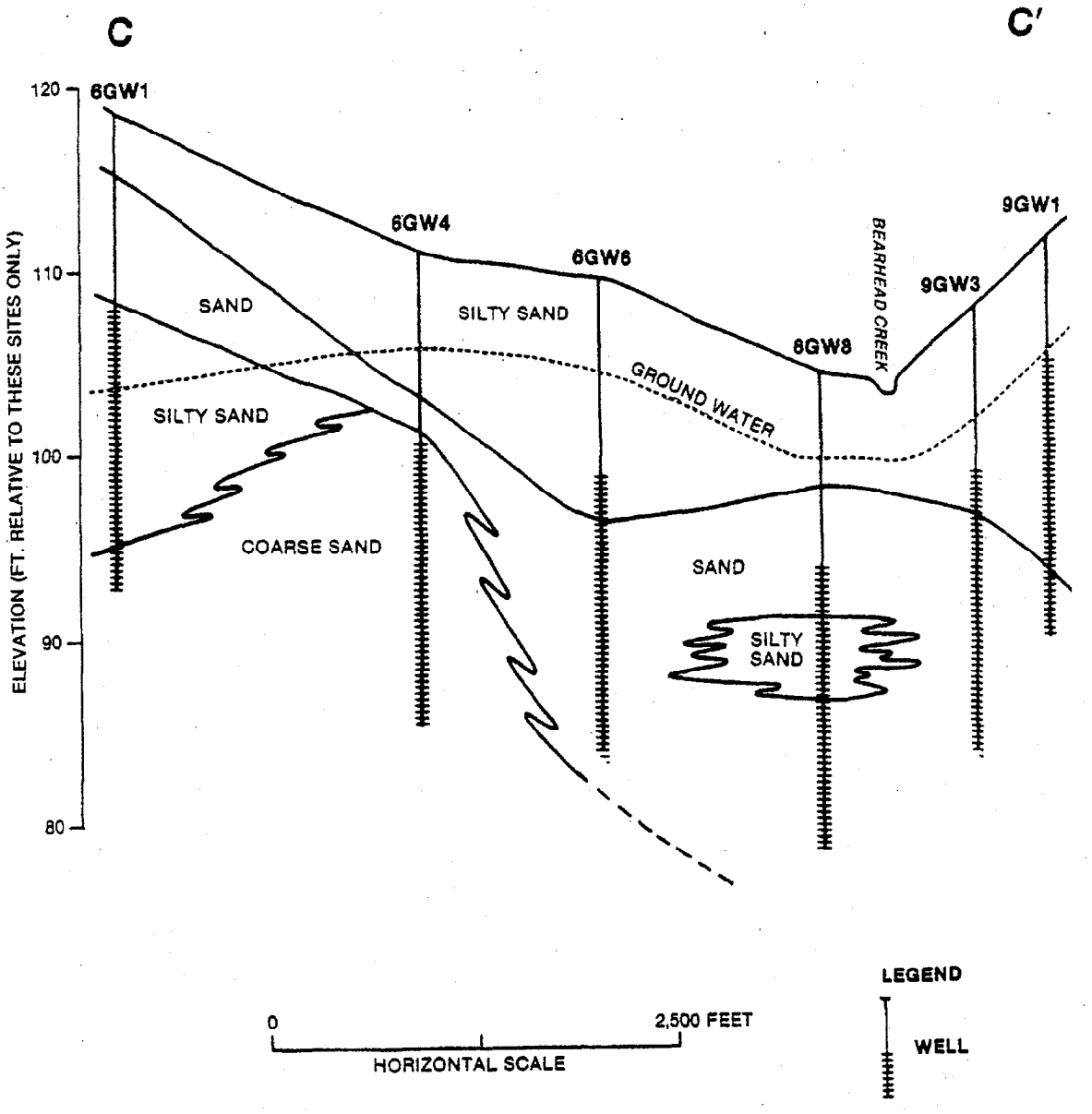


FIGURE 6-3
GEOLOGIC CROSS SECTIONS, SITES 6 AND 9, STORAGE LOTS 201 AND 203 AND FIRE FIGHTING TRAINING PIT
SITE 82: PINEY GREEN ROAD VOC AREA
CAMP LEJEUNE MILITARY RESERVATION
SOURCE: ES&E, 1990

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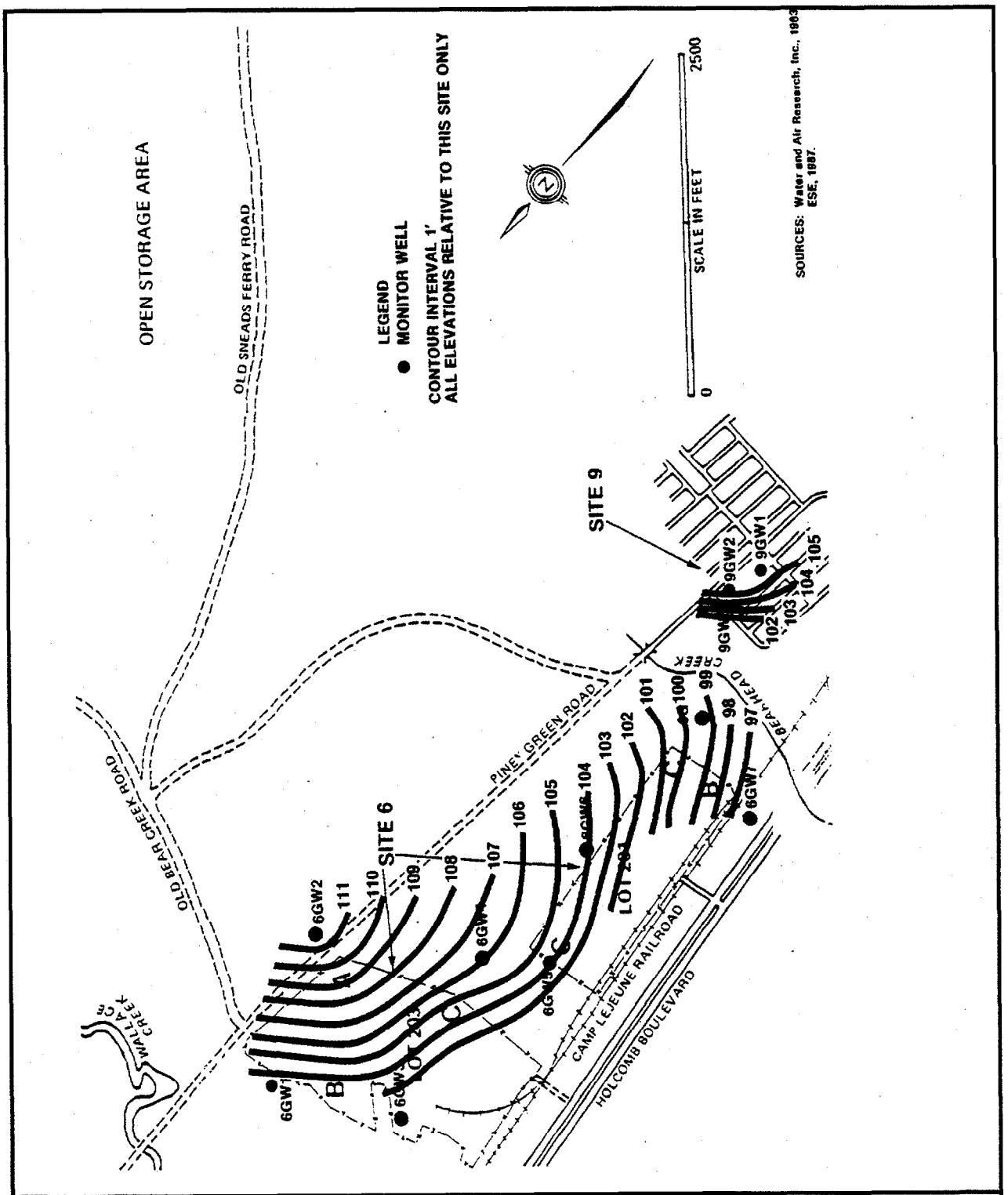


**FIGURE 6-4**
**GROUNDWATER CONTOUR MAP--SHALLOW AQUIFER, SITES 6 AND 9--STORAGE LOTS 201 AND 203 AND FIRE FIGHTING TRAINING PIT**
**SITE 82: PINEY GREEN ROAD VOC AREA**
**CAMP LEJEUNE MILITARY RESERVATION**
**SOURCE: ES&E, 1990**

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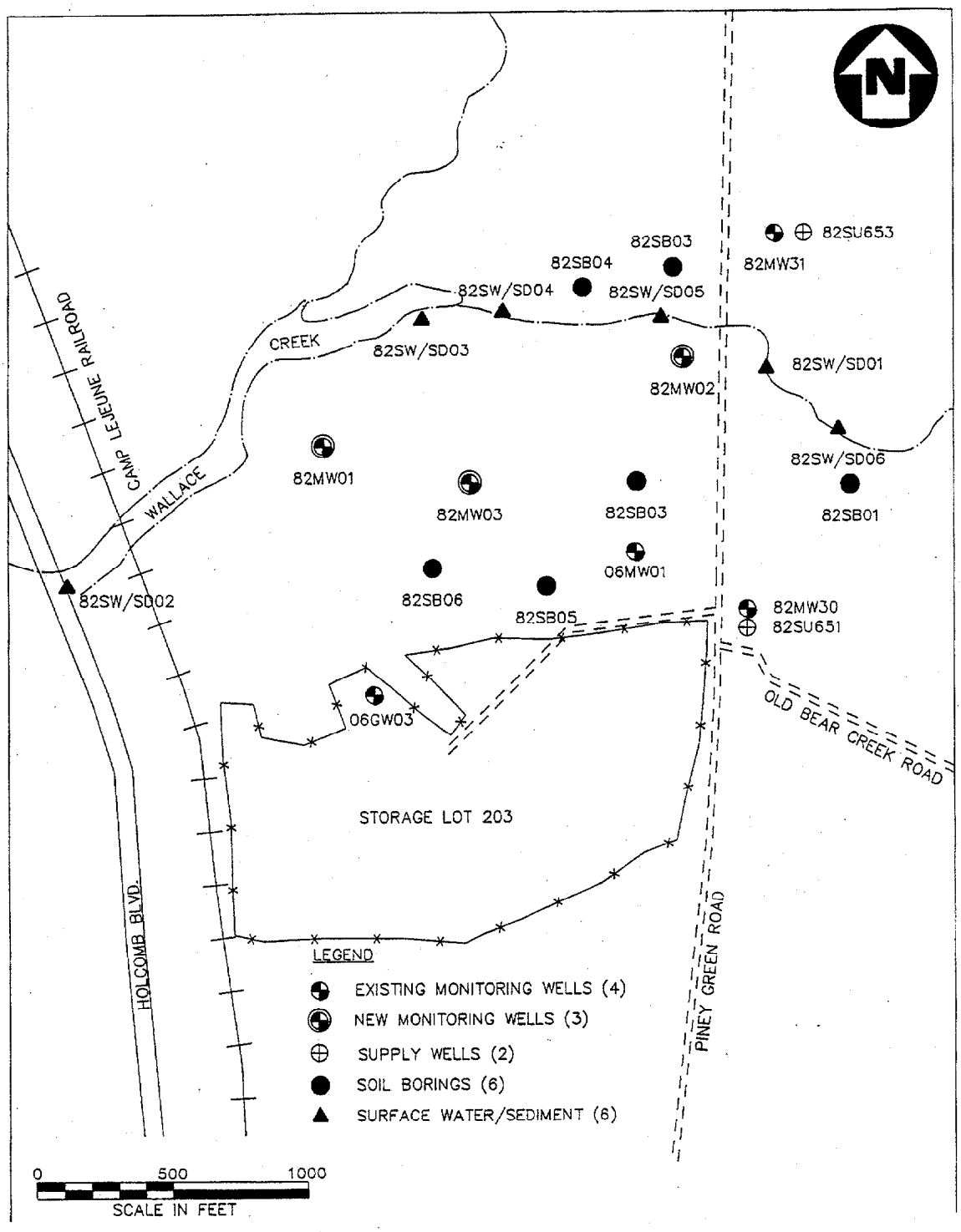


**FIGURE 6-5**
**SAMPLE LOCATIONS**
**SITE 82: PINEY GREEN ROAD VOC AREA**
**CAMP LEJEUNE MILITARY RESERVATION**

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## 6.3 DRILLING OPERATIONS

A surface geophysical survey will be performed at all the suggested drilling locations to more readily locate the proposed wells and soil borings in areas that are least likely to contain buried metallic objects. The survey will consist of using an electromagnetometer (Heliflux), which can locate metallic objects such as buried drums near the ground surface. The drilling operations for Site 82 are discussed in detail below.

### 6.3.1 Soil Boring Installation

A total of six 15-foot soil borings will be installed at Site 82. Two borings will be located on the north side of Wallace Creek to confirm that there are no sources in that area. The remaining four will be distributed throughout the area, with one located far enough upstream to provide a preliminary indication of the lateral extent of the suspected source area. The preliminary locations of the soil borings are shown in Figure 6-5. Final locations will be determined in the field pending access allowances and the results of the geophysics survey. In addition, the hydrogeologist will locate borings in suspected areas of contamination to maximize detection of target analytes.

Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 feet to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). None of the 6 soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 82SB01 through 82SB06 as shown on Figure 6-5. Split-spoon sampling intervals for the borings are given in Section 6.4.2.

### 6.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 82. Two wells will be located along Wallace Creek so that they are downgradient of the potential source area. The most upgradient well is located near the bridge on Piney Green Road, which is the area of the creek found to contain volatile organics during a previous investigation. One well will be located downstream toward Holcomb Boulevard. The third well will be located in the approximate center of the site. The locations of the proposed monitoring wells are shown in Figure 6-5.

Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 82MW01 through 82MW03 as shown on Figure 6-2. Wells shall be screened so that the top of the screen is 2 to 3 feet above the static water level. Well development will be performed on each new well as described in Section 13.3.5. One round of samples will be collected from the new wells for chemical analysis as described in Section 6.4.1. One round of synoptic water-level measurements will be obtained from new wells (82MW01-82MW03) and existing wells (82MW30 and 82MW31) within a 4-hour period as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 82 is given below:

- Install three shallow monitoring wells (82MW01-82MW03).
- Obtain synoptic water-level measurements from all new and existing wells within a 4-hour period.

## 6.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 82:

- Groundwater
- Subsurface soil
- Surface water
- Sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 6-1 provides a sampling and analysis program summary for Site 82. Table 6-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 6.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (82MW01, 82MW02, and 82MW03). Samples will also be taken from the existing wells 82MW30 and 82MW31. Groundwater sampling locations are shown in Figure 6-5. The laboratory analysis of groundwater samples is summarized in Table 6-3. All of the monitoring wells will be analyzed for the following parameters:

- TCL organics
- TCL pesticides
- TCL PCBs

### 6.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 6-4 for the six soil borings drilled at Site 82. Soil sampling locations are shown in Figures 6-5. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Tables 6-3 and 6-4, laboratory analyses will be conducted on two subsurface soil samples per boring and two subsurface soil samples per well. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description in order to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL organics
- TCL pesticides
- TCL PCBs

### 6.4.3 Surface Water Sampling

Surface water samples will be collected from a total of six locations in Wallace Creek, as shown in Figure 6-5. The intent is to refine the nature and extent of contamination in the creek that was first identified near Piney Green Road during a preliminary investigation. Two samples will be collected above Piney Green Road and from four locations downstream of the road, with the most downgradient location near Holcomb Boulevard. The laboratory analysis program for surface water

TABLE 6-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SITE 82: PINEY GREEN ROAD
CAMP LEJEUNE, NORTH CAROLINA

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 1 | 1 |
| | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 1 | 0 |
| | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |
| Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| | Temperature | NA | Field | 6 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 6 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 6 | 0 | 0 | 0 | 0 |
| Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 1 |
| | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 1 |
| | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 0 |



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**TABLE 6-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 82: PINEY GREEN ROAD**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

TABLE 6-2

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 82: PINEY GREEN ROAD
CAMP LEJEUNE, NORTH CAROLINA

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | 9 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 10 days to analysis |
| | TCL Pesticides/PCBs | 8 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Temperature, Specific, Conductance, pH | 5 | N/A | N/A | N/A | N/A |
| Surface Water | TCL VOAs | 8 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL Pesticides/PCBs | 8 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Temperature, Specific, Conductance, pH | 6 | N/A | N/A | N/A | N/A |
| Sediment | TCL VOAs | 9 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL Pesticides/PCBs | 8 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| Soil | TCL VOAs | 22 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL Pesticides/PCBs | 21 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

**TABLE 6-3**

**MONITORING WELL INSTALLATION AND SAMPLING DETAILS**
**SITE 82: PINEY GREEN ROAD**
**CAMP LEJEUNE, NORTH CAROLINA**

| Monitoring Well Number(1) | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Soil Sampling Inverval (feet) | Soil Sample Type | Soil Analysis (per sample) |
|---|---|---|---|---|---|---|---|---|
| 82MW01, 82MW02, 82MW03 | 25 | 25(2) | 17 | 10 | TCL VOAs<br>TCL Pesticides/PCBs | 0.0 - 2.0 | Split spoon | TCL VOAs<br>TCL Pesticides/PCBs |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(3) | Split spoon | TCL VOAs<br>TCL Pesticides/PCBs |

(1) Existing wells 82MW30 and 82MW31 will be resampled for the same analysis.
(2) Wells will be screened from approximately 7 feet below to 3 feet above water table.
(3) Sample to be taken directly above water table.

TABLE 6-4

SUBSURFACE SOIL SAMPLING DETAILS
SITE 82: PINEY GREEN ROAD
CAMP LEJEUNE, NORTH CAROLINA

| Soil Boring Number | Soil Sampling Interval (feet) | Soil Sample Type | Soil Analysis (per sample) |
|---|---|---|---|
| 82SB01, 82SB02, 82SB03, 82SB04, 82SB05, 82SB06 | 0.0 - 2.0 | Split spoon | TCL VOAs<br>TCL Pesticides/PCBs |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | TCL VOAs<br>TCL Pesticides/PCBs |

(1) Sample to be taken directly above water table.

is summarized in Table 6-5. All six surface water samples will be analyzed for the following parameters:

- TCL organics
- TCL pesticides
- TCL PCBs

### 6.4.4 Sediment Sampling

Six sediment samples will be collected at the same locations as the surface water samples as shown in Figure 6-5. The laboratory analysis program for the sediment samples includes pesticides and PCBs because they were detected during the preliminary investigation. The analyses are summarized in Table 6-5. All six sediment samples will be analyzed for the following parameters:

- TCL organics
- TCL pesticides
- TCL PCBs

## 6.5 SURVEYING OPERATIONS

The locations of all soil borings, monitoring wells, and surface water/sediment sample locations will be surveyed following their installation. A total of six soil borings (82SB01-82SB06), three monitoring wells (82MW01-82MW03), and six surface water/sediment sample locations (82SW/SD01-82SW/SD06) will be surveyed. In addition, the two existing monitoring wells (82MW30 and 82MW31) will be surveyed. The locations of the proposed monitoring wells, soil borings, and surface water/sediment samples are shown in Figure 6-2.

TABLE 6-5

SURFACE WATER/SEDIMENT SAMPLING DETAILS
SITE 82: PINEY GREEN ROAD
CAMP LEJEUNE, NORTH CAROLINA

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Surface Water | 82SW01<br>82SW02<br>82SW03<br>82SW04<br>82SW05<br>82SW06 | TCL VOAs<br>TCL Pesticides/PCBs |
| Sediment | 82SD01<br>82SD02<br>82SD03<br>82SD04<br>82SD05<br>82SD06 | TCL VOAs<br>TCL Pesticides/PCBs |

# 7.0 SITE 80: PARADISE POINT GOLF COURSE FIELD INVESTIGATION ACTIVITIES

## 7.1 SITE DESCRIPTION

The study area for this site consists of a 1-acre area at the back of the machine shop and the truck wash area at the Paradise Point Golf Course. The site contains an area of bare, hummocky soil, with a large soil mound. There are areas of dead and/or dying vegetation in the vicinity of the soil mound. In addition, there are unvegetated areas where soils have been disturbed. A drainage ditch runs from the truck wash area around the back of the machine shop and soil mound. Figure 7-1 presents a site map showing the major site features.

In addition to the machine shop, which is a potential source of waste oils, the routine application of pesticides and herbicides on the golf course and the potential inadvertent disposal of excess pesticides and herbicides behind the machine shop may also have contributed to potential contamination in this area. The truck wash area consists of a concrete pad and sumps that collect washwater from the sprayers. Prior to the construction of this pad, however, the disposition of washwater may have been completely uncontrolled. The presence of dead vegetation indicates that at a minimum, waste herbicides may have been disposed of behind the machine shop. There is no indication that other chemicals have been used or disposed of in this area.

## 7.2 WORK PLAN RATIONALE

Although the particular site history is not known, the types of chemicals used in this area are rather well defined. Waste oils and possibly small amounts of solvents may have been dumped from the machine shop, and residual pesticides or herbicides may have been disposed of in this area in the past. Final sample locations will be determined in the field by the project hydrogeologist. The hydrogeologist will locate samples in suspected areas of contamination to maximize detection of target analytes, if present.

The field investigation at this site will be limited to a soil investigation. The contaminants presumed to be present are highly immobile in the environment and tend to adhere to the organic carbon in soil. PCBs and pesticides have high organic carbon partition coefficients and low solubilities. Herbicides are slightly more soluble than PCBs, but if present, they should be detectable in the soil.

## 7.3 DRILLING OPERATIONS

In order to more readily locate the proposed soil borings in areas that are least likely to contain buried metallic objects, a surface geophysical survey will be performed at all the suggested drilling locations. The survey will consist of using an electromagnetometer (Heliflux), which can locate metallic objects, such as buried drums, near the ground surface. The drilling operations for Site 80 are discussed in detail below.

### 7.3.1 Soil Boring Installation

A total of four 15-foot soil borings will be installed at Site 80. Two borings are located behind the machine shop and two within the dirt area behind the machine shop. The locations of the proposed soil borings are shown in Figure 7-2.

Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 feet to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). None of the seven soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout

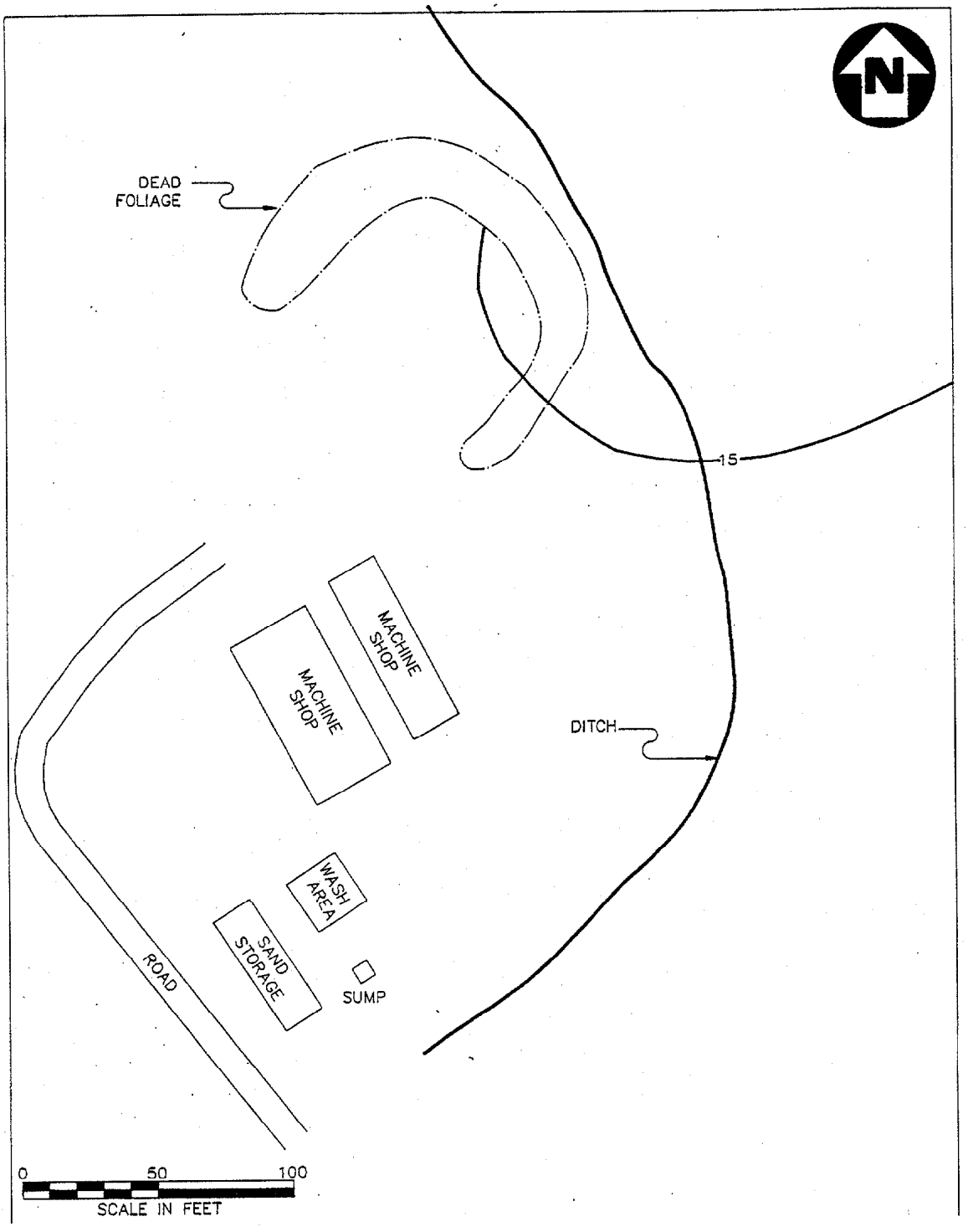


**FIGURE 7-1**
**SITE 80: PARADISE POINT GOLF COURSE**
**CAMP LEJEUNE MILITARY RESERVATION**

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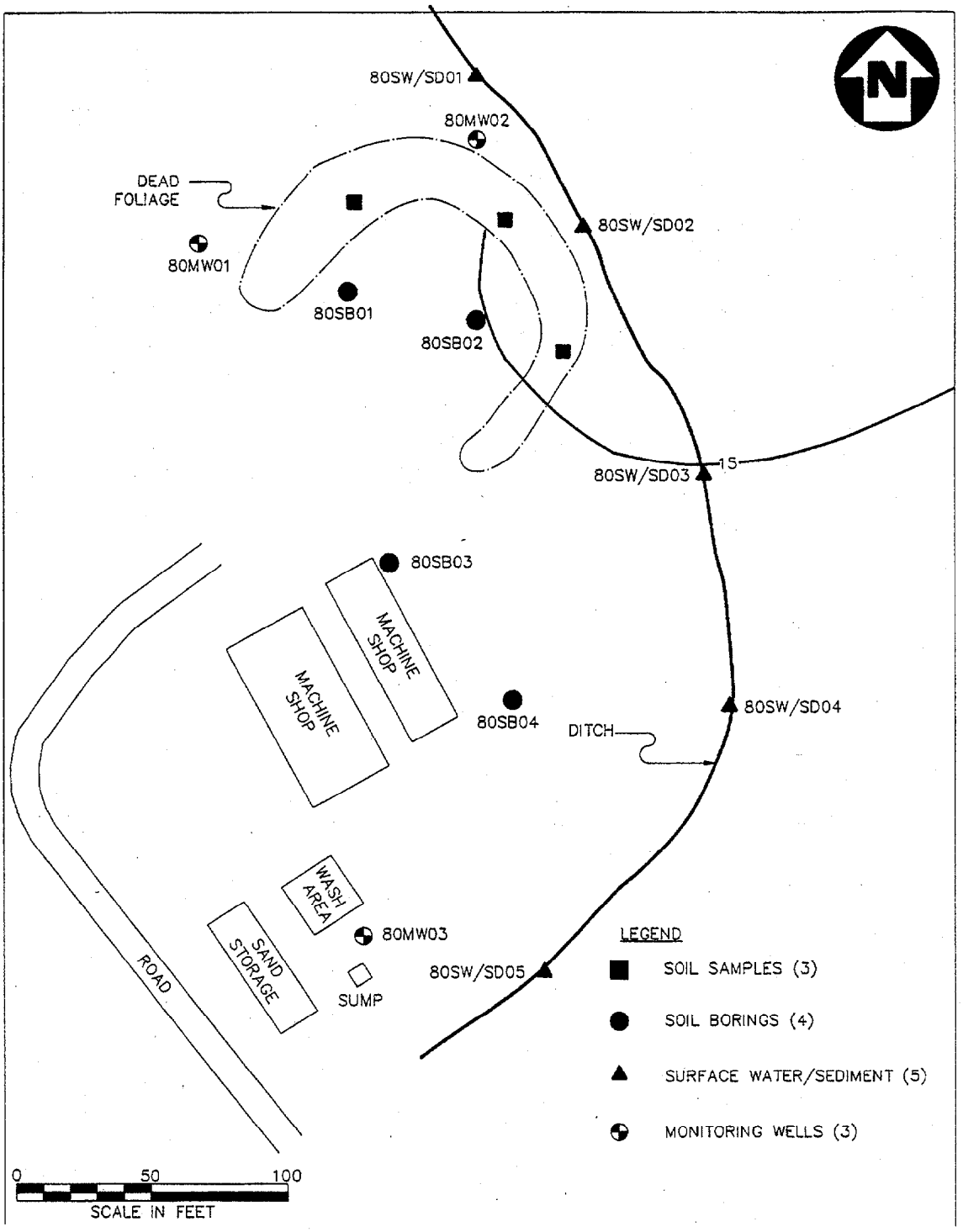


**FIGURE 7-2**
**SAMPLE LOCATIONS**
**SITE 80: PARADISE POINT GOLF COURSE**
**CAMP LEJEUNE MILITARY RESERVATION**

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following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 80SB01 through 80SB04, as shown on Figure 7-2. Split-spoon sampling intervals for the borings are given in Section 7.4.2.

### 7.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 80. Two wells will be located behind the soil mound in the area of dead vegetation along the stream. The third well will be located near the wash area and the sump. These preliminary locations are shown in Figure 7-2. Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 80MW01 through 80MW03, as shown on Figure 7-2. One round of samples will be collected from the new wells for chemical analysis, as described in Section 7.4.1. Well development will be performed on each new well, as described in Section 13.3.5. One round of synoptic water-level measurements will be obtained from all wells within a 4-hour period, as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 80 is given below:

- Install three shallow monitoring wells (80MW01-80MW03).
- Obtain synoptic water-level measurements from all new wells within a 4-hour period.

## 7.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 80:

- Groundwater
- Subsurface soil
- Surface water
- Sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 7-1 provides a sampling and analysis program summary for Site 80. Table 7-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 7.4.1 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 7-3 for the four soil borings drilled at Site 80. Soil sampling locations are shown in Figure 7-2. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Table 7-3, laboratory analyses will be conducted on two subsurface soil samples per boring. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description in order to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL VOAs
- TCL pesticides/PCBs

TABLE 7-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SITE 80: PARADISE POINT GOLF COURSE
CAMP LEJEUNE, NORTH CAROLINA

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 3 | 1 | 0 | 0 | 0 |
| | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | Chlorinated Herbicides | As per method | SW 8150 | 3 | 1 | 1 | 1 | 0 |
| | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Surface Water | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 5 | 1 | 0 | 0 | 0 |
| | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 1 |
| | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | Chlorinated Herbicides | As per method | SW 8150 | 5 | 1 | 1 | 0 | 0 |
| | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |

**TABLE 7-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 80: PARADISE POINT GOLF COURSE**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Sediment | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | Total Petroleum Hydrocarbons | 1 mg/kg | EPA 418.1 | 5 | 1 | 0 | 0 | 0 |
| | Chlorinated Herbicides | As per method | SW 8150/3550 | 5 | 1 | 1 | 0 | 0 |
| | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| Soil | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 17 | 2 | 0 | 0 | 0 |
| | Total Petroleum Hydrocarbons | 1 mg/kg | EPA 418.1 | 17 | 2 | 0 | 0 | 0 |
| | Chlorinated Herbicides | As per method | SW 8150/3550 | 17 | 2 | 1 | 0 | 0 |
| | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 17 | 2 | 0 | 0 | 1 |

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

**TABLE 7-2**

**SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES**
**SITE 80: PARADISE POINT GOLF COURSE**
**CAMP LEJEUNE, NORTH CAROLINA**

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | Total Petroleum Hydrocarbons | 4 | 1 | 1 liter glass bottle | HCl to pH<2 | 28 days |
| | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottles | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Chlorinated Herbicides | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Temperature, Specific Conductance, pH | 3 | NA | NA | NA | NA |
| Surface Water | Total Petroleum Hydrocarbons | 6 | 1 | 1 liter glass bottle | HCl to pH<2 | 28 days |
| | TCL VOAs | 7 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottles | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Chlorinated Herbicides | 7 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Temperature, Specific Conductance, pH | 5 | NA | NA | NA | NA |

**TABLE 7-2**
**SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES**
**SITE 80: PARADISE POINT GOLF COURSE**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Sediment | TCL Pesticides/PCBs | 6 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Total Petroleum Hydrocarbons | 6 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | Chlorinated Herbicides | 7 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL VOAs | 6 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| Soil | TCL Pesticides/PCBs | 19 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Total Petroleum Hydrocarbons | 19 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | Chlorinated Herbicides | 20 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL VOAs | 20 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

TABLE 7-3

SUBSURFACE SOIL SAMPLING DETAILS
SITE 80: PARADISE POINT GOLF COURSE
CAMP LEJEUNE, NORTH CAROLINA

| Soil Boring Number | Sampling Interval (feet) | Sample Type | Analysis (per sample) |
|---|---|---|---|
| 80SB01, 80SB02, 80SB03, 80SB04, 80SB05, 80SB06, 80SB07 | 0.0 - 2.0 | Split spoon | TCL VOAs<br>TCL Pesticides/PCBs<br>Chlorinated Herbicides<br>Total Petroleum Hydrocarbons (TPH) |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | TCL VOAs<br>TCL Pesticides/PCBs<br>Chlorinated Herbicides<br>Total Petroleum Hydrocarbons (TPH) |

(1) Sample to be taken directly above water table.

- Chlorinated herbicides
- Total petroleum hydrocarbons

### 7.4.2 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (80MW01, 80MW02, and 80MW03). Groundwater sampling locations are shown in Figure 7-2. The laboratory analysis of groundwater samples is summarized in Table 7-4. All of the monitoring wells will be analyzed for the following parameters:

- TCL VOAs
- TCL pesticides/PCBs
- Chlorinated herbicides
- Total petroleum hydrocarbons

### 7.4.3 Shallow Subsurface Soil Sampling

In addition to the soil borings, three shallow subsurface soil samples will be collected on the soil mound near areas of dead vegetation. These samples will be collected by hand, since a drill rig would not be able to reach the top of the mound. Laboratory analyses of the shallow soil samples are outlined in Table 7-5. Shallow soil sampling procedures and guidelines are given in Section 13.4.1.

All three soil samples will be analyzed for the following parameters:

- TCL VOA
- TCL pesticides/PCBs
- Chlorinated herbicides
- Total petroleum hydrocarbons

### 7.4.4 Surface Water Sampling

Surface water samples will be collected from a total of five locations in the drainage ditch that flows past the site, as shown in Figure 7-2. The laboratory analysis program for surface water is summarized in Table 7-6. All five surface water samples will be analyzed for the following parameters:

- TCL VOAs
- TCL pesticides/PCBs
- Chlorinated herbicides
- Total petroleum hydrocarbons

### 7.4.5 Sediment Sampling

Five sediment samples will be collected at the same locations as the surface water samples, as shown in Figure 7-2. The laboratory analysis program is summarized in Table 7-6.

All five sediment samples will be analyzed for the following parameters:

- TCL VOAs
- TCL pesticides/PCBs
- Chlorinated herbicides
- Total petroleum hydrocarbons

TABLE 7-4

MONITORING WELL INSTALLATION AND SAMPLING DETAILS
SITE 80: PARADISE POINT GOLF COURSE
CAMP LEJEUNE, NORTH CAROLINA

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|---|---|---|---|---|
| 80MW01, 80MW02, 80MW03 | 25 | 25(1) | 17 | 10 | TCL VOAs<br>TCL Pesticides/PCBs<br>Chlorindated Herbicides<br>Total Petroleum Hydrocarbons (TPH) | 0.0 - 2.0 | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(2) | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |

(1) Wells will be screened from approximately 7 feet below to 3 feet above water table.
(2) Sample to be taken directly above water table.

TABLE 7-5

SHALLOW SUBSURFACE SOIL SAMPLING DETAILS
SITE 80: PARADISE POINT GOLF COURSE
CAMP LEJEUNE, NORTH CAROLINA

| Soil Sample Number | Sampling Interval (feet) | Sample Type | Analysis (per sample) |
|---|---|---|---|
| 80S001, 80S002, 80S003 | 0.0 - 2.0(1) | Hand sample | TCL VOAs<br>TCL Pesticides/PCBs<br>Chlorinated Herbicides<br>Total Petroleum Hydrocarbons (TPH) |

(1) Sample to be taken by hand using stainless-steel sampling tools.

TABLE 7-6

SURFACE WATER/SEDIMENT SAMPLING DETAILS
SITE 80: PARADISE POINT GOLF COURSE
CAMP LEJEUNE, NORTH CAROLINA

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Surface Water | 80SW01<br>80SW02<br>80SW03<br>80SW04<br>80SW05 | TCL VOAs<br>TCL Pesticides/PCBs<br>Chlorinated Herbicides<br>Total Petroleum Hydrocarbons (TPH) |
| Sediment | 80SD01<br>80SD02<br>80SD03<br>80SD04<br>80SD05 | TCL VOAs<br>TCL Pesticides/PCBs<br>Chlorinated Herbicides<br>TCL PCBs<br>Total Petroleum Hydrocarbons (TPH) |

## 7.5 SURVEYING OPERATIONS

The locations of all soil borings, soil sample locations, and surface water/sediment sample locations will be surveyed following their installation. A total of four soil borings (80SB01-80SB04), three soil samples (80SO01-80SO03), three groundwater samples (80ME01-80MW03), and five surface water/sediment samples (80SW/SD01-80SW/SD05) will be surveyed. All sample locations are shown in Figure 7-2.

# 8.0 SITE 3: OLD CREOSOTE PLANT FIELD INVESTIGATION ACTIVITIES

## 8.1 SITE DESCRIPTION

The old creosote plant operated from 1951 to 1952 to supply treated lumber during construction of the railroad on the base. The facility was located at PWDM coordinates 5, N11-12/O11-12, approximately 800 feet east of Building 613, on the opposite side of Holcomb Boulevard. Logs were cut into railroad ties at the onsite sawmill, then pressure treated with hot creosote stored in a railroad tank car. There is no indication of creosote disposal on site, and records show that creosote remaining in the pressure chamber at the end of a treatment cycle was stored for future use.

Upon completion of the railroad, the plant and mill were dismantled and sold. The only site features remaining are creosote pads and the boiler chimney. Figure 8-1 shows the approximate site configuration and sample locations.

## 8.2 WORK PLAN RATIONALE

Because no work has been conducted at this site, the field investigation is intended to determine whether the potential for an environmental contamination problem exists. However, the proposed analyses focus on contaminants commonly found at creosote facilities. Figure 8-2 provides approximate drilling and sampling locations. Final sample locations will be determined in the field by the project hydrogeologist. The hydrogeologist will locate samples in suspected areas of contaminants to maximize detection of target analytes, if present.

## 8.3 DRILLING OPERATIONS

A surface geophysical survey will be performed at all the suggested drilling locations to more readily locate the proposed soil borings in areas that are least likely to contain buried metallic objects. The survey will consist of using an electromagnetometer (Heliflux), which can locate metallic objects such as buried drums near the ground surface. The drilling operations for Site 3 are discussed in detail below.

### 8.3.1 Soil Boring Installation

A total of five soil borings will be installed at Site 3. The borings will be 5 feet deep because of the immobile nature of the polyaromatic hydrocarbons (PAHs) and chlorinated phenols. The preliminary locations, as shown in Figure 8-2, were selected to provide a reasonable indication of the lateral and vertical extent of contamination, if present.

Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 feet to 2.0 feet). The second sample will be taken from 3.0 feet to 5.0 feet in the shallow borings and directly above the groundwater interface (approximately 15 feet) in the deeper borings.

None of the five soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 03SB01 through 03SB05, as shown on Figure 8-2. Split-spoon sampling intervals for the borings are given in Section 8.4.2.

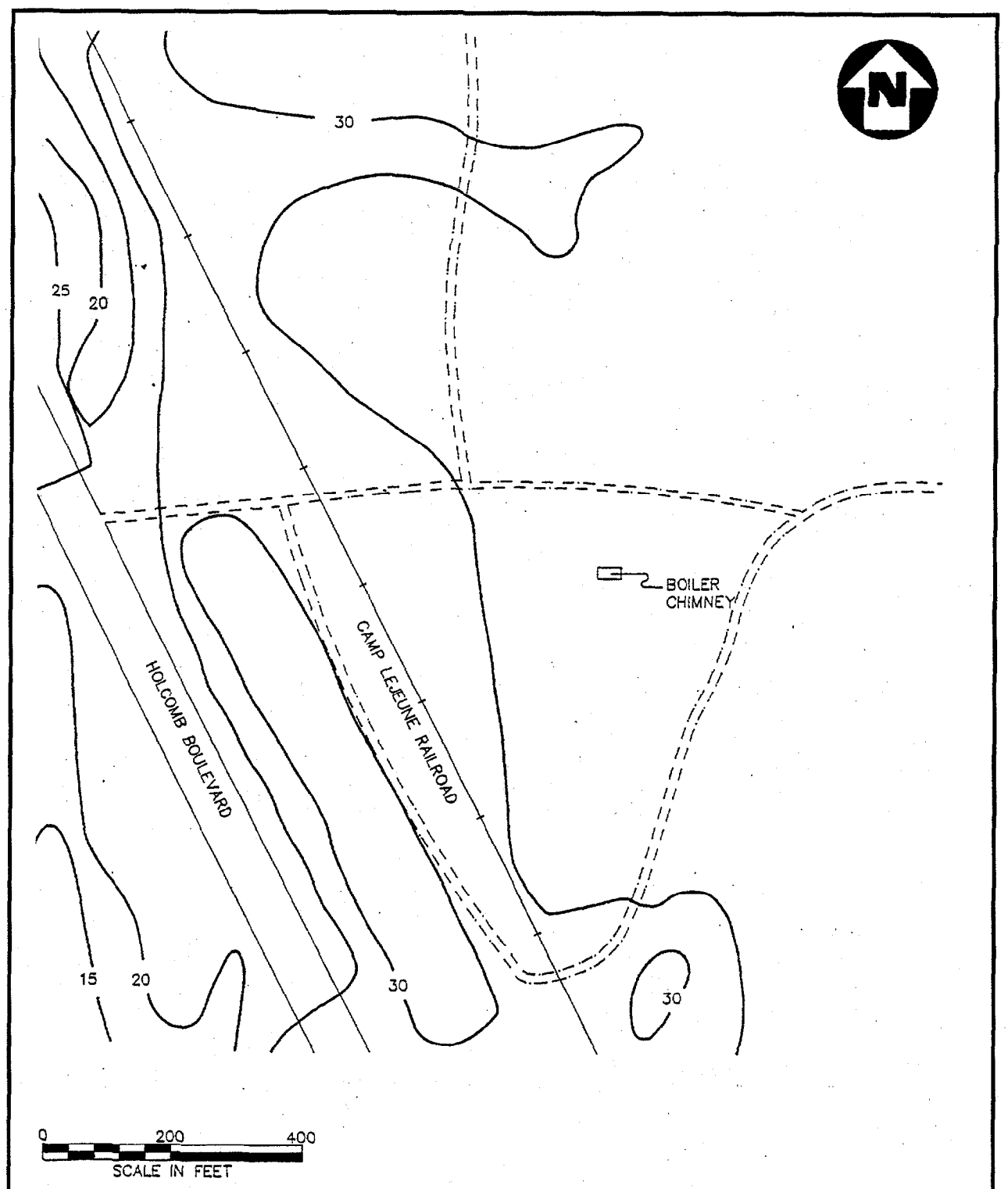


**FIGURE 8-1**
**SITE 3: OLD CREOSOTE PLANT**
**CAMP LEJEUNE MILITARY RESERVATION**

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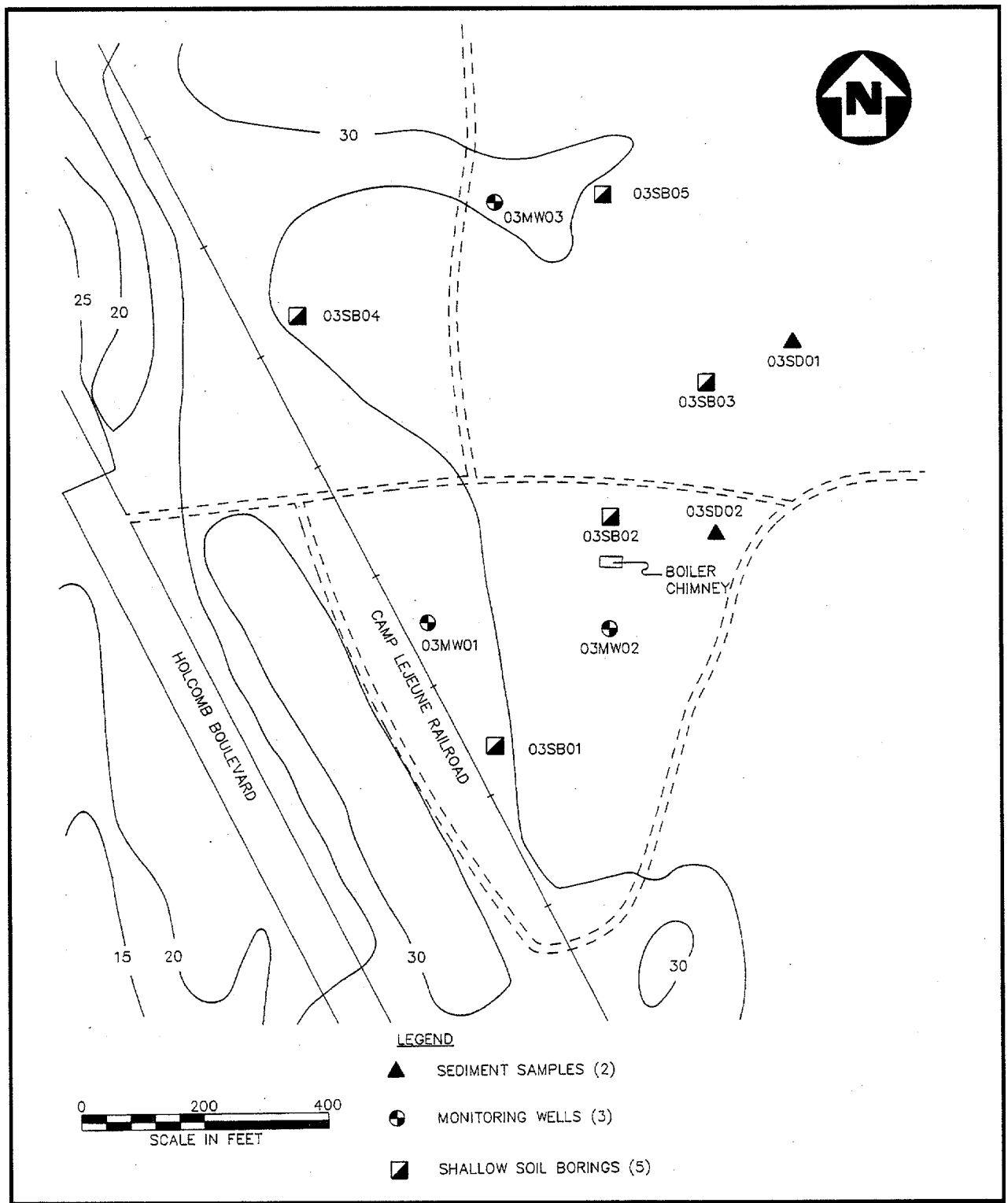


**FIGURE 8-2**
**SAMPLE LOCATIONS**
**SITE 3: OLD CREOSOTE PLANT**
**CAMP LEJEUNE MILITARY RESERVATION**

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### 8.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 03. Groundwater flow is not known at the time. The preliminary locations are shown in Figure 8-2.

Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 03MW01 through 03MW03, as shown on Figure 8-2. Wells shall be screened so that the top of the screen is 2 to 3 feet above the static water level. Well development will be performed on each new well as described in Section 13.3.5. One round of samples will be collected from the new wells for chemical analysis, as described in Section 9.4.1. One round of synoptic water-level measurements will be obtained from all wells (03MW01-03MW03) within a 4-hour period as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 03 is given below:

- Install three shallow monitoring wells (03MW01-03MW03).
- Obtain synoptic water-level measurements from all new wells within a 4-hour period.

## 8.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 3:

- Groundwater
- Subsurface soil
- Sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 8-1 provides a sampling and analysis program summary for Site 3. Table 8-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 8.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (03MW01, 03MW02, and 03MW03). Groundwater sampling locations are shown in Figure 8-2. The laboratory analysis of groundwater samples is summarized in Table 8-3. All of the monitoring wells will be analyzed for the following parameters:

- TCL acid extractables
- TCL base/neutral extractables

### 8.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 8-4 for the 5 soil borings drilled at Site 3. Soil sampling locations are shown in Figure 8-2. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Table 8-3, laboratory analyses will be conducted on two subsurface soil samples per boring. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. In the deeper borings, soil samples will also be taken at 5-foot intervals from

**TABLE 8-1**

**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 3: OLD CREOSOTE PLANT**
**CAMP LEJEUNE, NORTH CAROLINA**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL BNAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 1 | 0 | 0 |
| Sediment | TCL BNAs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 1 | 0 | 0 |
| Soil | TCL BNAs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 1 | 0 | 0 |

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

**TABLE 8-2**

**SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES**
**SITE 3: CREOSOTE PLANT**
**CAMP LEJEUNE, NORTH CAROLINA**

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL BNAs | 4 | 1 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| Sediment | TCL BNAs | 4 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| Soil | TCL BNAs | 19 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

TABLE 8-3

MONITORING WELL INSTALLATION AND SAMPLING DETAILS
SITE 03: OLD CREOSOTE PLANT
CAMP LEJEUNE, NORTH CAROLINA

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|---|---|---|---|---|
| 03MW01, 03MW02, 03MW03 | 25 | 25(1) | 17 | 10 | TCL Acid Extractables<br>TCL Base/Neutral Extractables | 0.0 - 2.0 | Split spoon | TCL Acid Extractables<br>TCL Base/Neutral Extractables |
| | | | | | None | 5.0 - 7.0 | Split spoon | None |
| | | | | | None | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(2) | Split spoon | TCL Acid Extractables<br>TCL Base/Neutral Extractables |

(1) Wells will be screened from approximately 7 feet below to 3 feet above water table.
(2) Sample to be taken directly above water table.

TABLE 8-4

SUBSURFACE SOIL SAMPLING DETAILS
SITE 3: CREOSOTE PLANT
CAMP LEJEUNE, NORTH CAROLINA

| Soil Boring Number | Sampling Interval (feet) | Sample Type | Analysis (per sample) |
|---|---|---|---|
| 03SB01<br>03SB02<br>03SB03<br>03SB04<br>03SB05 | 0.0 - 2.0 | Split spoon | Total Acid Extractions<br>TCL Base/Neutral Extractables |
| | 3.0 - 5.0 | Split spoon | Total Acid Extractions<br>TCL Base/Neutral Extractables |

(1) Sample to be taken directly above water table.

the ground surface to the bottom of each hole. All samples will be used for lithologic description to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL acid extractables
- TCL base/neutral extractables

### 8.4.3 Sediment Sampling

Two sediment samples will be collected in a nearby drainage ditch or potential wetlands areas for this investigation, as shown in Figure 8-2. The laboratory analysis program is summarized in Table 8-5. All four sediment samples will be analyzed for the following parameters:

- TCL acid extractables
- TCL base/neutral extractables

## 8.5 SURVEYING OPERATIONS

The locations of all soil borings and sediment sample locations will be surveyed following their installation. A total of five soil borings (03SB01-03SB05), three monitoring wells (03MW01-03MW03) and two sediment samples (03SD01-03SD02) will be surveyed. The approximate locations of for all samples are shown in Figure 8-2.

TABLE 8-5

SEDIMENT SAMPLING DETAILS
SITE 3: CREOSOTE PLANT
CAMP LEJEUNE, NORTH CAROLINA

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Sediment | 03SD01<br>03SD02 | TCL Acid Extractables<br>TCL Base/Neutral Extractables |

# 9.0 SITE 43: AGAN STREET DUMP FIELD INVESTIGATION ACTIVITIES

## 9.1 SITE DESCRIPTION

The Agan Street Dump is about 20 acres in size and is located near the old wastewater treatment plant at PWDM coordinates 23, H6-7/I6-7. Boards, trash, fiberglass, and wastewater treatment plant sludge were disposed of on the ground surface. The years of operation are unknown. Figure 9-1 shows the general site configuration and sampling locations.

## 9.2 WORK PLAN RATIONALE

The intent of the investigation at this site is to determine whether there is a potential for environmental contamination. Because there are no existing data, the proposed analyses are more comprehensive than for several other sites where the site history is better defined. Figure 9-2 provides approximate drilling and sampling locations. Final sample locations will be determined in the field by the project hydrogeologist. The hydrogeologist will locate samples in suspected areas of contaminants to maximize detection of target analytes, if present. Wells will be installed so that two are located downgradient and one upgradient. This will maximize detection of groundwater contamination, if present.

## 9.3 DRILLING OPERATIONS

A surface geophysical survey will be performed at all the suggested drilling locations to more readily locate the proposed soil borings in areas that are least likely to contain buried metallic objects. The survey will consist of using an electromagnetometer (Heliflux), which can locate metallic objects, such as buried drums, near the ground surface. The drilling operations for Site 43 are discussed below.

### 9.3.1 Soil Boring Installation

A total of five 15-foot soil borings will be located throughout Site 43, with preference given to areas of visible contamination. The preliminary locations are shown in Figure 9-2. Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 feet to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). None of the five soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 43SB01 through 43SB05 as shown on Figure 9-1. Split-spoon sampling intervals for the borings are given in Section 9.4.2.

### 9.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 43. Groundwater flow is not known at the time; however, it is assumed the groundwater flows east toward the New River. The preliminary locations are shown in Figure 9-2.

Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 43MW01 through 43MW03, as shown on Figure 9-2. Wells shall be screened so that the top of the

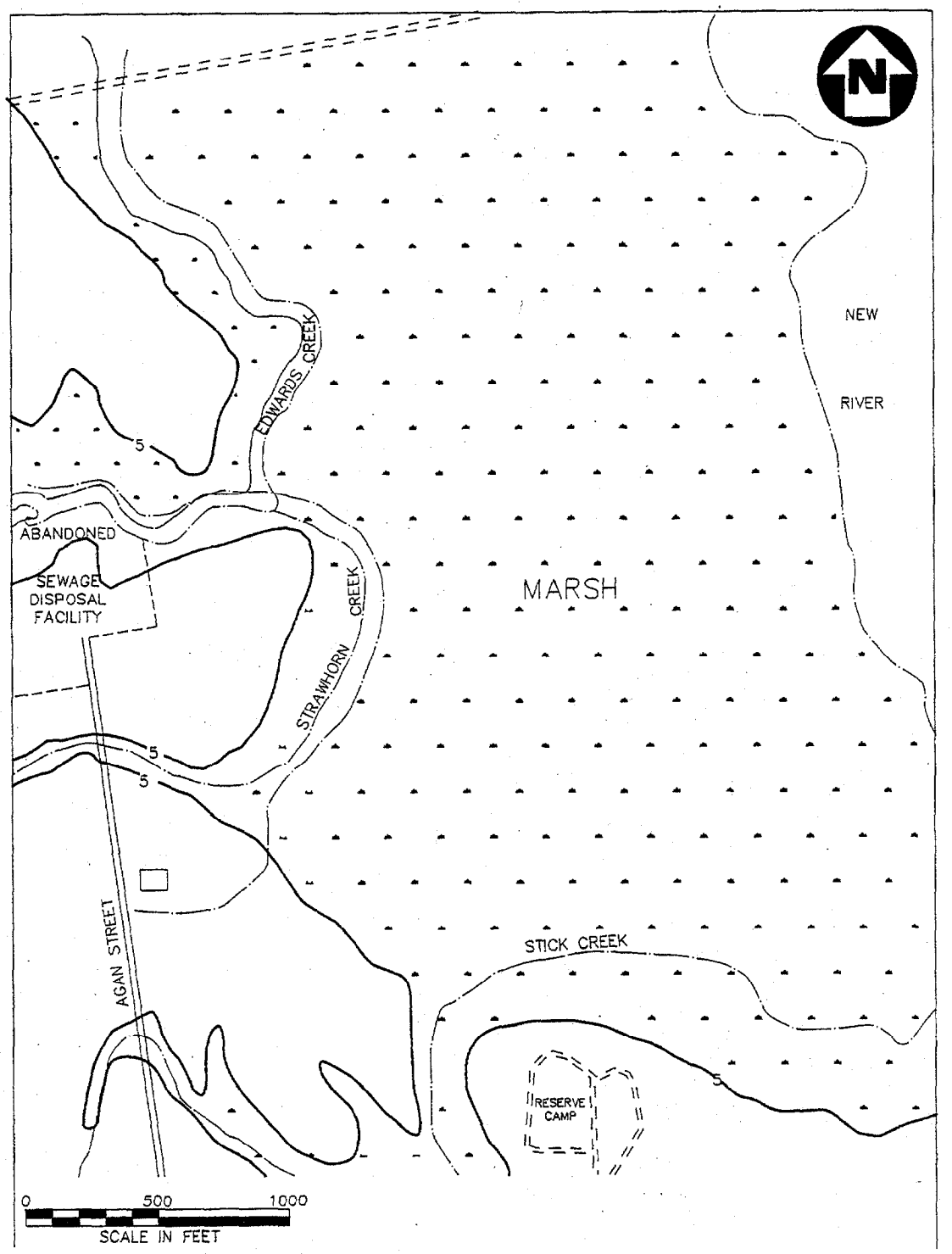


**FIGURE 9-1**
**SITE 43: AGAN STREET DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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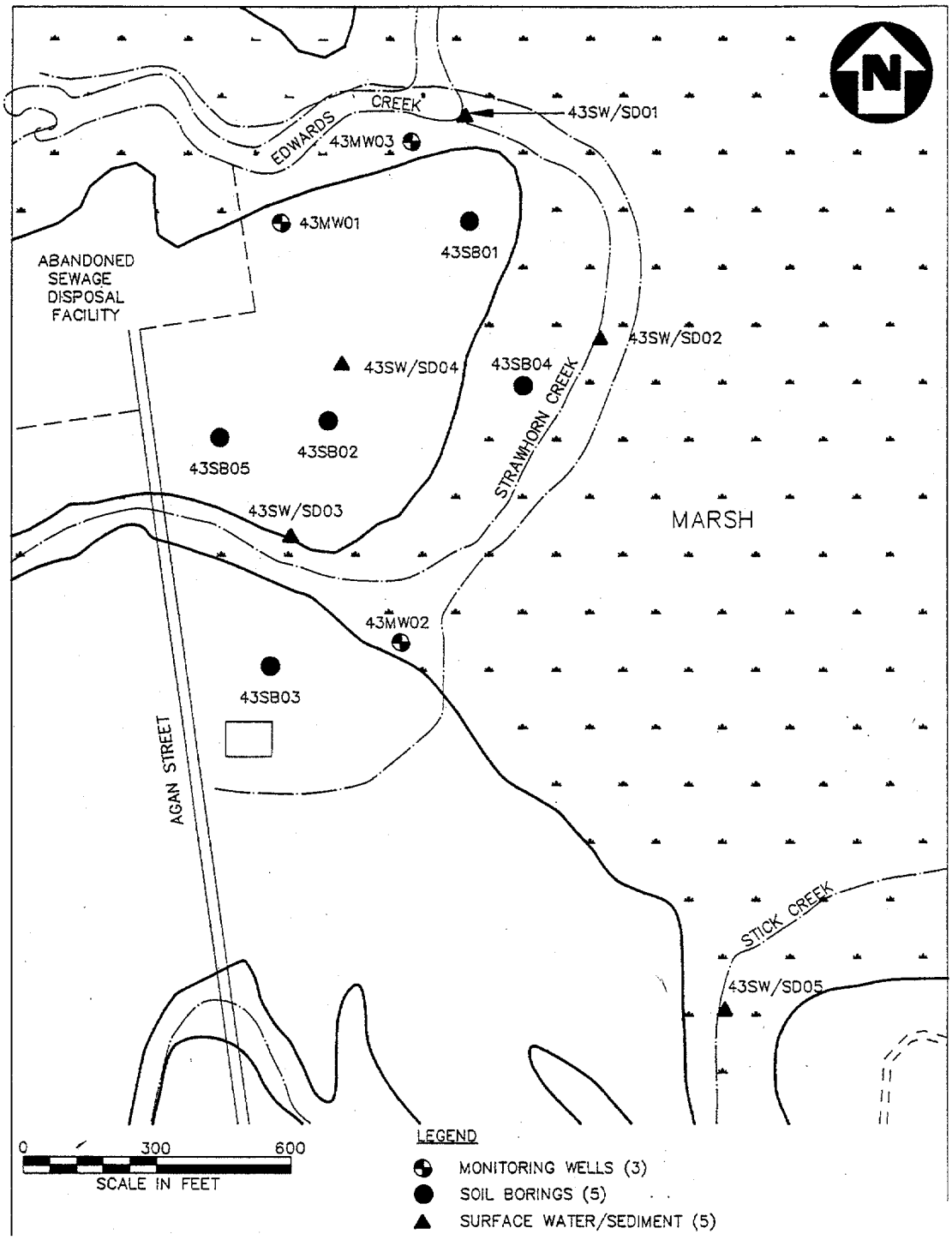


**FIGURE 9-2**
**SAMPLE LOCATIONS**
**SITE 43: AGAN STREET DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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screen is 2 to 3 feet above the static water level. Well development will be performed on each new well as described in Section 13.3.5. One round of samples will be collected from the new wells for chemical analysis, as described in Section 9.4.1. One round of synoptic water-level measurements will be obtained from all wells (43MW01-43MW03) within a 4-hour period as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 43 is given below:

- Install three shallow monitoring wells (43MW01-43MW03).
- Obtain synoptic water-level measurements from all new wells within a 4-hour period.

## 9.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 43:

- Groundwater
- Subsurface soil
- Surface water
- Sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 9-1 provides a sampling and analysis program summary for Site 43. Table 9-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 9.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (43MW01, 43MW02, and 43MW03). Groundwater sampling locations are shown in Figure 9-2. The laboratory analysis of groundwater samples is summarized in Table 9-3. All of the monitoring wells will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 9.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 9-4 for the 5 soil borings drilled at Site 43. Soil sampling locations are shown in Figure 9-2. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Table 9-4, laboratory analyses will be conducted on two subsurface soil samples per boring and two subsurface soil samples per well. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description in order to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

TABLE 9-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SITE 43: AGAN STREET DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 0 | 0 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 0 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 0 | 0 | 0 |
| | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 0 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 0 | 0 | 0 |

**TABLE 9-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 43: AGAN STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Surface Water (Continued) | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |
| Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 0 | 0 | 0 |
| Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 0 | 0 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 0 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 16 | 2 | 0 | 0 | 0 |

**TABLE 9-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 43: AGAN STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE THREE**

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

TABLE 9-2

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 43: AGAN STREET DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | 4 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 4 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 4 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | Cyanide | 4 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| Surface Water | TCL VOAs | 7 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 6 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | Cyanide | 6 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 5 | N/A | N/A | N/A | N/A |

TABLE 9-2
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 43: AGAN STREET DUMP
CAMP LEJEUNE, NORTH CAROLINA
PAGE TWO

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Sediment | TCL VOAs | 6 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 6 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 6 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| Soil | TCL VOAs | 19 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 18 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 18 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

**TABLE 9-3**

**MONITORING WELL INSTALLATION AND SAMPLING DETAILS**
**SITE 43: AGAN STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|---|---|---|---|---|
| 43MW01, 43MW02, 43MW03 | 25 | 25(1) | 17 | 10 | TCL Organics TCL Inorganics, Cyanide | 0.0 - 2.0 | Split spoon | TCL Organics TCL Inorganics, Cyanide |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(2) | Split spoon | TCL Organics TCL Inorganics, Cyanide |

(1) Wells will be screened from approximately 7 feet below to 3 feet above water table.
(2) Sample to be taken directly above water table.

**TABLE 9-4**

**SUBSURFACE SOIL SAMPLING DETAILS**
**SITE 43: AGAN STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Soil Boring Number | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|
| 43SB01, 43SB02, 43SB03, 43SB04, 43SB05 | 0.0 - 2.0 | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |

(1) Sample to be taken directly above water table.

### 9.4.3 Surface Water Sampling

Surface water samples will be collected from a total of five locations in local streams and wetland areas. Exact locations will be selected, based on likely deposition areas. The laboratory analysis program for surface water is summarized in Table 9-5. All five surface water samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 9.4.4 Sediment Sampling

Five sediment samples will be collected at the same locations as the surface water samples. The laboratory analysis program is summarized in Table 9-5. All five sediment samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

## 9.5 SURVEYING OPERATIONS

The locations of all soil borings, monitoring wells, and surface water/sediment sample locations will be surveyed following their installation. A total of five soil borings (43SB01-43SB05), three monitoring wells (43MW01-43MW03), and five surface water/sediment sample locations (43SW/SD01-43SW/SD05) will be surveyed. All sample locations are shown in Figure 9-2.

**TABLE 9-5**

**SURFACE WATER/SEDIMENT SAMPLING DETAILS**
**SITE 43: AGAN STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Surface Water | 43SW01<br>43SW02<br>43SW03<br>43SW04<br>43SW05 | TCL Organics<br>TCL Inorganics, Cyanide |
| Sediment | 43SD01<br>43SD02<br>43SD03<br>43SD04<br>43SD05 | TCL Organics<br>TCL Inorganics, Cyanide |

# 10.0 SITE 44: JONES STREET DUMP FIELD INVESTIGATION ACTIVITIES

## 10.1 SITE DESCRIPTION

The Jones Street Dump is located at PWDM coordinates 23,L6-7/M6-7 and is approximately 5 acres in size. It is located behind base housing on Jones Street. The dump was in operation in the 1950s and received mainly debris, cloth, boards, and paint cans. However, small quantities of hazardous materials may also have been disposed of in the fill. The approximate site configuration and sample locations are shown on Figure 10-1.

## 10.2 WORK PLAN RATIONALE

The intent of the investigation at this site is designed to determine whether there exists a potential for environmental contamination. Because there are no existing data, the proposed analyses are more comprehensive than at other sites with better defined site histories. Figure 10-2 provides approximate drilling and sampling locations. Final sample locations will be determined in the field by the project hydrogeologist. The hydrogeologist will locate samples in suspected areas of contaminants to maximize detection of target analytes, if present. Wells will be installed such that two are located downgradient and one upgradient. This will maximize detection of groundwater contamination, if present.

## 10.3 DRILLING OPERATIONS

A surface geophysical survey will be performed at all the suggested drilling locations to more readily locate the proposed soil borings in areas that are least likely to contain buried metallic objects. The survey will consist of using an electromagnetometer (Heliflux), which can locate metallic objects, such as buried drums, near the ground surface. The drilling operations for Site 44 are discussed below.

### 10.3.1 Soil Boring Installation

A total of six 15-foot soil borings will be installed at Site 44. The intent of these borings is to provide good spatial coverage of the site by filling in information from the areas not covered by the monitoring wells. Final locations will be determined in the field with preference given to those areas that have obvious visual signs of contamination. The preliminary locations are shown in Figure 10-2.

Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). None of the six soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 44SB01 through 44SB06, as shown on Figure 10-2. Split-spoon sampling intervals for the borings are given in Section 10.4.2.

### 10.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 44. Two wells are proposed for the northern, upgradient side of the site, and one well is proposed for the southern, downgradient side of the site. The preliminary locations are shown in Figure 10-2.

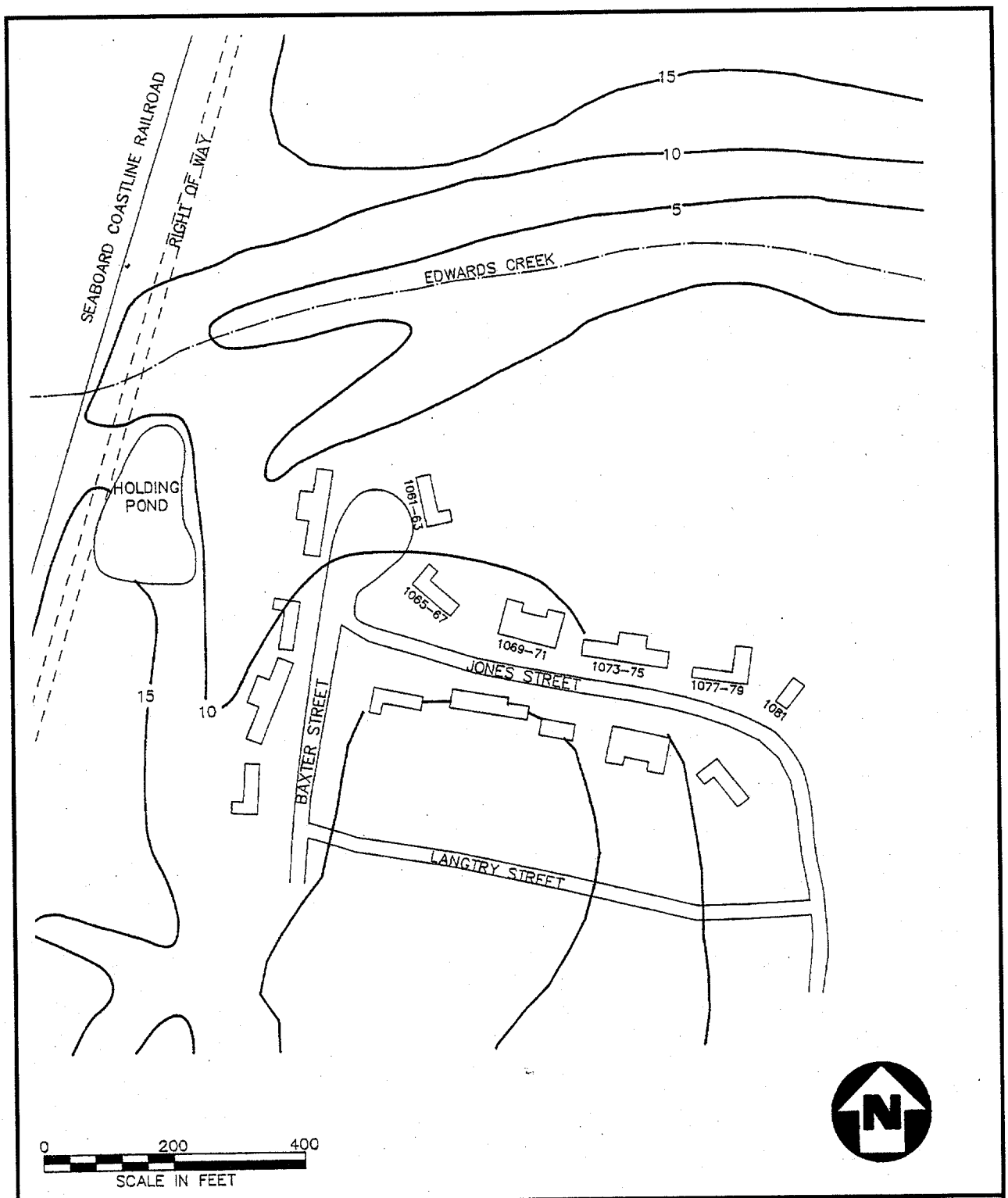


**FIGURE 10-1**
**SITE 44: JONES STREET DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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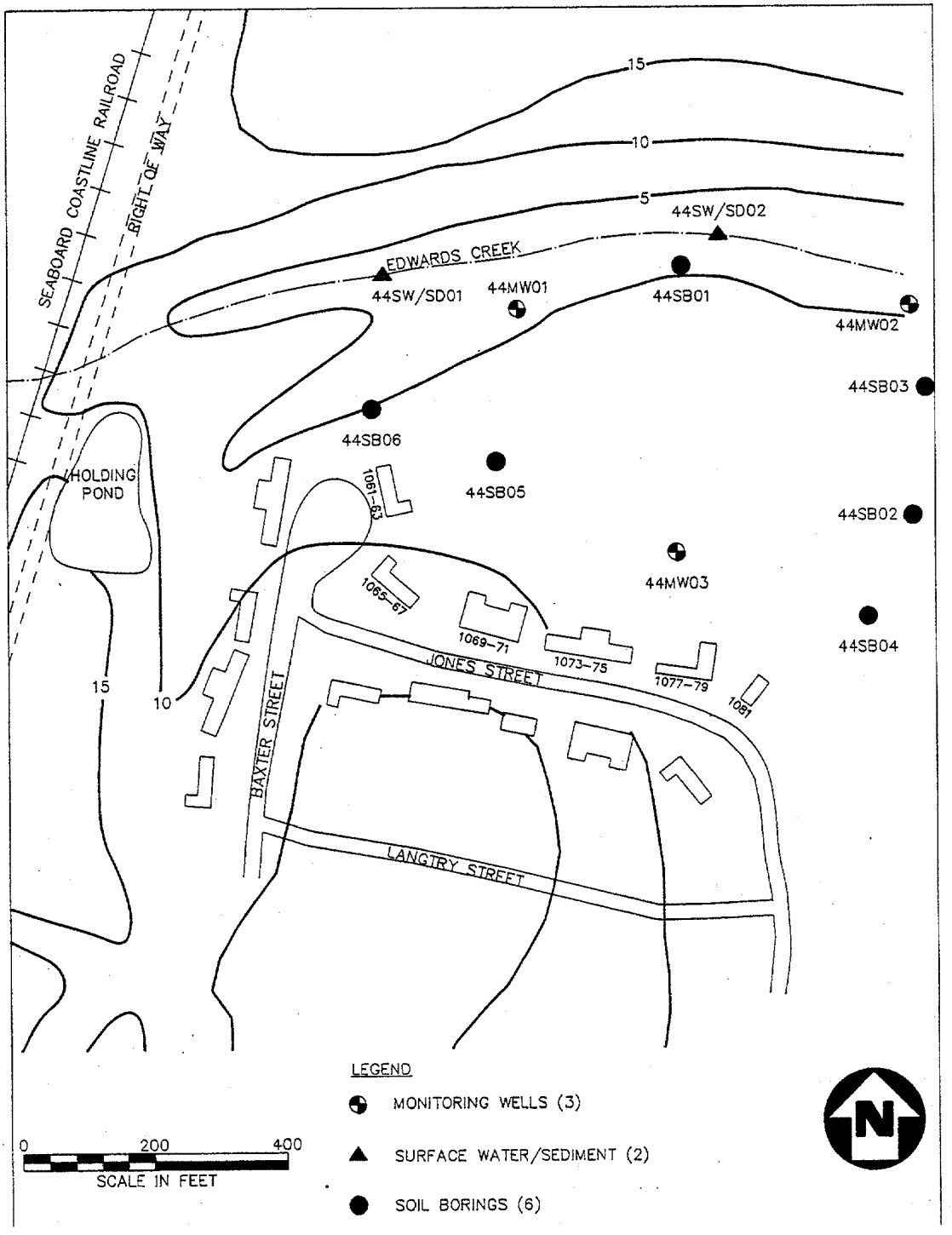


**FIGURE 10-2**
**SAMPLE LOCATIONS**
**SITE 44: JONES STREET DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 44MW01 through 44MW03, as shown on Figure 10-2. One round of samples will be collected from the new wells for chemical analysis, as described in Section 10.4.1. Well development will be performed on each new well as described in Section 13.3.5. One round of synoptic water-level measurements will be obtained from all wells (44MW01-44MW03) within a 4-hour period, as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 43 is given below:

- Install three shallow monitoring wells (44MW01-44MW03).
- Obtain synoptic water-level measurements from all new wells within a 4-hour period.

## 10.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 44:

- Groundwater
- Subsurface soil
- Surface water/sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0 of this document. Table 10-1 provides a sampling and analysis program summary for Site 44. Table 10-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site.

### 10.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (44MW01, 44MW02, and 44MW03). Groundwater sampling locations are shown in Figure 10-2. The laboratory analysis of groundwater samples is summarized in Table 10-3. All of the monitoring wells will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 10.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 10-4 for the six soil borings drilled at Site 44. Soil sampling locations are shown in Figures 10-2. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Table 10-4, laboratory analyses will be conducted on two subsurface soil samples per boring and two subsurface soil samples per well. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description in order to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

**TABLE 10-1**

**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 44: JONES STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 1 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 1 | 0 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 2 | 0 | 1 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 0 | 1 | 0 | 0 |
| | Temperature | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 2 | 0 | 0 | 0 | 0 |

**TABLE 10-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 44: JONES STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 0 | 0 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 0 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 0 | 0 | 0 | 0 |
| Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 0 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 18 | 2 | 0 | 0 | 0 |

**TABLE 10-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 44: JONES STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE THREE**

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

TABLE 10-2

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 44: JONES STREET DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | 4 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days; |
| | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| Surface Water | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | Temperature, Specific, Conductance, pH | 2 | N/A | N/A | N/A | N/A |
| Sediment | TCL VOAs | 4 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 3 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| Soil | TCL VOAs | 20 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 20 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 20 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

TABLE 10-3

MONITORING WELL INSTALLATION AND SAMPLING DETAILS
SITE 44: JONES STREET DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|---|---|---|---|---|
| 44MW01, 44MW02, 44MW03 | 25 | 25(1) | 17 | 10 | TCL Organics TCL Inorganics, Cyanide | 0.0 - 2.0 | Split spoon | TCL Organics TCL Inorganics, Cyanide |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(2) | Split spoon | TCL Organics TCL Inorganics, Cyanide |

(1) Wells will be screened from approximately 7 feet below to 3 feet above water table.
(2) Sample to be taken directly above water table.

**TABLE 10-4**

**SUBSURFACE SOIL SAMPLING DETAILS**
**SITE 44: JONES STREET DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Soil Boring Number | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|
| 44SB01, 44SB02, 44SB03, 44SB04, 44SB05, 44SB06 | 0.0 - 2.0 | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |

(1) Sample to be taken directly above water table.

### 10.4.3 Surface Water Sampling

Surface water samples will be collected from two locations on the site. The two locations are planned for Edwards Creek along the perimiter of the site. These locations, as shown on Figure 10-2, will provide an estimation of the lateral distribution of contamination that could be moving off site via the surface waters. The laboratory analysis program for surface water is summarized in Table 10-5.

All three surface water samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 10.4.4 Sediment Sampling

Two sediment samples will be collected at the same locations as the surface water samples. The laboratory analysis program is summarized in Table 10-5. Both sediment samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

## 10.5 SURVEYING OPERATIONS

The locations of all soil borings and monitoring wells will be surveyed following their installation. A total of six soil borings (44SB01-44SB06), two surface water/sediment sample locations, and three monitoring wells (44MW01-44MW03) will be surveyed. All sample locations are shown in Figure 10-2.

TABLE 10-5

SURFACE WATER/SEDIMENT SAMPLING DETAILS
SITE 44: JONES STREET DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Surface Water | 44SW01<br>44SW02 | TCL Organics<br>TCL Inorganics, Cyanide |
| Sediment | 44SD01<br>44SD0244SD0<br>3<br>44SD04<br>44SD05 | TCL Organics<br>TCL Inorganics, Cyanide |

# 11.0 SITE 65: ENGINEER AREA DUMP FIELD INVESTIGATION ACTIVITIES

## 11.1 SITE DESCRIPTION

The Engineer Area Dump is located at PWDM coordinates 17, K16 and is 4 to 5 acres in size. Two separate disposal areas were identified; a battery acid disposal area and a liquids disposal area. The types of liquids involved are believed to be petroleum, oil, and lubricant products. In addition, the dump was used to burn construction debris. The dump was in operation from before 1958 through 1972. A general site map is presented in Figure 11-1.

## 11.2 WORK PLAN RATIONALE

Two disposal areas have been identified from the available site information and the site visit. The proposed scope of work is designed to make a preliminary determination of the presence or absence of environmental contamination at the site. Complete analytical schemes are proposed to provide detailed information on the types of contamination present. Figure 11-2 provides approximate drilling and sampling locations. Final sample locations will be determined in the field by the project hydrogegologist. The hydrogeologist will locate samples in suspected areas of contaminants to maximize detection of target analytes, if present. Wells will be installed so that two are located downgradient and one upgradient. This will maximize detection of groundwater contamination, if present.

## 11.3 DRILLING OPERATIONS

A surface geophysical survey will be performed at all the suggested drilling locations to more readily locate the proposed soil borings in areas that are least likely to contain buried metallic objects. The survey will consist of using an electromagmetometer (Heliflux), which can locate metallic objects, such as buried drums, near the ground surface. The drilling operations for Site 65 are discussed below.

### 11.3.1 Soil Boring Installation

A total of five 15-foot soil borings will be installed at Site 65. The borings are located to provide coverage in areas without monitoring wells. These preliminary locations are shown on Figure 11-2.

Two samples will be collected from each of the borings for chemical analysis. The first sample will be taken at the ground surface (0.0 to 2.0 feet). The second sample will be taken directly above the groundwater interface (approximately 15 feet). None of the five soil borings at this site will be converted to monitoring wells. All of the borings will be backfilled with a cement/bentonite grout following sampling. Additional drilling procedures are presented in Section 13.3.3. Soil borings shall be numbered 65SB01 through 65SB03, as shown on Figure 11-2. Split-spoon sampling intervals for the borings are given in Section 11.4.2.

### 11.3.2 Monitoring Well Installation

A total of three 25-foot monitoring wells will be installed at Site 65. Two wells will be located on the downgradient side of the site and the third well will be located on the upgradient side of the site. These preliminary locations are shown in Figure 11-2. Two split-spoon soil samples will be taken during installation of the well borings for chemical analysis. Sample depths will be the same as for the soil borings. Additional monitoring well construction/installation procedures are presented in Section 13.3.4. Monitoring wells shall be numbered 65MW01 through 65MW03, as shown on Figure 11-2. One round of samples will be collected from the new wells for chemical analysis, as

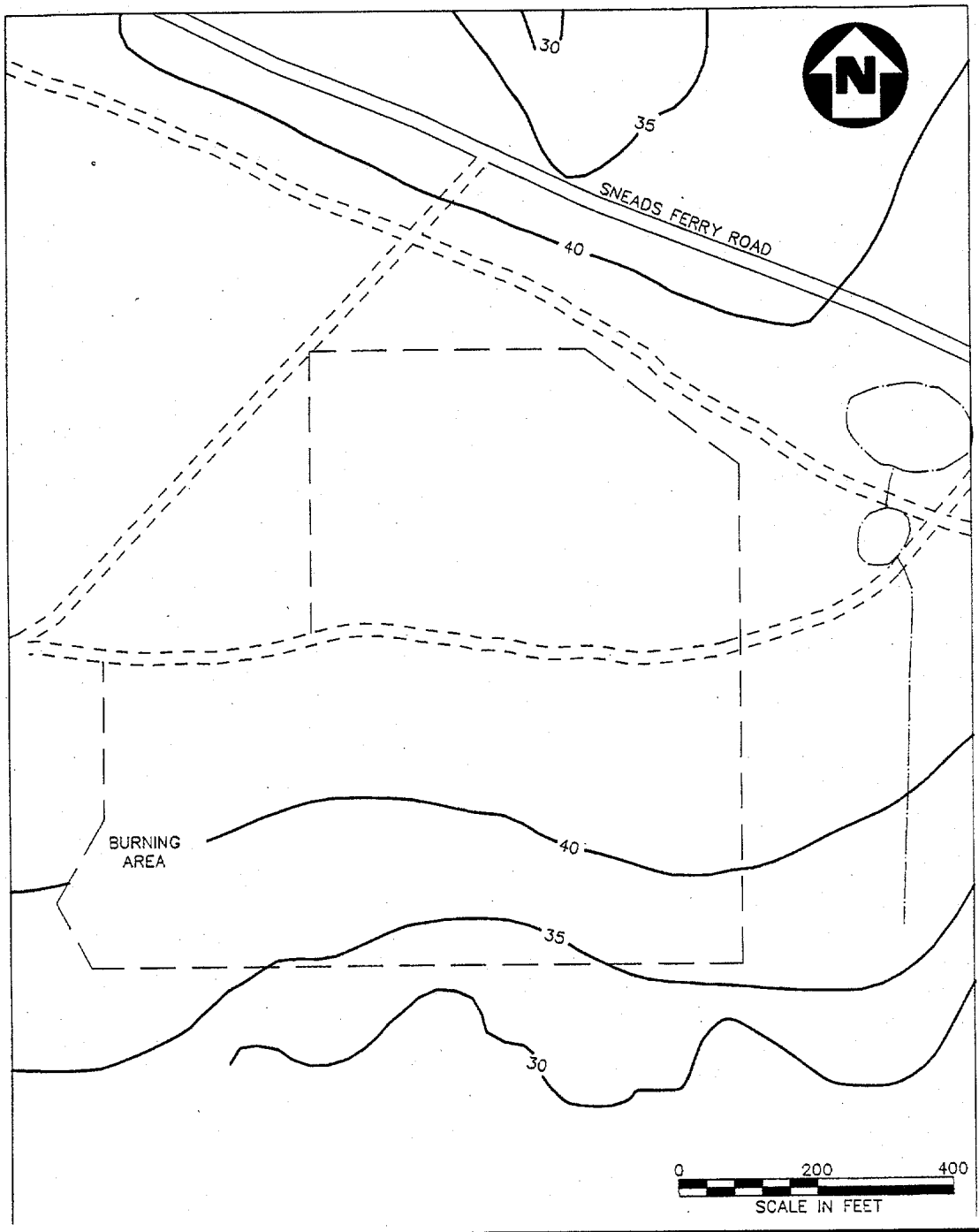


**FIGURE 11-1**
**SITE 65: ENGINEER AREA DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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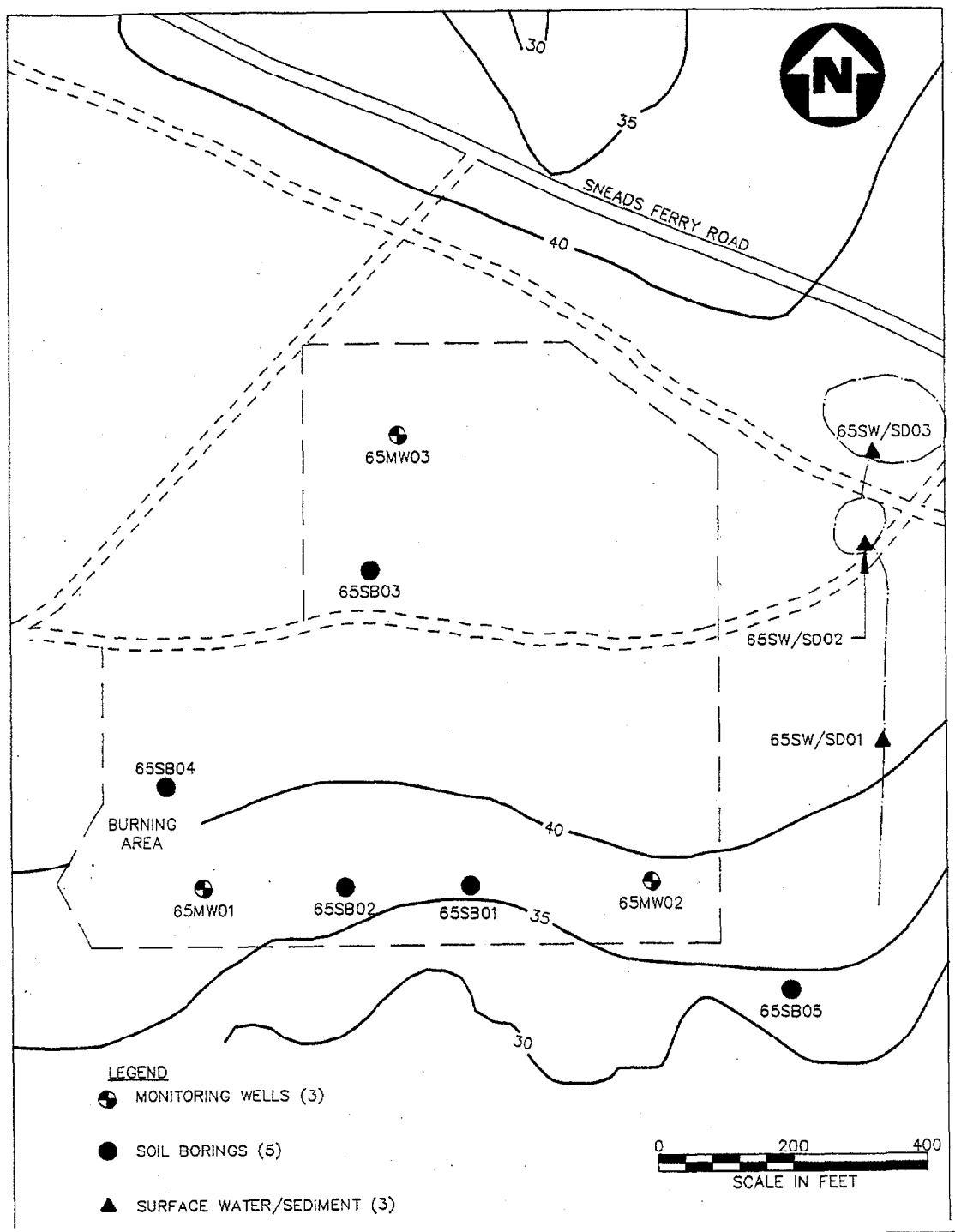


**FIGURE 11-2**
**LOCATION SAMPLES**
**SITE 65: ENGINEER AREA DUMP**
**CAMP LEJEUNE MILITARY RESERVATION**

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described in Section 11.4.1. Well development will be performed on each new well, as described in Section 13.3.5. One round of synoptic water-level measurements will be obtained from all wells (65MW01-65MW03) within a 4-hour period, as described in Section 13.3.7. A summary of the monitoring well installation activities for Site 65 is given below:

- Install three shallow monitoring wells (65MW01-65MW03).
- Obtain synoptic water-level measurements from all new wells within a 4-hour period.

## 11.4 MEDIA SAMPLING OPERATIONS

The following media will be sampled at Site 65:

- Groundwater
- Subsurface soil
- Surface water
- Sediment

The sample identification system used for the media is presented in Section 13.2.1. Sample handling, packaging and shipping, and documentation are discussed in Sections 13.2.2, 13.2.3, and 13.2.4, respectively. With respect to the quality of data needed to support these investigation activities, a Data Quality Objective (DQO) Level C will be used for all samples. Protocols for DQO Level C are described in Volume II, Section 9.0, of this document. Table 11-1 provides a sampling and analysis program summary for Site 11. Table 11-2 provides a summary of analyses, bottle requirements, preservation requirements, and holding times for this site. Following is a detailed discussion of the sampling by media for this site. Following is a detailed discussion of the sampling by media at this site.

### 11.4.1 Groundwater Sampling

One round of groundwater samples will be taken from the three newly installed wells (65MW01, 65MW02, and 65MW03). Groundwater sampling locations are shown in Figure 11-2. The laboratory analysis of groundwater samples is summarized in Table 11-3. All of the monitoring wells will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 11.4.2 Subsurface Soil Sampling

Details of split-spoon sampling and laboratory analyses are summarized in Table 11-4 for the five soil borings drilled at Site 65. Soil sampling locations are shown in Figures 11-2. Overburden drilling procedures and subsurface sampling guidelines are given in Section 13.3.3.

As shown in Table 11-4, laboratory analyses will be conducted on two subsurface soil samples per boring and two subsurface soil samples per well. Samples for chemical analysis will be taken at the ground surface and directly above the groundwater interface. Soil samples will also be taken at 5-foot intervals from the ground surface to the bottom of each hole. All samples will be used for lithologic description to better define the geologic conditions at the site. The soil boring samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

TABLE 11-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SITE 65: ENGINEERING AREA DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |

**TABLE 11-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 65: ENGINEERING AREA DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE TWO**

| Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|
| Surface Water (Continued) | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 16 | 1 | 1 | 0 | 1 |
| | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 16 | 1 | 1 | 0 | 0 |
| | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 16 | 1 | 1 | 0 | 0 |

**TABLE 11-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**SITE 65: ENGINEERING AREA DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE THREE**

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

TABLE 11-2

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
SITE 65: ENGINEERING AREA DUMP
CAMP LEJEUNE, NORTH CAROLINA

| Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|
| Groundwater | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 2 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days; CN - 14 days |
| | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 6 months; Hg - 28 days |
| | Temperature, Specific Conductance, pH | 3 | /A | N/A | N/A | N/A |
| Surface Water | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottles | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | Temperature, Specific Conductance, pH | 3 | NA | NA | NA | NA |
| Sediment | TCL VOAs | 3 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 3 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 3 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| Soil | TCL VOAs | 19 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | TCL BNA, Pesticides/PCBs | 18 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | TCL Metals and Cyanide | 18 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

**TABLE 11-3**

**MONITORING WELL INSTALLATION AND SAMPLING DETAILS**
**SITE 65: ENGINEERING AREA DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Monitoring Well Number | Total Boring Depth (feet) | Well Depth (feet) | Riser Length (feet) | Screen Length (feet) | Groundwater Analysis (per well) | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|---|---|---|---|---|
| 65MW01, 65MW02, 65MW03 | 25 | 25(1) | 17 | 10 | TCL Organics TCL Inorganics, Cyanide | 0.0 - 2.0 | Split spoon | TCL Organics TCL Inorganics, Cyanide |
| | | | | | | 5.0 - 7.0 | Split spoon | None |
| | | | | | | 10.0 - 12.0 | Split spoon | None |
| | | | | | | 15.0 - 17.0(2) | Split spoon | TCL Organics TCL Inorganics, Cyanide |

(1) Wells will be screened from approximately 7 feet below to 3 feet above water table.
(2) Sample to be taken directly above water table.

**TABLE 11-4**

**SUBSURFACE SOIL SAMPLING DETAILS**
**SITE 65: ENGINEERING AREA DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Soil Boring Number | Sampling Interval (feet) | Sample Type | Analysis (per well) |
|---|---|---|---|
| 65SB01, 65SB02, 65SB03, 65SB04, 65SB05 | 0.0 - 2.0 | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |
| | 5.0 - 7.0 | Split spoon | None |
| | 10.0 - 12.0 | Split spoon | None |
| | 15.0 - 17.0(1) | Split spoon | TCL Organics<br>TCL Inorganics, Cyanide |

(1) Sample to be taken directly above water table.

### 11.4.3 Surface Water Sampling

Surface water samples will be collected from a total of three locations on the site. One location is planned for the inlet to each of two ponds along the perimiter of the site. The remaining sample is located in the drainage ditch that runs along the perimiter and feed the two ponds. These locations, as shown on Figure 11-2, will provide an estimation of the lateral distribution of contamination that could be moving off site via the surface waters. The laboratory analysis program for surface water is summarized in Table 11-5.

All three surface water samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

### 11.4.4 Sediment Sampling

Three sediment samples will be collected at the same locations as the surface water samples. The laboratory analysis program is summarized in Table 11-5. All three sediment samples will be analyzed for the following parameters:

- TCL organics
- TCL inorganics, cyanide

## 11.5 SURVEYING OPERATIONS

The locations of all soil borings, monitoring wells, and surface water/sediment sample locations will be surveyed following their installation. A total of five soil borings (65SB01-65SB05), three monitoring wells (65MW01-65MW03), and three surface water/sediment sample locations (65SW/SD01-65SW/SD03) will be surveyed. All of the sample locations are shown in Figure 11-2.

**TABLE 11-5**

**SURFACE WATER/SEDIMENT SAMPLING DETAILS**
**SITE 65: ENGINEER AREA DUMP**
**CAMP LEJEUNE, NORTH CAROLINA**

| Sample Medium | Sample Location Number | Analysis (per location) |
|---|---|---|
| Surface Water | 65SW01<br>65SW02<br>65SW03 | TCL Organics<br>TCL Inorganics, Cyanide |
| Sediment | 65SD01<br>65SD02<br>65SD03 | TCL Organics<br>TCL Inorganics, Cyanide |

# 12.0 BACKGROUND SAMPLING

Three soil samples are proposed to provide an estimation of the background concentrations of metals in soils at the base. The samples will be collected from three different locations and will be analyzed for TCL inorganics (no cyanide) only. No organic analyses are required for the background samples because it is assumed that no organic chemicals are naturally occurring (with the exception of polynuclear aromatics in certain environments, such as bogs or coal deposits). These samples will provide a baseline to which the concentrations of metals at the various waste sites can be compared so that only metals that are truly present at elevated concentrations are examined in the risk assessment.

The locations of these samples have not been selected at this time, but the preferred locations will be in undeveloped areas of the base away from roads (because of the potential atmospheric deposition of lead) or from known or potential hazardous waste sites. Locations will be determined in the field by the geologist.

Samples will be numbered BS-1, BS-2 and BS-3 and will be collected by hand, as stated in Section 13.4.1. In addition to the three samples, one duplicate field sample will also be taken at one of the three background sample locations for QA/QC purposes.

When the field operations have been completed, background soil sample locations will be surveyed by a licensed surveyor and plotted on an existing base map.

# 13.0 SAMPLING PROCEDURES AND FIELD INVESTIGATION OPERATIONS

This section defines and discusses the sampling operations and procedures, including proper documentation, for the proposed field activities. The following items are discussed in this section:

- Documentation of procedures for preparation of reagents or supplies which become an integral part of the sample (e.g., filters, and adsorbing reagents).
- Procedures and forms for recording the exact location and specific considerations associated with sample acquisition.
- Documentation of specific sample preservation methods.
- Calibration documentation of field devices.
- Documentation of collection of replicate samples.
- Submission of field-biased blanks, where appropriate.
- Documentation of potential interferences at the facility.
- Selection and documentation of construction materials and techniques, associated with monitoring wells, piezometers, and drive points.
- Specification of appropriate field equipment.
- Specification of appropriate sampling order.
- Selection of appropriate sample containers.
- Specification of sample preservation.
- Documentation of chain-of-custody, including:
  - Standardized field tracking reporting forms to establish sample custody in the field prior to shipment.
  - Pre-prepared sample labels containing all information necessary for effective sample tracking.

## 13.1 FIELD INVESTIGATION ACTIVITIES

This field investigation will consist of the following tasks:

- Mobilization/demobilization.
- Drilling operations for soil borings and monitoring wells, and monitoring well installation.
- Subsurface and near-surface soil sampling.
- Groundwater sampling.
- Surface water and sediment sampling.
- Plane table surveying.
- Collection of static water level measurements from monitoring wells.

## 13.2 GENERAL FIELD GUIDELINES

This section describes the field procedures and quality assurance/quality control (QA/QC) methodologies which will be employed by NUS personnel and subcontractors during the field activities. The EPA Region IV Standard Operating Procedures and Quality Assurance Manual (EPA, April 1986) and the NUS Standard Operating Procedures (NUS, 1989) are used as references for field procedures. The NUS Standard Operating Procedures have been approved by EPA for use under the ARCS Programs and are commonly referenced in this plan because of the similarity to the EPA Region IV protocols. Any inconsistencies between NUS and Region IV protocols have been documented. NUS field personnel are well trained in the use of the NUS procedures; therefore, procedures are anticipated to be consistently implemented during all phases of work by NUS personnel.

### 13.2.1 Sample Identification System

Each sample collected from the various sites 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 soil samples or in the case of monitoring well groundwater samples). A fifth segment will be added to denote quality assurance samples, when appropriate. Any other pertinent information regarding sample identification will be recorded in the field logbooks.

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

**Character type**

- A = Alpha
- N = Numeric

**Site Number**

- The assigned Site number

**Medium**

- GW = Groundwater from monitoring well
- SB = Subsurface soil sample from soil boring
- SO = Soil sample from surface or hand auger
- SW = Surface Water
- SD = Sediment

**Station Location**

Sample locations of a given medium will be numbered sequentially beginning with "01" for all media except for monitoring wells. Numbers for new monitoring wells will follow sequentially from the highest number designated for the existing wells.

**Sample Identifier**

- For soil samples: Interval depth, in feet, of top of sample.
- For groundwater samples, floating product samples: Sample round.
- For surface water and sediment samples: This segment will be omitted.

**QA Sample Designation**

- D = Field Duplicate
- F = Field Blank
- R = Rinsate Blank
- T = Trip Blank

For example, a groundwater sample collected during Round 2 from Monitoring Well 7GW01 at Site 7 would be designated as:

07-GW-01-02

A subsurface soil sample collected from Soil Boring 65SB03 at Site 65 from 1 to 1.5 feet below the ground surface would be designated as:

65-SB-03-01.0

A duplicate sample from this soil sample would be:

65-SB-03-01.0-D

### 13.2.2 Sample Handling and QA/QC Samples

Sample handling includes the field-related considerations connected with the selection of sample containers, preservatives, allowable holding times, and the analyses requested. The EPA Region IV Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, Appendix A, addresses the topics of containers and sample preservation. Table 3-1 in the Quality Assurance Project Plan provides a unit-specific summary of all sample handling considerations. The planned field QA/QC samples for all sites (3, 7, 43, 44, 54, 63, 65, 80,and 82) are specified in the laboratory analyses tables for each site in their respective sections and in Table 3-1 in the Quality Assurance Project Plan. Definitions of the four types of QA/QC samples are given below.

- **Field Duplicate** - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). The number of field duplicates to be collected is shown in Table 3-1 in the Quality Assurance Project Plan. These samples will be collected at a rate of approximately 1 sample per every 10 samples per medium.

- **Rinsate Blanks** - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. The number of rinsate blanks to be collected is shown in Table 3-1 in the Quality Assurance Project Plan. These samples will be collected at a rate of approximately 1/day/medium.

- **Field Blanks** - Samples consisting of (1) the source water used in decontamination and (2) steam cleaning for a total of two (2) volumes per sample frequency. The number of field blanks to be collected is shown in Table 3-1 in the Quality Assurance Project Plan. These samples will be collected at the rate of approximately 1/event/media.

- **Trip Blanks** - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds.

### 13.2.3 Sample Packaging and Shipping

Samples will be packaged and shipped in accordance with Appendix C of the the EPA (Region IV) Standard Operating Procedures and Quality Assurance Manual. This document is located in Appendix A. 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(ces), and concentration(s) of samples shipped.
- Method of shipment (e.g., overnight, 2-day).
- Date of shipment.
- Suspected hazards associated with the samples or site.

### 13.2.4 Documentation

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 he/she secured it 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 NUS personnel. The chain-of-custody (COC) also serves as a sample logging mechanism for the laboratory. Section 5.3 of NUS SOP SA-6.1 (see Appendix A) provides a description of the COC procedures that will be followed.

The following is a discussion of the documentation necessary for tracking samples from collection to receipt of the analytical data.

**Sample Labels**

One label will be filled out for each sample container sent for 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 NUS SOP SA-6.1 Section 5.2 (see Appendix A).

**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 onsite or offsite. Procedures for using this form are contained in SOP SA-6.1 (see Appendix A). At the completion of field activities the Chain-of-Custody Record Form will be placed in the project file.

**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 with an accompanying Chain-of-Custody Record Form. Procedures for using Chain-of-Custody seals are described in SOP SA-6.1 (see Appendix A).

**Sample Logsheet and Logbook**

A sample logsheet will be filled out for each sample. A sample logsheet is a notebook (3-ring binder) page that is used to record specified types of data pertaining to the samples. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems encountered during sampling. Data such as container source and description, sample description type, and disposition, as well as time, date and sample method are recorded on this form. The sample logbook is a 3-ring binder which contains sample logsheets for each sample collected. 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.

**Equipment Calibration Log Form**

Each NUS field instrument requiring calibration will have a separate equipment calibration log form 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 following field instruments:

- HNU or OVA
- pH meter
- Specific Conductivity meter
- Electronic water level indicator

These forms will be maintained in a 3-ring notebook. At the completion of field activities the notebook containing the equipment calibration log forms will be placed in the project file.

### 13.2.5 Field Changes

Changes in project procedures may be necessary as a result of altered field conditions or unanticipated events. A summary of the sequence of events associated with field changes is as follows:

- The Field Operations Leader (FOL) notifies the NUS Project Manager (PM) of the need for the change.

- If necessary, the NUS PM will discuss the change with the pertinent individuals (e.g., NUS Senior Technical Advisors, NUS Contracting Officer, Remedial Project Manager, and Camp Lejeune Project Coordinator) and will provide a verbal approval or denial to the FOL for the proposed change.

- The FOL will document the change on a Task Modification Request Form and forward the form to the NUS PM immediately.

- The NUS PM will sign the form and distribute copies to the NUS Contracting Officer, NUS Quality Assurance Officer, Remedial Project Manager, Camp Lejeune Project Coordinator, the NUS FOL, and the Project File.

- A copy of the completed Task Modification Request Form will also be attached to the field copy of the affected document (i.e., Site Work Plan).

### 13.2.6 Onsite Project Administration

All onsite project administration activities are the responsibility of the NUS FOL. NUS field personnel will assist the FOL, as needed, in the day-to-day execution of these activities which include the following:

- Track, review, and approve (as needed) subcontractor submittals and payment requests.
- Maintain daily activities record forms.
- Maintain site logbook, field notebooks, and other field records.

Descriptions of the above activities are provided in the following sections.

**Subcontractor Submittals**

The NUS Project Manager or designee shall be responsible for tracking, reviewing, and approving subcontractor submittals such as requests for payment, boring logs, and well construction forms.

**Daily Activities Record Form**

The daily activities record is designed for tracking the schedule and budget and progress reporting. This record documents the pay items involved with the daily activities and progress for each Subcontractor. These sheets summarize the work performed and form the basis of payment to the subcontractors. Thus, this information is used to check the subcontractor request for payment.

Each field team leader who is supervising a subcontractor activity must complete a Daily Activities Record Form. The subcontractor's signature is required at the end of each working day to verify work accomplished and the various pay items (e.g., hours worked, standby time, and material used).

**Site Logbook**

A site logbook will be maintained by the NUS FOL and/or designee. This book will serve to record all major on site activities during the site investigation. The logbook is a bound notebook with consecutively number pages that cannot be removed. It will contain a summary of the day's activities and will reference the other controlled documents (field notebooks, sampling logsheets, chain-of-custody form numbers, calibration logsheets, etc.) when applicable.

The site logbook is initiated at the start of the first onsite activity (e.g., initial reconnaissance survey). Entries are made for every day that onsite activities take place.

The NUS site logbook is issued by the PM (or designee) to the FOL for the duration of the project. It is the responsibility of the FOL to keep the site logbook current throughout the project.

The cover of the site logbook contains the following information:

- Project Name and MCB, Camp Lejeune Work Assignment Number
- NUS Project Number
- Field Operation Leader'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 Administrative Officer'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.

The sample logsheet for each sample collected 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.

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, initialed, and dated. At the completion of entries by any individual, the logbook must be signed. It must also be signed by the FOL at the end of each day. Figure 13-1 provides an example of a typical site logbook entry.

**Field Notebook**

A bound, weatherproof field notebook (daily diary) will be maintained by each NUS representative as designated by the NUS FOL. The field notebook will serve to record the daily activities during the facility investigation. At a minimum, the following NUS field personnel will be responsible for maintaining a personal field notebook (daily diary):

- Field Operations Leader
- Health and Safety Site Officer
- Sampling Leader
- Site Geologist

These NUS representatives shall record daily the appropriate information related to field activities. All entries shall be made in black ink. This information may include, but, not be limited to the following:

- Front cover of field notebook will contain:
  - Project name and MCB, Camp Lejeune Point assignment number.
  - NUS project number.
  - "Field Notebook" descriptor and sequential book number.

- First page will contain:
  - Name of person(s) responsible for maintaining the book, including start and end date.
  - Address and phone number of NUS Pittsburgh office for each person.
  - Table of contents referencing page numbers relevant to daily entries

SITE NAME: _____

START TIME: _____ DATE: _____

FIELD OPERATIONS LEADER: _____

| NUS | CONTRACTOR | NAVY/EPA |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

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

ACTIVITIES:

1. _____ calibrated HNu Number N-1640. See Notebook No. 3, page 10, and Calibration Log, page 2 for details.

2. Asbestos removal activities at building _____ resumes. _____ observed removal activities. See Notebook No. 1, page 29-20, for details. Sample No. 123-21-S4 collected; see Logbook No. 1, page 31. Removal activities completed at 11:50. See Notebook No. 1, page 31.

3. Tanker truck PF-123 steam-cleaned at decontamination pit. Then set up at tank _____ for _____ waste removal. Activities observed by _____. See Notebook No. 2, page 39 for details.

4. Navy project manager arrives on site at 14:25 hours.

5. Large dump truck 129-FA arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up at building _____. Begin filling truck with scrap metal. _____ observed removal activities. See Notebook No. 1, page 32 for details.

6. Express carrier picked up samples (see Logbook No. 2, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel offsite, gate locked.

_____ _____

FIELD OPERATIONS LEADER OR DESIGNEE DATE

FIGURE 13-1
TYPICAL SITE LOGBOOK ENTRY
CAMP LEJEUNE MILITARY RESERVATION

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- Daily chronological synopsis of observations, activities, and accomplishments concerning the project, including work performed by the subcontractors and names of people involved, level of Health and Safety, etc.

- Sampling activities, including time, location, identification number, sampler's name, reference to sample logsheet, etc.

- Sample pickup (chain-of-custody form numbers, sample numbers, carrier, airbill numbers, time).

- Unusual events, nonconformances, problems, etc., should be described in detail.

- Equipment calibration information including time, equipment type and serial numbers, reference to calibration logsheet, and name of person performing calibration.

- Description of photographs including direction of view, roll number, photo number, special lenses, etc. This can be placed in a separate section of the book (i.e., reserve the last 10 to 20 pages for all photographs).

- Arrival/departure of equipment.

- Signature of unspecified person(s) making entries (at the end of each entry) and signature at the bottom of each page of person responsible for maintaining the notebook. Each field notebook is initiated at the start of the first onsite activity of the person responsible for maintaining it.

Entries are made for every day that onsite activities take place which involve the person responsible for maintaining the book, as assigned or as designated by the NUS PM. 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. Any blank page or blank portions of pages shall also be crossed out, initialed, and dated. It is the responsibility of this person (or designee) to keep the field notebook current while in his possession, and return it to the FOL or to relinquish it to another NUS representative, who signs and dates the inside cover, thus assuming responsibility of it.

**NUS Sampling Documentation**

Sampling documentation will include, but not be limited to the following:

- Chain-of-custody form
- Sample logsheets and logbook
- Equipment calibration logsheet

At the completion of field activities, the FOL shall submit to the NUS Project Manager all field records, data, field notebooks, logbooks, chain-of-custody receipts, sample log sheets, drilling logs, daily logs, etc. The NUS Project Manager shall ensure that these materials are entered into the document control system in accordance with appropriate administrative guidelines.

## 13.3 GENERAL FIELD OPERATIONS

### 13.3.1 Mobilization/Demobilization

Following approval of the Work Plan and this Sampling and Analysis, NUS will prepare drilling specifications, obtain a drilling subcontractor, and begin mobilization activities. All field team members will review the Work Plan, Sampling & Analysis Plan, and the Health and Safety Plan (HASP).

In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

Equipment mobilization may include, but will not be limited to, the mobilization and set-up of the following equipment:

- Sampling equipment.
- Hydrogeologic monitoring equipment.
- Health, safety, and decontamination equipment.
- Subcontractor equipment.
- Survey equipment.

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

The subcontractor who is awarded the contract to perform the drilling will begin to mobilize equipment immediately after receiving notice to proceed. The subcontractor will be responsible for mobilizing and demobilizing the necessary equipment in order to perform the work outlined in the bid specifications. The subcontractor specification(s) will be prepared following acceptance of the Final Work Plan by the MCB and EPA.

### 13.3.2 Drilling Operations

The proposed locations for soil borings and monitoring wells as discussed in Sections 3 through 11, were selected based on the suspected source areas, the overall expected groundwater flow pattern for the area and the data requirements need for the site investigation.

### 13.3.3 Overburden Drilling Procedures

Drilling operations for overburden soil borings will be conducted using any combination of drilling methods needed to drill through the sediments, with the only restriction being that potable water is the only fluid allowed if one is required. The preferred method of drilling is the hollow-stem auger method. The borings shall be advanced in accordance with the drilling specifications developed for this project.

For borings which penetrate the saturated portion of the water table aquifer, the depth of the water table will be measured and/or confirmed by the field geologist prior to termination of the borehole drilling. Drill cuttings shall be containerized in a marked 55-gallon drum and left on site adjacent to the new well or boring. The analytical results from soil and water samples will be obtained and the drum contents evaluated. If contaminants are found to be nonhazardous, the contents will be placed on site. If the analysis reveals significant contaminant levels, the drum contents will be disposed of in accordance with Federal and state regulations.

During drilling operations of overburden material, standard penetration tests and split-spoon sampling shall be performed. These sampling procedures shall be performed in accordance with ASTM D1586-84 (Section 7, see Appendix A) for each soil boring. In addition to any samples sent for laboratory analysis, all split-spoon soil samples will be analyzed for lithologic description in the field. Field descriptions will be in accordance with NUS SOP GH-1.5: Sections 5.2, 5.4, and 5.5 (see Appendix A).

Each soil sample collected for lithologic description will be placed in an 8-ounce jar (to be provided by the drilling subcontractor), labeled, and the pertinent data recorded (i.e., project, boring and sample

numbers, depth, blow counts, and date) by the field geologist. The driller shall prepare a separate written boring log for each boring drilled, to be submitted to the field geologist at the conclusion of the field activities.

A complete log of each well boring will be maintained by NUS in accordance with NUS SOP GH-1.5, Section 5.5. Appendix A contains an example of the boring log description form. At a minimum the boring log will contain the following information, when applicable, for each overburden well boring:

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

In addition, depths of changes in lithology, sample moisture observations, depth to water, OVA/HNU readings (if taken), drilling methods, and total depth of each borehole should be included on each log, as well as any other pertinent observations. Sample bottles containing soil samples collected solely for lithologic description from each monitoring well boring will be consecutively numbered starting with S-1. In addition, the following information shall be recorded on the lid of these sample jars:

- Job name and number
- Well number and sample number
- Date
- Depth of sample
- Blow counts

### 13.3.4 Monitoring Well Construction/Installation

Overburden wells will be constructed of 2-inch-diameter, flush-joint-threaded, Schedule 40 PVC casing and well screens equipped with a PVC end plug. Each section of casing and screen shall be NSF approved. Figure 13-2 illustrates typical well construction details for overburden wells. The slot size will be no larger than 0.02 inches.

The PVC well installation procedure will consist of backfilling the boring (if required) with sand to the desired depth for the bottom of the well screen. The PVC pipe and screen will be placed at the desired depth in the completed boring and the annulus of the boring, around the well screen, and 1 to 2 feet above the well screen will be backfilled with clean silica sand (Nos. 20 and 30 U.S. Standard Sieve size or as determined by the site geologist). A bentonite pellet seal (minimum 2-foot thickness) will then be installed and allowed to hydrate as per the manufacturer's recommendation; the remainder of the annulus of the boring (from the seal to ground surface) will then be backfilled with cement/bentonite grout placed using a tremie pipe. The depths of all backfill materials will be constantly monitored during the well installation process by means of a weighted stainless steel or plastic tape. A sample of the PVC used in well installation will be sent to L. Boucher. This sample will be archived throughout the course of the project.

A 4-inch-diameter protective steel casing equipped with a locking steel cap will be installed around all wells. These casings will be grouted a minimum of 3 feet into the ground and will have at least one drain hole positioned approximately 0.5 feet above the ground surface. In addition a concrete apron measuring 5 feet by 5 feet by 0.5 feet will be constructed equally portioned around the casing of each well. For wells in high traffic areas, four marker posts (4-inch nominal diameter, 7-foot-long steel pipe filled with cement) will be embedded in each concrete apron. The marker posts will be positioned equidistant from one another and near the corners of the concrete apron. All locks

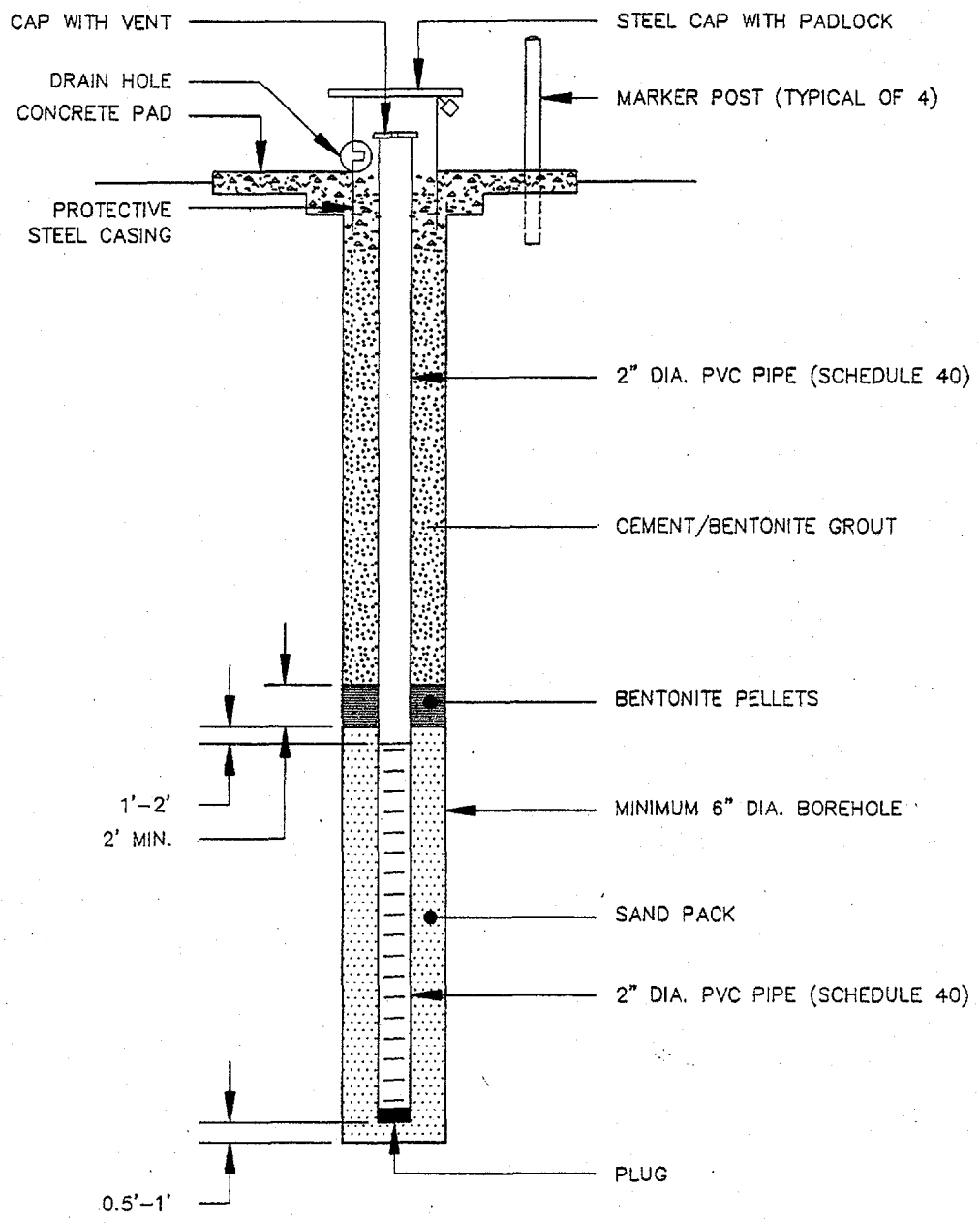


**FIGURE 13-2**
**TYPICAL OVERBURDEN MONITORING WELL CONSTRUCTION DETAILS**
**CAMP LEJEUNE MILITARY RESERVATION**

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supplied for the wells will be keyed alike. After installation, the ground surface, the top of the riser pipe, and the top of the protective casing will be surveyed to within 0.01-foot vertical accuracy. In addition, the well will be surveyed to a 0.1-foot horizontal accuracy.

A monitoring well construction diagram will be completed for each well installed. A sample of the monitoring well construction form is provided in Appendix A.

### 13.3.5 Justification for the Use of PVC Well Construction Materials

PVC has been successfully used for well construction at numerous Superfund sites, as well as for RCRA investigations. Literature is available to support is use with a variety of contaminants.

Based on known site history and prior sampling results, the majority of the sites at Camp Lejeune are thought to contain primarily volatile organic chemicals. However, there is one site that is expected to contain primarily PAHs, and another site that is a pesticide/herbicide site. However, most of the sites will be analyzed for a full spectrum of organic and inorganic contaminants on the Target Compound List.

PVC is considered to be the best compromise if both organic and inorganic pollutants are to be determined in groundwater collected from the same well (USATHAMA, January 1990). Teflon is more absorbent than PVC, and stainless steel oxidizes in the presence of water forming ferric hydroxides that can adsorb a variety of inorganics.

The major problems reported in the literature regarding the use of PVC have focused on the use of adhesives and sorption/desorption of organic chemicals in contact with the well material. No adhesives will be used in the construction process; only threaded PVC is proposed. Adhesives may contain a variety of ketones (4-methyl-2-pentanone (MIBK), 2-butanone (MEK), and cyclohexanone) and tetrahydrofuran (THF). These chemicals can mask certain Target Compound List chemicals. For example, MEK coelutes with 1,2-dichloroethane, THF coelutes with 1,1-dichloroethane, and cyclohexanone coelutes with bromoform. High concentrations of extraneous volatile organic chemicals can be found if new PVC bailers are used or if a well is not properly purged prior to sampling (Sosebee et.al., January 1982).

Purging of wells prior to sampling is essential to the collection of representative groundwater samples. Standard protocol calls for purging of at least three well volumes and continuing until pH, conductivity, and temperature are stabilized. These parameters are measured in the field and are recorded on sample log sheets. Samples are collected from all wells within 24 hours of purging. With this residence time of water in the wells, the literature reports no statistical differences are reported between wells constructed of PVC, teflon, and 316 stainless steel (Sykes et. al., 1986). This study used several volatile organics (monocyclic aromatics and halogenated aliphatics) at concentrations ranging from 87 to 150 µg/L, and measured the concentrations at the end of 1 hour, 24 hours, and 7 days, focusing on sorption of the spiked chemicals.

Additional support for the use of PVC comes from ARCO. Pieces of PVC screen were placed in three different pure gasolines for 6.5 months (Schmidt, 1987). At the end of that time, electron microscopy was used to evaluate the changes in slot size. No changes were observed between the control (in water) and the three samples placed in gasoline.

It is known that some compounds in pure or highly concentrated form affect the quality of PVC pipe (Watersaver). For example, more than 10 percent weight loss is reported within 1 to 28 days for PVC immersed in 100 percent methanol, JP-4, and kerosene, while significant deterioration is reported with pure toluene, trichloroethene, phenol, and benzene and concentrated sulfuric acid. No concentrations of this magnitude are expected at any site at Camp Lejeune. If pure product is found, well construction methods would be altered.

In addition to all the above points, PVC is more cost-effective and has been successfully applied by the Navy's contractor at Superfund sites in Regions I, II, and III; at RCRA sites in Regions I, II, III, and IV; and at military sites throughout the United States under the Air Force IRP program.

### 13.3.6 Well Development

Monitoring wells will be developed after installation to remove fines and sediments from around the well screens and to remove drill cuttings and residual drilling fluids from the area around the monitored interval of the boring. Wells will be developed by air lift, bailing and surging, or by pumping, as determined by the field geologist. Wells will be developed until water removed is visibly clear of suspended solids or until approved by the field geologist. The regular pH and specific conductance measurements will be collected for the purged water. Wells will be developed until these readings become stable and when the purged water is visibly clear, as described above. All development water and purge water will be containerized on site in labeled 55-gallon drums. The analytical results from soil and water samples collected from the site will be obtained and the drum contents will be placed on site. If samples are found to be nonhazardous, the contents will be placed on site. If the analysis reveals significant contaminant levels, the drum contents will be disposed in accordance with Federal and state regulations.

### 13.3.7 Water-Level Measurements

Synoptic water-level measurements will be taken from all existing and newly installed monitoring wells at all sites. To minimize the potential influence of tides on the water levels, synoptic water-level measurements within a site will be taken as quickly as possible (within a 4-hour period). To minimize potential tidal effects, wells closest to the Atlantic Coast, the New River or its tributaries will be measured first, and wells located furthest inland will be measured last. The exact sampling sequence will be determined in the field by the site geologist.

Measurements will be taken with an M-scope (electrical water-level indicator), pressure transducer, steel tape and chalk, or popper, using 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 log book.

### 13.3.8 Reporting

The following reports and documentation will be the responsibility of the field geologist during the drilling activities. A copy of applicable forms that will be used by the site geologist are located in Appendix A for the following:

- Soil Boring Description Log
- Overburden Monitoring Well Construction Sheet
- Data Sheet for Slug Test

The field geologist's logbook shall contain information about the drilling activities such as start/finish times, standby times, and problems or changes encountered during drilling. Drilling/ monitoring well construction information (e.g., footage drilled, depth of casing, etc.) will be recorded daily on the boring log and the overburden monitoring well sheet. The boring log, along with the geologist's logbook, will be used to prepare the Daily Activities Record Form. This report will identify drilling activity and quantities of material used on a daily basis, and shall be signed by the drilling contractor foreman (or equivalent) and the site geologist. The reports shall be submitted to the NUS Project Manager at the completion of each well installation. These reports will also be used to fill out the Site Logbook.

## 13.4 GENERAL SAMPLING OPERATIONS

### 13.4.1 Soil Samples Collected Using Hand Equipment

From Site 80, some soil samples for laboratory chemical analysis will be collected from just below the surface. A total of three soil samples will be collected for chemical analysis using hand equipment as described in Section 7.3.2. Stainless steel equipment such as spoons, hand augers, shovels, or scoops shall be used to collect soil samples. The equipment shall be properly decontaminated (see Section 13.6 for decontamination procedures) prior to usage.

If sampling occurs where a vegetative cover has been established, the turf shall be removed and set aside during the sampling operations. The turf shall be replaced after sampling is completed. When the soil sample is obtained, it shall be deposited into a glass or stainless steel bowl for mixing prior to filling the sample containers. Samples obtained for volatile organic analyses shall be taken immediately upon opening of the sampler and shall not be mixed in any manner. Mixing of the soil sample for chemical analysis shall be performed using a stainless steel spoon in the glass or stainless steel mixing bowl. The soil will be homogeneously mixed and then placed into the respective containers for packaging and shipment to the laboratory for chemical analysis. If this material is not a major constituent of the soil, large gravel- or cobble-size material which displays no visible porosity (e.g., quartz or feldspar) or evidence of contaminant staining of the rock surface, will be selectively discarded from the sample.

Prior to sampling surface soils, leaves, grass, and surface debris should be removed from the area to be sampled using a clean stainless steel spoon or shovel. Surface soil samples shall then be collected using a precleaned, stainless steel scoop, trowel, or spoon. Shallow soil samples shall be collected by digging a hole or trench with a stainless steel shovel, then removing all of the loose soil and collecting a sample at the desired depth using a stainless steel spoon, trowel, or scoop. Soil samples will be preserved in accordance with NUS SOP SF-1.2, Section 5 (see Appendix A). Preservation requirements can be found in Table 3-1 of the Quality Assurance Project Plan.

### 13.4.2 Groundwater Sampling

One round of groundwater samples will be collected from new and existing wells. Groundwater samples will be collected in accordance with NUS SOP SA-1.1, Section 5 (Appendix A).

Prior to obtaining samples, the static water level and well depth will be measured and the wells will be purged using a dedicated stainless steel bailer or a suction pump. Three to five well volumes will be purged. If the wells are purged dry with less than three well volumes removed, the water level in the well will be allowed to recover at least 70 percent, then a sample will be collected. In the event that recovery is slow, samples will be collected the following day.

Field measurements shall be taken on the groundwater as it is purged and prior to sampling. These field measurements include:

- pH
- Specific conductance
- Temperature
- Turbudity

Stabilization criteria for field measurements are as follows:

- pH ± .5
- Specific conductance ± 10 percent
- Temperature ± 1°C
- Turbidity NTU 5

In addition, color shall be noted on the sample log form for each water sample obtained and for each purged well volume. Procedures for obtaining these field measurements will be in accordance with NUS SOP SF-1.1 (Sections 5.1, 5.2, and 5.3, respectively). Unfiltered samples will be obtained for metals analysis (see Table 3-1 of the Quality Assurance Project Plan).

Dedicated stainless steel bailers will be used for sample collection. The sample will be poured directly from the bailer into the appropriate sample bottles for analysis.

Groundwater samples will be preserved in accordance with NUS SOP SF-1.2, Section 5 (see Appendix A). Preservation requirements are listed in Table 3-1 of the Quality Assurance Project Plan.

All pertinent field data shall be recorded using a Groundwater Sample Log Sheet and the field log book.

### 13.4.3 Surface Water and Sediment Sampling

Surface and sediment samples will be collected from various locations. Field Technicians will adhere to NUS SOP SA-1.2 for all surface water and sediment sampling activities. As stated in the SOP, surface water samples will be collected from areas of low current velocity and low turbulance to preclude stripping of volatile organics.

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

- pH
- Specific conductance
- Temperature

Color and turbidity shall also be noted on the sample log form for each surface water sample. Procedures for obtaining these field measurements will be in accordance with NUS SOP SF-1.1 (Sections 5.1, 5.2, and 5.3, respectively).

Surface water and sediment samples will be preserved in accordance with NUS SOP SF-1.2, Section 5 (see Appendix A). Preservation requirements are listed in Table 3-1 in the Quality Assurance Project Plan.

All pertinent field data shall be recorded using Sample Log Sheets (example forms are presented in Appendix A) and the field log book.

## 13.5 SAMPLE ANALYSIS

Samples collected at the sites will be submitted for laboratory analyses. Table 3-1 in the Quality Assurance Project Plan summarizes the analyses, bottle requirements, preservation requirements, and holding times for each sample. Groundwater and surface water samples will be unfiltered. This may result in conservatively biased analytical results.

## 13.6 DECONTAMINATION

The equipment involved in field sampling activities will be decontaminated prior to and during drilling and sampling activities. Such equipment includes drilling rigs, downhole tools, augers, pumps, well casing and screens, soil and water sampling equipment, and water level measurement devices.

### 13.6.1 Major Equipment

All drilling equipment, including the drill rig and its transport system, shall be steam cleaned prior to beginning work, between the drilling of separate boreholes, any time the drilling rig leaves the facility or unit prior to completing a boring, and at the conclusion of the drilling program.

Decontamination operations will consist of washing equipment using a high-pressure steam wash. All decontamination activities will take place over an onsite area to be designated during mobilization. Additional requirements for drilling equipment decontamination can be found in NUS SOP GH-1.6, Section 5 (Appendix A). Isopropanol will be used instead of acetone or methanol to comply with EPA Region IV requirements. Deionized water is acceptable to use in decontamination since the procedure calls for air drying.

### 13.6.2 Sampling Equipment

All sampling equipment used for collecting samples will be decontaminated both prior to sampling in the field and between samples. Decontamination procedures will be in accordance with NUS SOP SF-2.3, Section 5 (see Appendix A). In general, the following decontamination steps will be taken:

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

Field analytical equipment such as instrument probes will be rinsed first with distilled/deionized water then with sample.

### 13.6.3 Personnel

Personnel decontamination is discussed in the Health and Safety Plan.

# (FINAL)
# QUALITY ASSURANCE PROJECT PLAN
# FOR SITE INSPECTIONS
# AT
# SITES 3, 7, 43, 44, 54, 63, 65, 80, AND 82

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# 1.0 PROJECT BACKGROUND

This Data Collection Quality Assurance Plan provides guidance for the Site Inspection activities at the Department of the Navy, Atlantic Division for the Camp Lejeune Military Reservation (CLEJ).

This section provides a brief review of the facility history and description, as well as the scope of work for the Site Inspections.

## 1.1 FACILITY LOCATION

Camp Lejeune Military Reservation (CLEJ) is located in Onslow County, North Carolina (Figure 1-1). The facility currently covers approximately 170 square miles and is bisected by the New River. The Atlantic Ocean forms the southeastern boundary of the base. The western and northeastern boundaries are U.S. 17 and State Road 24, respectively.

There are five major areas of development at Camp Lejeune: Camp Geiger, Montford Point, Courthouse Bay, the Rifle Range area, and Marine Corps Air Station (MCAS) New River. MCAS New River is a helicopter base and is a separate command on the west side of the New River. Helicopter Outlying Landing Field (HOLF) Oak Grove, approximately 25 miles to the north, and Outlying Landing Field (OLF) Camp Davis, 10 miles to the southwest are also under the command of MCAS New River. HOLF Oak Grove is no longer active and is under caretaker status.

Within 15 miles of Camp Lejeune are three large, publicly owned tracts of land: Croatan National Forest, Hofmann Forest, and Camp Davis Forest. In addition to the forested areas, the low elevations of the coastal plain have created vast acreage of inland and coastal wetlands.

## 1.2 SITE HISTORY

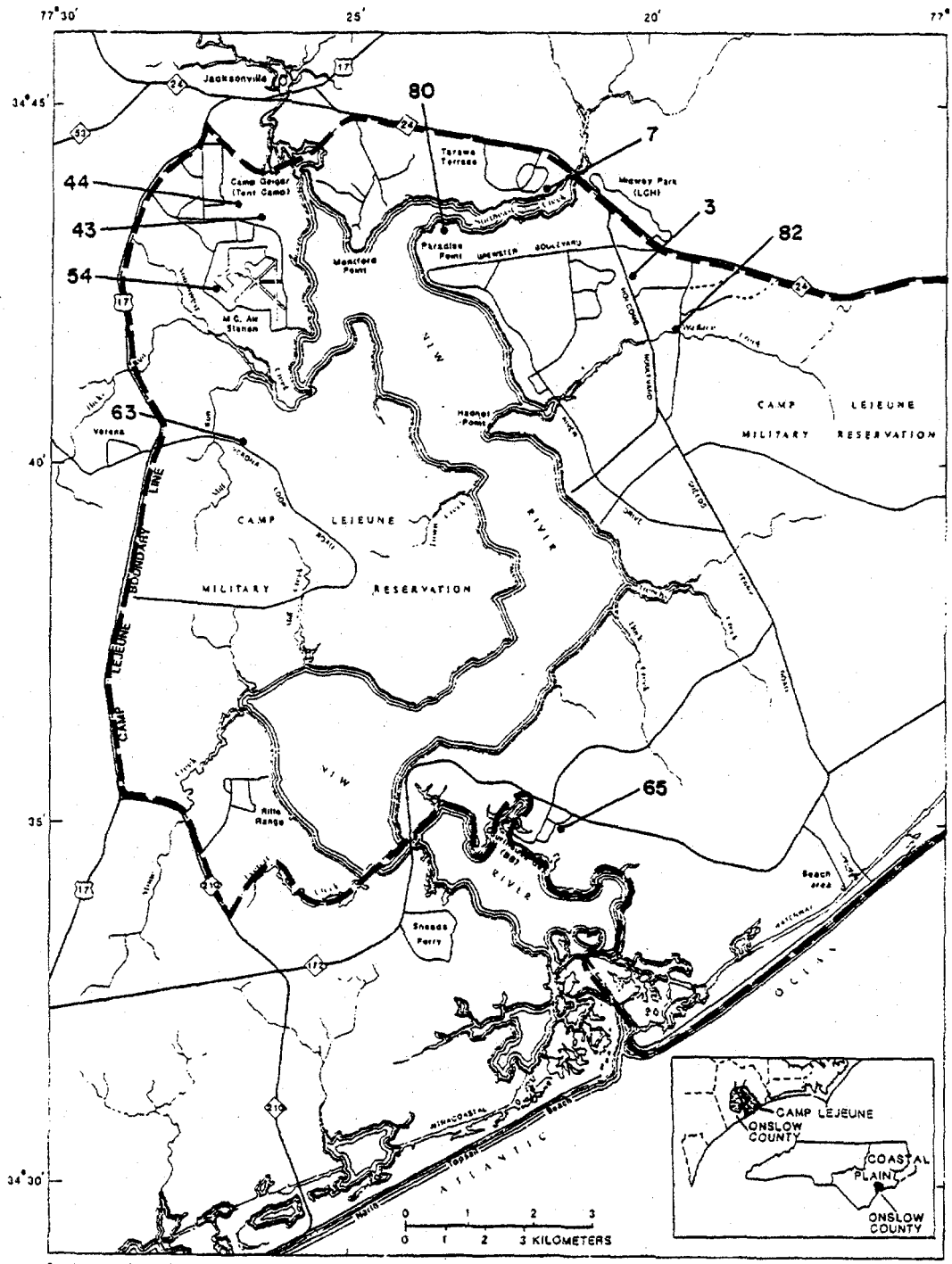
Construction of MCB Camp Lejeune began in 1941 at Hadnot Point where functions were centered. During construction, 9 million board feet of timber were harvested from the reservation. From 1944 to 1954, a sawmill was operated by base personnel.

During World War II, and the Korean and Vietnam conflicts, Camp Lejeune was used as a training area to prepare Marines for combat. The base serves as the home base for the Second Marine Division, and Fleet Marine Force (FMF) units have also been stationed as tenant commands. Construction in the Montford Point, Camp Geiger, and Courthouse Bay areas was completed by 1945. Montford Point, originally developed for training of troops is now used for Marine Corps Service Support Schools. Courthouse Bay hosts amphibious training, while Paradise Point is the site of housing for commissioned personnel. Noncommissioned personnel housing is provided at such locations as Tarawa Terrace I and II and Midway Park.

The U.S. Naval Hospital opened in 1943 and has served military personnel during World War II and the Korean War. In addition, the hospital provides medical services for all assigned military personnel and their dependents.

MCAS New River was set up as a separate command in 1951. At that time it was called Peterfield Point, but the name was changed to New River in 1968. In 1942 three new runways were added and the station came under the jurisdiction of MCAS Cherry Point. During this time PBJ Squadron was based here and the facility was also used for glider training. During the Korean Conflict, it was used as a helicopter training base and for touch-and-go training for jet fighters.

In 1968, Maine Corps Outlying Landing Field (MCOLF) Oak Grove was placed under the jurisdiction of MCAS New River. The field was used as a helicopter base and renamed HOLF Oak Grove. During




Base taken from Defense Mapping Agency Hydrographic Center, Camp Lejeune Special Map, 1:50,000

**FIGURE 1-1**
**LOCATION MAP**
**CAMP LEJEUNE MILITARY RESERVATION**
**IAS site numbers are identified above with approximate locations.**

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World War II, the field was under the command of MCAS Cherry Point. At the end of the war, all structures were destroyed with the exception of the runways.

## 1.3 SCOPE OF WORK

The objectives and scope of work for the Site Inspections are presented in detail in the Work Plan (NUS, 1990).The nine sites covered in this project are listed below:

- IAS Site 7 - Tarawa Terrace Dump
- IAS Site 63 - Verona Loop Dump
- IAS Site 54 - Crash Crew Burn Pit
- New Site 82 - Piney Green Road VOC Area
- New Site 80 - Paradise Point Golf Course
- IAS Site 3 - Old Creosote Plant
- IAS Site 43 - Agan Street Dump
- IAS Site 44 - Jones Street Dump
- IAS Site 65 - Engineer Area Dump

The Site Inspections follow the Installation Restoration Program (IRP) format for Camp Lejeune Military Reservation. The nine sites listed above include six Initial Assessment Study (IAS) sites which were previously recommended for no further action, one site that is being investigated to obtain additional data to perform a risk assessment, and two recently identified sites.

The project is part of the ongoing Installation Restoration Program at CLEJ. The first program objective was to collect and evaluate historical evidence indicating existence of pollutants that may have contaminated the installation or that pose an imminent health hazard on or off the facility. The IAS (Water and Air Research, Inc., March 1983), which is essentially equivalent to a Preliminary Assessment conducted by the EPA under the Superfund Program, accomplished this goal by identifying 76 suspect sites.

The first objective for each of the sites is to determine whether the site requires a Remedial Investigation/Feasibility Study (RI/FS) or if no further action is required.

The second objective of the program is to determine via sampling and analysis activities, whether specific toxic and hazardous materials identified in the IAS, and possibly other contaminants, exist in concentrations considered to be hazardous. This Work Plan fulfills this part of the objective for the nine sites identified above.

The work activities proposed in this document are based upon the available history of the site, current data on the site, and discussions in the scoping meeting of September 27 and 28, 1990. The plan focuses on sampling and analytical efforts that will provide data to define present and future risks to human health and the environment as well as to evaluate potential remedial alternatives.

# 2.0 PROJECT ORGANIZATION AND MANAGEMENT

This section provides a brief description of site access, project organization, and an overview of the schedule of the proposed field activities.

## 2.1 SITE CONTROL

The 9 sites designated for investigation are all located within the Camp Lejeune Military Reservation. No NUS or subcontractor personnel will enter the site without signing in at the base gate.

All hand tools and light equipment will be returned to the command post and secured at the end of of each work day. Any equipment (e.g., drilling rig) left on site will be secured to the extent possible to prevent unauthorized removal or vandalism. Any unfinished wells will be covered or capped in such a manner as to prevent tampering. Finished wells will be locked.

## 2.2 PROJECT ORGANIZATION

The overall project organization and responsibilities of key management personnel are also discussed in Section 13.0 of the Work Plan. The organizational chart is presented here as Figure 2-1.

Field work will be performed by a single team under the direction of the FOL. As shown in Figure 2-1, the FOL reports directly to the Project Manager. The FOL will be responsible for coordinating the overseeing of all field activities and will interface with the Health and Safety Officer (HSSO) in planning and performing the SI tasks.In accordance with the Health and Safety Plan, the HSSO or his designee will interact with the field team members during performance of their tasks. The specific responsibilities of the FOL and the HSSO are discussed below.

- Field Operations Leader (FOL) - The FOL is responsible for all day-to-day aspects of the RFI field work. The responsibilities of the FOL include

  - Assuring that all field team members are familiar with the project Work Plan.

  - Assuring that all field team members have completed health and safety training.

  - Coordinating the activities of all field teams.

  - Reporting to the Project Manager on a regular basis regarding the status of all field work and any problems encountered.

  - Completing Task Modification Requests, as necessary, for approval by the Project Manager.

  - Providing field team members with daily assignments.

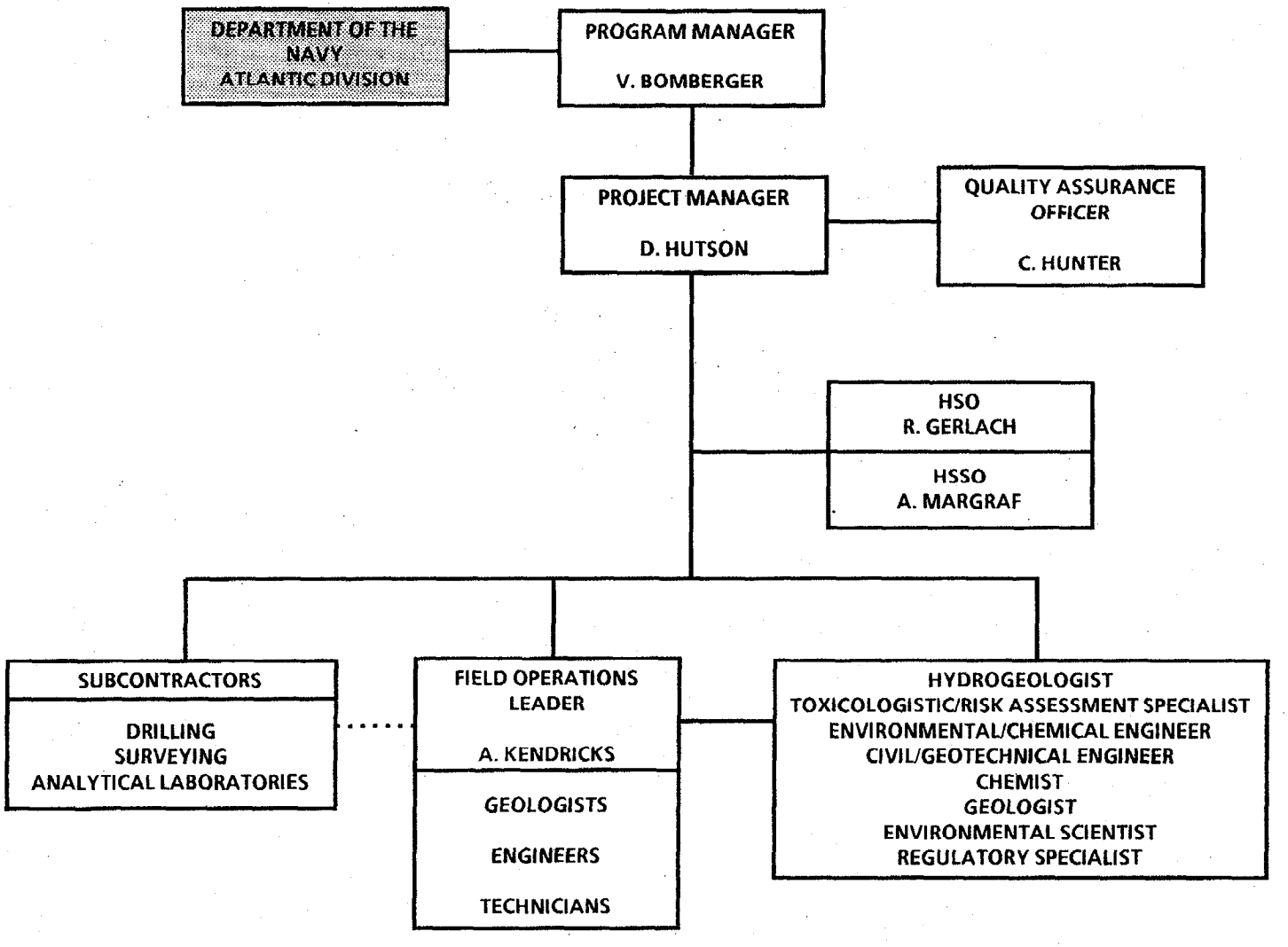
  - Assuring that field team members comply with the procedures outlined in the Work Plan.

  - Coordinating field activities to ensure sample shipping schedules are met.

- Health and Safety Site Officer (HSSO) - The HSSO reports to the NUS Manager of Health and Safety and indirectly to the FOL and Project Manager. Details of the HSSO's responsibilities are presented in the HASP and include:

FIGURE 2-1

PROJECT ORGANIZATION
CAMP LEJEUNE
SITE INSPECTIONS



- Controlling specific health and safety related field operations such as personnel decontamination, monitoring of worker heat or cold stress, distribution of safety equipment, etc.

- Assuring that field team personnel comply with all procedures established by the HASP.

- Identifying assistant HSSOs or HSSO designees.

- Terminating work if an imminent safety hazard, emergency situation, or other potentially dangerous situation is encountered.

# 3.0 QUALITY ASSURANCE OBJECTIVES

The Work Plan for the sites at Camp Lejeune contains a summary of available site information, defines the objectives, and identifies the types and amount of data necessary to perform the Site Inspections.

In order to meet these objectives, additional site data are required. The data collection and quality assurance requirements described in this document are intended to provide data that are adequate in both number and quality to support completion of the Site Inspections.

The overall Site Inspection objective is to determine via sampling and analysis activities, whether specific toxic and hazardous materials identified in the IAS, and possibly other contaminants, exist in concentrations considered to be hazardous. The specific objectives by site are summarized below:

- Site 54 - Obtain data required to perform a risks assessment and determine if the contaminants present pose a risk to human health or the environment.

- Sites 3, 7, 43, 44, and 63 - To obtain data required to perform a risk assessment and verify previous NFA decisions documented in the IAS (1983) Report, and that the sites do not pose a risk to human health or the environment.

- Sites 65, 80, 82 - To obtain data required to perform a risk assessment and determine whether these sites pose a risk to human health or the environment.

## 3.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the Site Inspection activities. In order to develop site-specific DQOs, the intended use of the data must be defined. This use must be balanced between data quality needs and time as well as cost constraints.

Specific analytical protocols are selected to meet the DQOs in the following ways:

- Compare Applicable or Relevant and Appropriate Requirements (ARARs), risk-based criteria, and data needs for risk assessment or engineering purposes to the detection limits for available analytical methods.

- Select analytical methods to allow quantification of the analytes at levels sufficiently below the ARARs to minimize the number of critical data points.

- Evaluate the maximum allowable variability in the data based on the ARARs comparison.

- Develop site-specific acceptable variability based on the intended data use and method-specific precision and accuracy information.

Table 3-1 presents a summary of the proposed sampling and analysis program for the sites at Camp Lejeune. The information in this table was developed to meet the Site Inspection objectives.

## 3.2 PRECISION, ACCURACY, REPRESENTATIVENESS, COMPLETENESS, AND COMPARABILITY (PARCC) GOALS

The quality of a data set is measured by certain characteristics of the data, namely the PARCC parameters. Some of the parameters are expressed quantitatively, while others are expressed qualitatively. The objectives of the Site Inspection and the intended use of the data define the PARCC goals.

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
CAMP LEJEUNE

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 7: Tarawa Terrace Dump | Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 0 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 0 | 0 |
| | | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 1 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 1 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 16 | 2 | 1 | 1 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE TWO**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 63: Verona Loop Dump | Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 1 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 1 | 0 |
| | | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 2 | 1 | 0 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 1 | 0 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE THREE**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 63: Verona Loop Dump (Continued) | Surface Water (Continued) | Temperature | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 0 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 1 | 0 | 0 | 0 |
| | Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 0 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 18 | 2 | 1 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE FOUR**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 54: Crash Crew Burn Pit | Groundwater | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 1 | 0 |
| | | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 1 | 0 |
| | | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 3 | 0 | 0 | 0 | 0 |
| | | BTEX | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 1 |
| | | Hexavalent Chromium | 10 µg/L | EPA 218.4 | 3 | 1 | 1 | 1 | 0 |
| | | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Surface Water | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 1 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 1 | 0 | 0 |
| | | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 5 | 0 | 0 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE FIVE**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 54: Crash Crew Burn Pit (Continued) | Surface Water (Continued) | BTEX | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 1 |
| | | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 0 |
| | | Hexavalent Chromium | 10 µg/L | EPA 218.4 | 5 | 1 | 1 | 0 | 0 |
| | | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | Sediment | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 1 | 0 | 0 |
| | | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 0 |
| | | Total Petroleum Hydrocarbons | 0.5 mg/kg | EPA 418.1 | 5 | 0 | 0 | 0 | 0 |
| | | BTEX | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 0 | 0 |
| | | Hexavalent Chromium | 10 µg/kg | EPA 218.4 | 5 | 1 | 1 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE SIX**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 54: Crash Crew Burn Pit (Continued) | Soil | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 6 | 1 | 1 | 0 | 0 |
| | | TCL PCBs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| | | Total Petroleum Hydrocarbons | 1 mg/kg | EPA 418.1 | 6 | 1 | 0 | 0 | 0 |
| | | BTEX | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 1 |
| | | Hexavalent Chromium | 100 µg/kg | EPA 218.4 | 6 | 1 | 1 | 0 | 0 |
| Site 82: Piney Green Road | Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 1 | 1 |
| | | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 1 | 1 | 0 |
| | | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE SEVEN**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 82: Piney Green Road (Continued) | Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| | | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| | | Temperature | NA | Field | 6 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 6 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 6 | 0 | 0 | 0 | 0 |
| | Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 1 |
| | | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 6 | 1 | 1 | 0 | 0 |
| | Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 1 |
| | | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 1 | 0 | 0 |
| Site 80: Paradise Point Golf Course | Groundwater | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 3 | 1 | 0 | 0 | 0 |
| | | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | | Chlorinated Herbicides | As per method | SW 8150 | 3 | 1 | 1 | 1 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE EIGHT**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 80: Paradise Point Golf Course (Continued) | Groundwater (Continued) | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Surface Water | Total Petroleum Hydrocarbons | 0.5 mg/L | EPA 418.1 | 5 | 1 | 0 | 0 | 0 |
| | | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 1 |
| | | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | | Chlorinated Herbicides | As per method | SW 8150 | 5 | 1 | 1 | 0 | 0 |
| | | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | Sediment | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | | Total Petroleum Hydrocarbons | 1 mg/kg | EPA 418.1 | 5 | 1 | 0 | 0 | 0 |
| | | Chlorinated Herbicides | As per method | SW 8150/3550 | 5 | 1 | 1 | 0 | 0 |
| | | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 1 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE NINE**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 80: Paradise Point Golf Course (Continued) | Soil | TCL Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 17 | 2 | 0 | 0 | 0 |
| | | Total Petroleum Hydrocarbons | 1 mg/kg | EPA 418.1 | 17 | 2 | 0 | 0 | 0 |
| | | Chlorinated Herbicides | As per method | SW 8150/3550 | 17 | 2 | 1 | 0 | 0 |
| | | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 17 | 2 | 0 | 0 | 1 |
| Site 3: Old Creosote Plant | Groundwater | TCL BNAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 1 | 0 | 0 |
| | Sediment | TCL BNAs | CRDL | CLP Statement of Work - 2/88 | 2 | 1 | 1 | 1 | 0 |
| | Soil | TCL BNAs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 1 | 1 | 0 |
| Site 43: Agan Street Dump | Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 0 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 0 | 0 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 0 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 0 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE TEN**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 43: Agan Street Dump (Continued) | Groundwater (Continued) | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 0 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 0 | 0 | 0 |
| | | Temperature | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 5 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 5 | 0 | 0 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE ELEVEN**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 43: Agan Street Dump (Continued) | Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 5 | 1 | 0 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 5 | 1 | 0 | 0 | 0 |
| | Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 0 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 16 | 2 | 0 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 16 | 2 | 0 | 0 | 0 |
| Site 44: Jones Street Dump | Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 1 |
| | | TCL Extractables | CRDL | CLP Statement of Work - 2/88 | 3 | 1 | 1 | 1 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 1 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 1 | 1 | 1 | 0 |
| | | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE TWELVE**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 44: Jones Street Dump (Continued) | Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 1 | 0 | 0 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 1 | 0 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 2 | 0 | 1 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 0 | 1 | 0 | 0 |
| | | Temperature | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 2 | 0 | 0 | 0 | 0 |
| | Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 0 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 2 | 0 | 0 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 2 | 0 | 0 | 0 | 0 |
| | Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 0 | 0 | 0 |
| | | TCL Extractables | CRDL | CLP Statement of Work - 2/88 | 18 | 2 | 0 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 18 | 2 | 0 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE THIRTEEN**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 65: Engineer Area Dump | Groundwater | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Surface Water | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | | TCL Metals | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | | Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |

TABLE 3-1
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE FOURTEEN**

| Site Name | Matrix | Analysis | Target Detection Limit | Proposed Analytical Method | Number of Samples | Field Duplicates (A) | Equipment Rinsate(B) | Field Blanks (C) | Trip Blanks (D) |
|---|---|---|---|---|---|---|---|---|---|
| Site 65: Engineer Area Dump (Continued) | Surface Water (Continued) | Temperature | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | Specific Conductance | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | | pH | NA | Field | 3 | 0 | 0 | 0 | 0 |
| | Sediment | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 3 | 0 | 0 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 3 | 0 | 0 | 0 | 0 |
| | Soil | TCL VOAs | CRDL | CLP Statement of Work - 2/88 | 16 | 1 | 1 | 0 | 1 |
| | | TCL BNA, Pesticides/PCBs | CRDL | CLP Statement of Work - 2/88 | 16 | 1 | 1 | 0 | 0 |
| | | TCL Metals and Cyanide | CRDL | CLP Statement of Work - 7/88 | 16 | 1 | 1 | 0 | 0 |

**TABLE 3-1**
**SUMMARY OF SAMPLING AND ANALYSIS PROGRAM**
**CAMP LEJEUNE**
**PAGE FIFTEEN**

(A) Field Duplicate - A single sample split into two portions, each of which is submitted blindly to the laboratory. Assesses the overall precision of sampling and analysis program (also known as a Replicate Sample). Will be collected at a rate of 1/10 samples media.

(B) Rinsate Blanks - Samples generated from the sampling equipment in use. Equipment is tested for carryover contamination before use and between subsequent uses by collecting a rinsate sample. Will be collected at a rate of 1/day/media, but will be analyzed every other day.

(C) Field Blanks - Samples consisting of the source water used in (1) decontamination and (2) steam cleaning, for a total two (2) samples. Will be generated at the rate of 1/event/media.

(D) Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

NA Not Applicable.
CLP Contract Laboratory Program.
CRDL Control Required Detection Limit.
EPA Methods for chemical analysis of water and wastes, EPA-600/4-79-020.
SW Test methods for evaluation of solid wastes, physical/chemical methods, 3rd Edition.

### 3.2.1 Precision and Accuracy

Precision and accuracy characterize 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:

$$\text{Range} = \text{OR} - \text{DR}$$

$$\text{and} \qquad \text{RPD} = \frac{\text{OR} - \text{DR}}{1/2\,(\text{OR} + \text{DR})} \text{ X } 100\%$$

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 quality assurance check.

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:

$$\%\text{R} = \frac{\text{E}}{\text{T}} \text{ X } 100\%$$

where:

E = experimental result
T = true value or theoretical result

$$\text{with} \qquad \text{Theoretical result} = \frac{(\text{Sample aliq.})(\text{Sample conc.}) + (\text{Spike aliq.})(\text{Spike conc.})}{\text{Sample aliquot}}$$

Control limits for accuracy are set at the mean plus or minus three times the standard deviation of a series of %R values. Organic %R values are set at the mean plus or minus two times the standard deviation.

Field and laboratory precision and accuracy performance can affect the attainment of project objectives, particularly when compliance with established criteria is based on laboratory analysis of environmental samples. Such criteria are used in risk assessment and screening of remedial alternatives. Given the uncertainties associated with field work and laboratory activity, the following overall precision and accuracy goals are identified to meet the project objectives:

- Precision: ± 50 percent RPD
- Accuracy: ± 50 percent recovery

Analytical precision and accuracy will be evaluated upon receipt of the laboratory data. Analytical precision will be measured as the relative standard deviation of the data from the laboratory (internal) duplicates. Analytical accuracy measures the bias as the percent recovery from matrix spike and surrogate spike samples. CLP requirements will be used for the TCL compounds.

Field sampling precision and accuracy are not easily measured. Field contamination, sample preservation, and sample handling will affect precision and accuracy. By following the appropriate NUS Standard Operating Procedures (SOPs, see Appendix A), precision and accuracy errors associated with field activities can be minimized. Field duplicates and blanks (field, equipment, and rinsate) will be used to estimate field sampling and accuracy.

No project resources will be expended to develop precision and accuracy data for method (field or analytical) validation except those commonly applied for collection of routine QA/QC data. Routine QA/QC data will include analyses from field duplicates and equipment rinsate blanks based on the existing guidance that specifies the type and proportion of samples submitted for QA/QC (NEESA, June 1988).

Validity of data (i.e., 95 percent confidence limit) with respect to its intended use will be assessed based on laboratory-supplied QA/QC data and protocols routinely employed for validation of CLP results. In general, results that are rejected by the validation process will be disqualified from application to the intended use. Qualified data will be used to the greatest extent practicable.

### 3.2.2 Representativeness

Representativeness describes the degree to which analytical data accurately and precisely define the material being measured. Several elements of the sampling and sample handling process must be controlled to maximize the representativeness of the analytical data. Sample collection, preservation, and storage are discussed in the Sampling and Analysis Plan and also summarized in Sections 4.0 and 5.0 of this document. The Work Plan contains details on the site sampling program and the rationale for sampling locations. The sampling program is designed to ensure that the data obtained during the Site Inspections accurately represent the site conditions.

Representativeness of data is also affected by sampling techniques. Sampling techniques are described in Section 13.0 of the Sampling and Analysis Plan. To ensure that the data are representative, NUS' Standard Operating Procedures will be used.

To ensure that sample aliquots to be analyzed are representative, samples will be homogenized in the laboratory by removing non-representative materials (e.g., sticks and stones), then stirring, shaking, crushing, and/or blending the sample as appropriate to the matrix.

### 3.2.3 Completeness

Completeness describes the amount of data generated that meets the objectives for precision, accuracy, and representativeness versus the amount of data expected to be obtained. For relatively clean, homogeneous matrices, 100 percent completeness is expected. However, as matrix complexity and heterogenicity increase, completeness may decrease. Where analysis is precluded or where data quality objectives are compromised, effects on the overall investigation must be considered. Whether or not 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.

The sampling and analysis program for the site is sufficiently broad in scope to prevent a single data point or parameter from sacrificing attainment of the Site Inspection objectives. Each medium is critical to the site assessment. Consequently, there exists some critical data requirement below which the objectives of the study will be compromised.

Critical data points may not be evaluated until all the analytical results are evaluated. Additionally, several sampling points, in aggregate, may be considered to be critical either by location (e.g., downgradient monitoring wells) or by analysis (e.g., lead). If in the evaluation of laboratory results it becomes apparent that the data for a specific medium are of insufficient quality, either with respect

to the number of samples or an individual analysis, resampling of the deficient data points will be necessary.

### 3.2.4 Comparability

One of the objectives of the Data Collection Quality Assurance Plan is to provide analytical data of comparable quality both between sample locations and with data from previous investigations. Both analytical procedures (i.e., CLP) and sample collection techniques (as defined in NUS SOPs) will maximize the comparability of the Site Investigation data within this investigation and to any previous investigations. Additionally, to enhance comparability between samples, consideration will be given to seasonal conditions, stream flow, or other environmental conditions that could influence the analytical results.

# 4.0 FIELD INVESTIGATION ACTIVITIES

The field investigation activities for the sites at Camp Lejeune are explained in detail in the Sampling and Analysis Plan.

Table 4-1 summarizes the selection of sample containers, preservatives, allowable holding times, and the analyses required for the samples being collected at Camp Lejeune. The EPA User's Guide to the Contract Laboratory Program (EPA, December 1988), NEESA's Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Program (NEESA, June 1988), and the Federal Register (EPA, October 26, 1984) were used as guidance for identifying the sample containers, preservatives, and allowable holding times for the various analyses requested for the sites at Camp Lejeune.

TABLE 4-1

SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA

| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 7: Tarawa Terrace Dump | Groundwater | TCL VOAs | 5 | 3 | 40 ml VOA vials | HCl to pH< 2; Cool to 4°C | 14 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 5 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | | Cyanide | 5 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| | Soil | TCL VOAs | 20 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 19 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 19 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| Site 63: Verona Loop Dump | Groundwater | TCL VOAs | 7 | 3 | 40 ml VOA vials | HCl to pH< 2; Cool to 4°C | 14 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 6 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
PAGE TWO

| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 63: Verona Loop Dump (Continued) | Groundwater (Continued) | Cyanide | 6 | 1 | 1 liter polyethylene bottle | NaOH to pH > 12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| | Surface Water | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH < 2; Cool to 4°C | 14 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH < 2; Cool to 4°C | 6 months; Hg - 28 days |
| | | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH > 12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 2 | N/A | N/A | N/A | N/A |
| | Sediment | TCL VOAs | 3 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 3 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 3 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
PAGE THREE

| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 63: Verona Loop Dump (Continued) | Soil | TCL VOAs | 21 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 21 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 21 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| Site 54: Crash Crew Burn Pit | Groundwater | TCL Metals | 4 | 4 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | | TCL PCBs | 6 | 1 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Total Petroleum Hydrocarbons | 3 | 1 | 1 liter glass bottle | HCl to pH<2; | 28 days |
| | | BTEX | 7 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | Hexavalent Chromium | 6 | 1 | 500 ml polyethylene bottle | Cool to 4°C | 24 hours |
| | | Cyanide | 4 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |

**TABLE 4-1**
**SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES**
**CAMP LEJEUNE, NORTH CAROLINA**
**PAGE FOUR**

| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 54: Crash Crew Burn Pit (Continued) | Surface Water | TCL Metals | 7 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | | TCL PCBs | 7 | 2 | 1 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Total Petroleum Hydrocarbons | 5 | 1 | 1 liter glass bottle | HCl to pH<2 | 28 days |
| | | BTEX | 8 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | Hexavalent Chromium | 7 | 1 | 500 ml polyethylene bottle | Cool to 4°C | 24 hours |
| | | Cyanide | 7 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 5 | N/A | N/A | N/A | N/A |
| | Sediment | TCL Metals and Cyanide | 7 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| | | PCBs | 7 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Total Petroleum Hydrocarbons | 5 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | | BTEX | 7 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | Hexavalent Chromium | 7 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 24 hours |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
PAGE FIVE

| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 54: Crash Crew Burn Pit (Continued) | Soil | TCL Metals and Cyanide | 9 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| | | TCL PCBs | 8 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Total Petroleum Hydrocarbons | 7 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | | BTEX | 9 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | Hexavalent Chromium | 8 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 24 hours |
| Site 82: Piney Green Road | Groundwater | TCL VOAs | 9 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 10 days to analysis |
| | | TCL Pesticides/PCBs | 8 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Temperature, Specific Conductance, pH | 5 | N/A | N/A | N/A | N/A |
| | Surface Water | TCL VOAs | 10 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | TCL Pesticides/PCBs | 9 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Temperature, Specific Conductance, pH | 6 | N/A | N/A | N/A | N/A |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
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| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 82: Piney Green Road (Continued) | Sediment | TCL VOAs | 10 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL Pesticides/PCBs | 9 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Soil | TCL VOAs | 23 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL Pesticides/PCBs | 22 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| Site 80: Paradise Point Golf Course | Groundwater | Total Petroleum Hydrocarbons | 4 | 1 | 1 liter glass bottle | HCl to pH<2 | 28 days |
| | | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | TCL Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottles | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Chlorinated Herbicides | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
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| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 80: Paradise Point Golf Course (Continued) | Surface Water | Total Petroleum Hydrocarbons | 6 | 1 | 1 liter glass bottle | HCl to pH<2 | 28 days |
| | | TCL VOAs | 7 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | TCL Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottles | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Chlorinated Herbicides | 7 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Temperature, Specific Conductance, pH | 5 | N/A | N/A | N/A | N/A |
| | Sediment | TCL Pesticides/PCBs | 6 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Total Petroleum Hydrocarbons | 6 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | | Chlorinated Herbicides | 7 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL VOAs | 6 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |

**TABLE 4-1**
**SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES**
**CAMP LEJEUNE, NORTH CAROLINA**
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| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 80: Paradise Point Golf Course (Continued) | Soil | TCL Pesticides/PCBs | 19 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | Total Petroleum Hydrocarbons | 19 | 1 | 32 oz. wide mouth glass jar | Cool to 4°C | 28 days |
| | | Chlorinated Herbicides | 20 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL VOAs | 20 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| Site 3: Creosote plant | Groundwater | TCL BNAs | 4 | 1 | 8 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Sediment | TCL BNAs | 5 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | Soil | TCL BNAs | 20 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| Site 43: Agan Street Dump | Groundwater | TCL VOAs | 4 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 4 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 4 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | | Cyanide | 4 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
PAGE NINE

| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 43: Agan Street Dump (Continued) | Surface Water | TCL VOAs | 7 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 6 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 6 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | | Cyanide | 6 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 5 | N/A | N/A | N/A | N/A |
| | Sediment | TCL VOAs | 6 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 6 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 6 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| | Soil | TCL VOAs | 19 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 18 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 18 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

**TABLE 4-1**
**SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES**
**CAMP LEJEUNE, NORTH CAROLINA**
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| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 44: Jones Street Dump | Groundwater | TCL VOAs | 4 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days; |
| | | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| | Surface Water | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 3 | 2 | 80 oz. amber glass bottle | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days; |
| | | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 14 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| | Sediment | TCL VOAs | 4 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 3 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 3 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
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| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 44: Jones Street Dump (Continued) | Soil | TCL VOAs | 20 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 20 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 20 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| Site 65: Engineer Area Dump | Groundwater | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH<2; Cool to 4°C | 14 days to analysis |
| | | TCL BNA, Pesticides/PCBs | 3 | 2 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days; CN - 14 days |
| | | Cyanide | 3 | 1 | 1 liter polyethylene bottle | NaOH to pH>12; Cool to 4°C | 6 months; Hg - 28 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |

TABLE 4-1
SUMMARY OF ANALYSES, BOTTLE REQUIREMENTS, PRESERVATION REQUIREMENTS, AND HOLDING TIMES
CAMP LEJEUNE, NORTH CAROLINA
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| Site Name | Media | Analysis | No. of Samples (A) | No. of Containers per Sample | Type of Container | Preservation Requirements | Holding Time |
|---|---|---|---|---|---|---|---|
| Site 65: Engineer Area Dump (Continued) | Surface Water | TCL VOAs | 3 | 3 | 40 ml VOA vials | HCl to pH, <2; Cool to 4°C | 14 days to analysis |
| | | TCL Extractables | 3 | 2 | 80 oz. amber glass bottles | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals | 3 | 1 | 1 liter polyethylene bottle | $HNO_3$ to pH<2; Cool to 4°C | 6 months; Hg - 28 days |
| | | Temperature, Specific Conductance, pH | 3 | N/A | N/A | N/A | N/A |
| | Sediment | TCL VOAs | 3 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL Extractables | 3 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 3 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |
| | Soil | TCL VOAs | 19 | 4 | 40 ml VOA vials | Cool to 4°C | 10 days to analysis |
| | | TCL Extractables | 18 | 1 | 8 oz. wide mouth glass jar | Cool to 4°C | 7 days to extraction; 40 days to analysis |
| | | TCL Metals and Cyanide | 18 | 1 | 8 oz. wide mouth glass jar | None | 6 months; Hg - 28 days; CN - 14 days |

(A) Number of samples includes field QA/QC samples.
NA Not applicable.

# 5.0 LABORATORY SAMPLE CUSTODY

To ensure the integrity of a sample from collection through analysis, it is necessary to have an accurate, written record that traces the possession and handling of the sample. This documentation is referred to as the sample chain-of-custody.

A sample is under custody if

- The sample is in the physical possession of an authorized person.
- The sample is in view of an authorized person after being in his/her possession.
- The sample is placed in a secure area by an authorized person after being in his/her possession.
- The sample is in a secure area, restricted to authorized personnel only.

Sample custody during collection and shipping is discussed in Section 4.5.1 of NUS SOP SA-6.1. Laboratory sample custody is discussed in the following sections. Further details are presented in Attachment F of the CLP Statement of Work (EPA, February 1988). All laboratories used in this study must follow these procedures.

## 5.1 SAMPLE RECEIPT

When samples are received, the shipping manifest is signed and dated to acknowledge sample receipt. The sample custodian must examine the shipping containers and verify that the correct number of containers was received. The shipping containers are then opened and the enclosed sample paperwork is removed.

Samples are removed from the shipping containers and the bottle condition must be noted. The information on the chain-of-custody, the airbill, the containers and sample tags, and the laboratory request is reviewed to note any discrepancies. Discrepancies must be resolved through the NUS Project Manager.

## 5.2 SAMPLE STORAGE

All samples received by the laboratory must be stored at 4°C until analysis. Laboratory holding times are specified by the CLP contract and are presented in Table 4-1.

## 5.3 LABORATORY SAMPLE TRACKING

Laboratory sample tracking procedures are discussed in Section F of the CLP Statement of Work (EPA, February 1988). All laboratories used must conform to these requirements.

# 6.0 CALIBRATION PROCEDURES AND FREQUENCY

Instrument used in the field and in the laboratory will be calibrated according to the procedures described below.

## 6.1 FIELD INSTRUMENTS

Several monitoring instruments may be used during field activities, including

- Temperature probe
- Specific conductance meter
- pH meter
- Electronic water-level meter

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

Calibration will be documented on an Equipment Calibration Log (NUS SOP SA-6.4, Attachment D-1). During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts are repaired or replaced.

## 6.2 LABORATORY INSTRUMENTS

Calibration frequency for each of the environmental measurement parameters is presented below.

- TCL Volatile Organics; BTEX - Continuing instrument calibration will be performed on each working day that samples are analyzed. Response factors for the gas chromatogram (GC) will be verified.

- TCL Extractable Organics - Continuing instrument calibration will be performed on each working day that samples are analyzed. The response factor will be verified by the measurement of two or more calibration standards, including one at the beginning of the day, and one at the end of the day.

- TCL Metals; Cyanide, Hexavalent Chromium - Calibration curves will be generated using a blank and three standards, at a minimum. A continuing calibration will be conducted for every hour of continuous sample analysis.

- Chlorinated Herbicides - Continuing instrument calibration will be performed on each working day that samples are analyzed. Response factors for the gas chromatogram (GC) will be verified.

- Total Petroleum Hydrocarbons - Calibration curves will be generated using a blank and three standards at a minimum each day that samples are run.

# 7.0 ANALYTICAL PROCEDURES

Solid and aqueous samples will be collected for chemical analyses. The analytical procedures to be used are summarized in Table 7-1. Method references are included as footnotes.

**TABLE 7-1**

**ANALYTICAL METHODS FOR CHEMICAL AND PHYSICAL PARAMETERS**
**CAMP LEJUENE**

| Analytical Parameter | Solid Matrix Analytical Method | Aqueous Matrix Analytical Method |
|---|---|---|
| TCL Volatile Organics | CLP Statement of Work 2/88 | CLP Statement of Work 2/88 |
| BTEX | CLP Statement of Work 2/88 | CLP Statement of Work 2/88 |
| TCL Extractables | CLP Statement of Work 2/88 | CLP Statement of Work 2/88 |
| TCL Metals | CLP Statement of Work 7/88 | CLP Statement of Work 7/88 |
| Cyanide | CLP Statement of Work 7/88 | CLP Statement of Work 7/88 |
| Hexavalent Chromium | EPA 218.4 | EPA 218.4 |
| Chlorinated Herbicides | SW 8150, 3550 | NA |
| Total Petroleum Hydrocarbons | EPA 418.1 | EPA 418.1 |

EPA EPA, March 1983. "Methods for Chemical Analysis of Water and Wastes."
SW EPA, September 1986. "Test Methods for Evaluating Solid Wastes - Physical/Chemical Method," 3rd Edition.
NA Not Applicable.

# 8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Data reduction, validation, and reporting will be conducted as described below. Data validation will be conducted by independent data validation. The validation will be performed with reference to the EPA Functional Guidelines for Data Validation. In instances where the Functional Guidelines are not specific or applicable, or method-specific quality control criteria will be used to evaluate the data.

## 8.1 DATA REDUCTION

The calculation of final results from raw data varies from parameter to parameter with the calibration approach. The ratio of instrument response to analyte concentration is determined for one or more standards. In general, if the concentration/instrument response ratio is linear, the average of the ratios is used to calculate sample results. If the response is not linear, response is plotted against concentration, and sample results are quantitated from the resultant curve.

Results are generally expressed to two significant figures. Results for aqueous samples are expressed in µg/l. Organic results for solid samples are expressed in µg/kg, whereas inorganic results are expressed in mg/kg.

## 8.2 DATA VALIDATION AND REPORTING

The results of quality control checks are the primary tools used for data validation. Quality control checks are described in Section 9.0. Acceptance criteria (control limits) are discussed in Section 3.0. Raw data and final results are reviewed by the laboratory group leader on a daily basis. The group leader confirms that documentation is complete and legible; qualitative identifications are accurate; calculations are accurate; results are expressed in the appropriate units and number of significant figures; and the required quality control checks were run and met acceptance criteria. Review and approval of the data is documented by the group leader.

The chemical-analytical data generated by the laboratory will be reviewed by the NUS Chemistry and Toxicology Department. Review of the chemical-analytical data will include a quality assurance assessment to determine whether specified protocols were followed by the laboratory personnel. Results for field blanks and duplicates will be reviewed for consistency (i.e., relative percent difference values) and to identify contaminants. The laboratory will provide reagent blank, surrogate spike, and matrix spike results. This information will also be reviewed through comparison with the specified control limits (see Section 3.0). All data validation will be performed in accordance with the latest EPA Functional Guidelines. Documentation of the validity of laboratory results will be provided to the Project Manager in the form of letter reports.

Chemical-analytical data generated during the study will be reduced to a concise form for presentation in the Site Inspection Report. The analytical results will be managed using an existing computer program developed by NUS specifically for chemical data bases. This program is capable of handling all TCL compounds, and will be customized for sites at Camp Lejeune to accommodate all indicator parameters. Quality assurance procedures will be implemented to assure that no errors occur during data entry. The data entered into the program are checked by the computer operator, and the printouts are checked against the original laboratory sheets by a chemist. The data entered into the program are checked by the computer operator, and the printouts are checked against the original laboratory by a chemist.

# 9.0 INTERNAL QUALITY CONTROL CHECKS

Quality Control checks to be implemented in the field and in the laboratory are described below.

## 9.1 FIELD QUALITY CONTROL CHECKS

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

Field Duplicates - Field duplicates are samples that are divided into two portions at the time of sampling. Field duplication provides precision information regarding homogeneity, handling, shipping, storing, preparation, and analysis. Field duplicates will be submitted at a frequency of 1 per every 10 samples, or 1 per sampling trip if less than 10 samples are collected.

Rinsate Blanks - Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment (bailer, split spoon, corer, etc.) after decontamination and placing it in the appropriate sample containers for analysis. Rinsate blanks will be used to assess the effectiveness of decontamination procedures. Rinsate blanks will be collected for each type of nondedicated sampling equipment used and will be submitted at a frequency of 1 per day per media.

Field Blanks - Samples consisting of the source water used in decontamination and steam cleaning. Field blanks will be generated at the rate of 1/event/media.

Trip Blanks - Allow the evaluation of contamination generated from sample containers and changes occurring during the shipping process. Samples are prepared prior to the sampling trip. Trip blanks are not exposed to field conditions. These are typically associated with the analysis of volatile organic compounds. Will be generated at a rate of 1/cooler used for shipping VOAs.

The proposed field quality control samples are included in Table 3-1 (Section 3.0).

## 9.2 LABORATORY QUALITY CONTROL CHECKS

Laboratory analysis will be conducted in accordance with the appropriate analytical methods (Table 7-1). Internal laboratory quality control checks include surrogate and matrix spike addition and analysis and reagent blank generation and analysis. Laboratory quality control procedures for TCL compounds, BTEX, and hexavalent chromium will be performed as summarized in the CLP Statement of Work, Attachment E.

### 9.2.1 Chlorinated Herbicides

The quality control procedures routinely employed in Gas Chromatography (GC) analyses of water for chlorinated herbicides are presented below.

**Standardization**

The GC is calibrated initially with five standards covering the working range of the instrument.

After each 10 samples are analyzed, or each day that analyses are performed, the instrument is standardized against a standard solution containing the compounds of interest. A response factor (RF) can be determined by the internal standard (IS) method, each time the standardization is

performed. Internal standards are added to all standards as well as to all blanks and samples before injection into the GC system. Internal standard areas for each sample are monitored to detect changes in instrument conditions. The standardization response factor is calculated as follows:

$$RF = \frac{A_S C_{IS}}{A_{IS} C_S}$$

Where:

$A_S$ = Integrated area of the characteristic ion for the pollutant standard.
$A_{IS}$ = Integrated area of the characteristic ion for the internal standard.
$C_{IS}$ = Amount (mg) of the internal standard.
$C_S$ = Amount (mg) of the pollutant standard.

A constant amount of internal standard is added to all samples, and the concentration (Co) of each chlorinated herbicide in the sample is calculated using the following equation:

$$C_o \text{ in } \mu g/l = \frac{(A_S)(C_{IS})}{(A_{IS})(RF)(V_O)}$$

Where:

$V_O$ is the volume of original sample in liters.

**Surrogate Standards**

Surrogate standards are added to all samples and blanks during sample preparation. The recoveries of the surrogate compounds are used to isolate any problems that could occur throughout the entire analytical process. For example, for chlorinated herbicide analysis, a preliminary extraction is required prior to analysis. The surrogates are added prior to the extraction so that not only instrument problems, but also extraction problems and sample matrix problems, can be detected.

**Blanks**

An aliquot of deionized water is taken through each preparation procedure each day samples are analyzed as a check for glassware and reagent contamination.

# 10.0 PERFORMANCE AND SYSTEM AUDITS

The laboratory conducting the analyses will be fully certified and approved by the Navy as part of the Naval Energy and Environmental Support Activity. The laboratory will be audited as per the requirements of this approval process.

# 11.0 PREVENTIVE MAINTENANCE

Measuring equipment used in environmental monitoring or analysis and test equipment used for calibration and maintenance shall be controlled by established procedures. Measuring and test equipment shall have an initial calibration and shall be recalibrated at scheduled intervals against certified standards, according to the CLP Statement of Work, Attachment E, or the procedures for other methods. Equipment will be calibrated periodically. Test equipment used for calibration of sensors shall also be calibrated at least once a year or when maintenance or damage indicates a need for recalibration.

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

# 12.0 DATA ASSESSMENT FOR PRECISION, ACCURACY, AND COMPLETENESS

The procedures used to assess precision, accuracy, and completeness (PAC) of laboratory data are described in Section 3.0. Upon completion of the analytical phases of the project, data will be reviewed and validated as outlined in Section 8.0. In conjunction with the data review and validation, the specific PAC results will be compared with the laboratory quality control criteria and the completeness objective. Discrepancies may affect the usefulness of the data.

# 13.0 CORRECTIVE ACTION

The need for corrective action may become apparent during surveillance of field activities, procurement of services and supplies, or other operations that may affect the quality of work. Corrective action will be taken immediately by the Project Manager and/or field personnel.

The identification of significant conditions adverse to quality, the cause of the conditions, and the corrective actions shall be documents by the FOL and reported to the appropriate levels of management. The NUS Project Manager will have overall responsibility for implementing corrective actions, and must identify those responsible for initiating corrective action to remedy immediate effects of the problem.

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

Acceptability of laboratory data is defined by the PARCC parameters in Section 3.0 of this Quality Assurance Plan. If the data do not meet these criteria, it may be necessary to resample the locations for which deficiencies were noted. This laboratory has audit and corrective action procedures in place that they must follow.

# 14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Project Manager shall prepare a report summarizing the quality assurance and quality control status for the project and any conditions adverse to quality. Topics to be included in the report are as follows:

- Results of any audits.
- Results of surveillances.
- Any nonconformances initiated.
- Training provided to project personnel.
- Any significant quality assurance problems, together with recommended solutions.

Assessment of the measurement data for precision, accuracy, and completeness is performed by the Chemistry/Toxicology Group and is reported to the Project Manager in the form of data validation letters.

# REFERENCES


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Water and Air Research, Inc., 1983, Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina, Report Number UIC-M67001, Gainesville, Florida.

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# APPENDIX A

# STANDARD OPERATING PROCEDURES

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## APPENDIX A

LIST OF NUS SOPs USED AS REFERENCE PROCEDURES

SA-1.1: Groundwater Sample Acquisition

SA-1.2: Surface Water and Sediment Sampling

SA-6.1: Sample Identification and Chain-of-Custody

SF-1.1: Onsite Water Quality Testing

SF-1.2: Sample Preservation

SF-2.3: Decontamination of Chemical Sampling Equipment and Field Analytical Equipment

GH-1.5: Borehole and Sample Logging

GH-1.6: Decontamination of Drilling Rigs and Monitoring Well Materials

GH-2.4: In-situ Hydraulic Conductivity Testing

GH-3.2: Magnetic and Metal Detection Surveys

ADDITIONAL REFERENCED PROCEDURES

ASTM D 1586-84 (Section 7): Split-Barrel Sampling Procedures

EPA (Region IV) Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual - Appendix C: Packaging and Shipping Procedures

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## 1.0 PURPOSE

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

## 2.0 SCOPE

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

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

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

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

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

## 5.0 PROCEDURES

### 5.1 GENERAL

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

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged to dryness with the sampling equipment being used, the well shall be evacuated and allowed to recover prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is preferred.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

- A submersible pump, intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level decreases. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished a bailer may be used to collect the sample for chemical analysis.

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

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

## 5.2 SAMPLING, MONITORING, AND EVACUATION EQUIPMENT

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

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

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

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

- Pumps

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

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

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

- Pails - Plastic, graduated.

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

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

## 5.3 CALCULATIONS OF WELL VOLUME

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

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well (if not known from past records) by sounding using a clean, decontaminated weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons ($V = 0.163Tr^2$).

  where:

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

- Determine the minimum amount to be evacuated before sampling.

## 5.4 EVACUATION OF STATIC WATER (PURGING)

### 5.4.1 General

The amount of flushing a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, electrical conductance, and pH have stabilized. Onsite measurements of these parameters shall be recorded on the field data form.

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

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

### 5.4.2 Evacuation Devices

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

#### 5.4.2.1 Bailers

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

Advantages of bailers include:

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

Limitations on the use of bailers include the following:

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

#### 5.4.2.2 Suction Pumps

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

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

#### 5.4.2.3 Gas-Lift Samplers

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

#### 5.4.2.4 Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

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

## 5.5 SAMPLING

### 5.5.1 Sampling Plan

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

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

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

- Sample preservation requirements.

- Working schedule.

- List of team members.

- List of observers and contacts.

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

### 5.5.2 Sampling Methods

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

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

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

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

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

5. Lower purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner. Lower the purging device, as required, to maintain submergence.

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

7. Observe peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. Never collect volatile organics samples using a vacuum pump.

8. Purge a minimum of three-to-five casing volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice.

9. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to sampling level before filling (this requires use of other than a 'bucket-type' bailer).

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

10. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours), sample collection can be delayed until the following day. If the well has been bailed early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

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

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

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

15. Decontaminate all equipment

### 5.5.3 Sample Containers

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

### 5.5.4 Preservation of Samples and Sample Volume Requirements

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

### 5.5.5 Handling and Transporting Samples

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

### 5.5.6 Sample Holding Times

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

## 5.6 RECORDS

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

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

## 5.7 CHAIN-OF-CUSTODY

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

## 6.0 REFERENCES

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## 7.0 ATTACHMENTS

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

## ATTACHMENT A
## SAMPLE LOG SHEET

NUS CORPORATION
A Halliburton Company

# SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☐ Other _____

Page _____ of _____
Case # _____
By _____

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

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

| Sample Date & Time: | Sample Data | | | |
|---|---|---|---|---|
| | pH | S.C. | Temp. (°C) | Color & Turbidity |
| Sampled By: | | | | |

Signature(s):

Observations / Notes:

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

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

# ATTACHMENT B
## PURGING EQUIPMENT SELECTION

### Purging Equipment Selection

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

| Manufacturer | Model name/ number | Principle of operation | Maximum outside diameter/length (inches) | Construction materials (w/lines & tubing) | Lift range (ft) | Delivery rates or volumes | 1982 price (dollars) | Comments |
|---|---|---|---|---|---|---|---|---|
| BarCad Systems, Inc. | BarCad Sampler | dedicated; gas drive (positive displacement) | 1.5/16 | PE, brass, nylon, aluminum oxide | 0-150 with std. tubing | 1 liter for each 10-15 ft of submergence | 220-350 | requires compressed gas; custom sizes and materials available; acts as piezometer |
| Cole-Parmer Inst. Co. | Master Flex 7570 Portable Sampling Pump | portable; peristaltic (suction) | <1.0/NA | (not submersible) Tygon®, silicone Viton® | 0-30 | 670 mL/min with 7015-20 pump head | 500-600 | AC/DC; variable speed control available; other models may have different flow rates |
| ECO Pump Corp. | SAMPLifier | portable; venturi | <1.5 or <2.0/NA | PP, PE, PVC, SS, Teflon®, Tefzel® | 0-100 | 0-500 mL/min depending on lift | 400-700 | AC, DC, or gasoline driven motors available; must be primed |
| Geltek Corp. | Bailer 219-4 | portable; grab (positive displacement) | 1.66/38 | Teflon® | no limit | 1075 mL | 120-135 | other sizes available |
| GeoEngineering, Inc. | GEO-MONITOR | dedicated; gas drive (positive displacement) | 1.5/16 | PE, PP, PVC, Viton® | probably 0-150 | app. 1 liter for each 10 ft of submergence | 185 | acts as piezometer; requires compressed gas |
| Industrial and Environmental Analysts, Inc. (IEA) | Aquarius | portable; bladder (positive displacement) | 1.75/43 | SS, Teflon®, Viton® | 0-250 | 0-2800 mL/min | 1500-3000 | requires compressed gas; other models available; AC, DC, manual operation possible |
| IEA | Syringe Sampler | portable; grab (positive displacement) | 1.75/43 | SS, Teflon® | no limit | 850 mL sample vol. | 1100 | requires vacuum and/or pressure from hand pump |
| Instrument Specialties Co. (ISCO) | Model 2600 Well Sampler | portable; bladder (positive displacement) | 1.75/50 | PC, silicone, Teflon®, PP, PE, Delrin® acetal | 0-150 | 0-7500 mL/min | 990 | requires compressed gas (40 psi minimum) |
| Keck Geophysical Instruments, Inc. | SP-81 Submersible Sampling Pump | portable; helical rotor (positive displacement) | 1.75/25 | SS, Teflon®, PP, EPDM, Viton® | 0-160 | 0-4500 mL/min | 3500 | DC operated |
| Leonard Mold and Die Works, Inc. | GeoFilter Small Dia. Well Pump (#0500) | portable; bladder (positive displacement) | 1.75/38 | SS, Teflon®, PC, Neoprene® | 0-400 | 0-3500 mL/min | 1400-1500 | requires compressed gas (55 PSI minimum); pneumatic or AC/DC control module |
| Oil Recovery Systems, Inc. | Surface Sampler | portable; grab (positive displacement) | 1.75/12 | acrylic, Delrin® | no limit | app. 250 mL | 125-160 | other materials and models available; for measuring thickness of "floating" contaminants |
| Q.E.D. Environmental Systems, Inc. | Well Wizard® Monitoring System (P-100) | dedicated; bladder (positive displacement) | 1.66/36 | PVC | 0-230 | 0-2000 mL/min | 300-400 | requires compressed gas; piezometric level indicator; other materials available |

Source: Barcelona et al., 1983

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

**Construction Materials Abbreviations**

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

**Other Abbreviations**

- NA Not Applicable
- AC Alternating Current
- DC Direct Current

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

Source: Barcelona et al., 1983

| NUS CORPORATION<br>ENVIRONMENTAL MANAGEMENT GROUP | STANDARD OPERATING PROCEDURES | Number SA-1.2 | Page 1 of 10 |
|---|---|---|---|
| | | Effective Date 05/04/90 | Revision 2 |
| | | Applicability EMG | |
| | | Prepared Earth Sciences | |
| Subject SURFACE WATER AND SEDIMENT SAMPLING | | Approved D. Senovich | |

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## 1.0 PURPOSE

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

## 2.0 SCOPE

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

## 3.0 GLOSSARY

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

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

## 4.0 RESPONSIBILITIES

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

## 5.0 PROCEDURES

### 5.1 INTRODUCTION

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

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

## 5.2 DEFINING THE SAMPLING PROGRAM

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

### 5.2.1 Sampling Program Objectives

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

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

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

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

### 5.2.2 Location of Sampling Stations

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

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

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

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

### 5.2.3 Frequency of Sampling

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

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

## 5.3 SURFACE WATER SAMPLE COLLECTION

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

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

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

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

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

### 5.3.2 Lakes, Ponds and Reservoirs

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

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

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

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

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

### 5.3.3 Estuaries

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

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

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

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

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

### 5.3.4 Surface Water Sampling Equipment

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

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

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

The criteria for selecting a sampler include:

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

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

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

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

**5.3.4.1 Dip Sampling**

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

**5.3.4.2 Weighted Bottle Sampling**

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

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

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

#### 5.3.4.3 Kemmerer

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

### 5.3.5 Surface Water Sampling Techniques

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

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

## 5.4 SEDIMENT SAMPLING

### 5.4.1 General

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

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

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

### 5.4.2 Sampling Equipment and Techniques

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

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

The following samplers may be used to collect bottom materials:

- Scoop sampler
- Dredge samplers

#### 5.4.2.1 Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if it can be waded, the easiest and "cleanest" way to collect a sediment sample is to use a scoop sampler. This reduces the potential for cross-contamination. This method is accomplished by reaching over or wading into the water body and, while facing upstream (into the current), scooping in the sample along the bottom in the upstream direction. It is very difficult not to disturb fine-grained materials of the sediment-water interface when using this method.

#### 5.4.2.2 Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices (i.e., coarse-grained or partially-cemented materials) or when large quantities of materials are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Most dredges are heavy (up to several hundred pounds) and require use of a winch and crane assembly for sample retrieval. There are three major types of dredges: Peterson, Eckman and Ponar dredges.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the "shock wave" and permitting direct access to the secured sample without opening the closed jaws. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. Access to the secured sample through the covering screens permits subsampling of the secured material with coring tubes or Teflon scoops, thus minimizing the change of metal contamination from the frame of the device.

## 6.0 REFERENCES

Feltz, H. R., 1980. Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

Kittrell, F. W., 1969. A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135p.

U.S. EPA, 1980. Standard Operating Procedures and Quality Assurance Manual. Water Surveillance Branch, USEPA Surveillance and Analytical Division, Athens, Georgia.

U.S. Geological Survey, 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Virginia.

## 7.0 ATTACHMENTS

None.

| NUS CORPORATION<br>ENVIRONMENTAL MANAGEMENT GROUP | STANDARD OPERATING PROCEDURES | Number SA-6.1 | Page 1 of 14 |
|---|---|---|---|
| | | Effective Date 05/04/90 | Revision 2 |
| | | Applicability EMG | |
| | | Prepared Earth Sciences | |
| Subject SAMPLE IDENTIFICATION AND CHAIN-OF-CUSTODY | | Approved D. Senovich | |

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## 1.0 PURPOSE

This purpose of this procedure is to provide information on chain-of-custody procedures to be used under the NUS Program.

## 2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of all samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities. Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence. This procedure identifies the necessary custody records and describes their completion.

This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

## 3.0 GLOSSARY

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. A Chain-of-Custody Record Form is a controlled document, provided by the regional office of EPA.

The chain-of-custody form is a two-page carbon-copy type form. The original form accompanies the samples during shipment, and the pink carbon-copy is retained in the project file.

Controlled Document - A consecutively-numbered form released by EPA or Program Management Office (PMO) for use on a particular work assignment. All unused forms must be returned or accounted for at the conclusion of the assignment.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under your custody if:

- It is in your actual possession.
- It is in your view, after being in your physical possession.
- It was in your physical possession and then you locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

## 4.0 RESPONSIBILITIES

Field Operations Leader - Responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record and maintaining custody of samples until they are relinquished to another custodian, to the shipper, or to the common carrier.

Remedial Investigation Leader - Responsible for determining that chain-of-custody procedures have been met by the sample shipper and analytical laboratory.

## 5.0 PROCEDURES

### 5.1 OVERVIEW

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is what it is represented to be. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom and, secondly, provide security for the evidence as it is moved and/or passes from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain of possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

### 5.2 SAMPLE IDENTIFICATION

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records, with identifying information.

#### 5.2.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling Plan. Each sample container is identified by a sample label (see Attachment B). Sample labels are provided by the PMO. The information recorded on the sample label includes:

- **Project:** EPA Work Assignment Number (can be obtained from the Sampling Plan).
- **Station Location:** The unique sample number identifying this sample (can be obtained from the Sampling Plan).
- **Date:** A six-digit number indicating the day, month, and year of sample collection; e.g., 12/21/85.
- **Time:** A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- **Medium:** Water, soil, sediment, sludge, waste, etc.

- **Concentration:** The expected concentration (i.e., low, medium, high).
- **Sample Type:** Grab or composite.
- **Preservation:** Type of preservation added and pH levels.
- **Analysis:** VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- **Sampled By:** Printed name of the sampler.
- **Case Number:** Case number assigned by the Sample Management Office.
- **Traffic Report Number:** Number obtained from the traffic report labels.
- **Remarks:** Any pertinent additional information.

Using just the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

### 5.2.2 Sample Identification Tag

A Sample Identification Tag (Attachment F) must also be used for samples collected for CLP (Contract Laboratory Program) analysis. The Sample Identification Tag is a white, waterproof paper label, approximately 3-by-6 inches, with a reinforced eyelet, and string or wire for attachment to the neck of the sample bottle. The Sample Tag is a controlled document, and is provided by the regional EPA office. Following sample analysis, the Sample Tag is retained by the laboratory as evidence of sample receipt and analysis.

The following information is recorded on the tag:

- **Project Code:** Work Assignment Number.
- **Station Number:** The middle portion of the Station Location Number, (between the hyphens).
- **Month/Day/Year:** Same as Date on Sample Label.
- **Time:** Same as Time on Sample Label.
- **Designate - Comp/Grab:** Composite or grab sample.
- **Station Location:** Same as Station Location on Sample Label.
- **Samplers:** Same as Sampled By on Sample Label.
- **Preservative:** Yes or No.
- **Analyses:** Check appropriate box(es).

- **Remarks:** Same as Remarks on Sample Label (make sure the Case Number and Traffic Report numbers are recorded).

- **Lab Sample Number:** For laboratory use only.

The tag is then tied around the neck of the sample bottle.

If the sample is to be split, it is aliquoted into similar sample containers. Identical information is completed on the label attached to each split.

Blank, duplicate, or field spike samples shall not be identified as such on the label, as they may compromise the quality control function. Sample blanks, duplicates, spikes, and splits are defined in Procedure SA-6.6.

## 5.3 CHAIN-OF-CUSTODY PROCEDURES

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

### 5.3.1 Field Custody Procedures

- Samples are collected as described in the site-specific Sampling Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the sample log sheet and Chain-of-Custody Record exactly.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label because a ballpoint pen would not function in freezing weather.

### 5.3.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. Chain-of-Custody Record Forms used in EPA Regions I-IV are shown in Attachments A through D. The appropriate form shall be obtained from the EPA Regional Office. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as follows:

- Enter header information (project number, samplers, and project name -- project name can be obtained from the Sampling Plan).

- Sign, date, and enter the time under "Relinquished by" entry.

- Enter station number (the station number is the middle portion of the station location number, between the hyphens).
- Check composite or grab sample.
- Enter station location number (the same number as the station location on the tag and label).
- Enter the total number of containers per station number and the type of each bottle.
- Enter either the inorganic traffic report number, the organic traffic report number, or the SAS number for each station number in the remarks column.
- Enter the tag number from the bottom of the sample identification tag in the remarks column for each station location.
- Make sure that the person receiving the sample signs the "Received by" entry, or enter the name of the carrier (e.g., UPS, Federal Express) under "Received by." Receiving laboratory will sign "Received for Laboratory by" on the lower line and enter the date and time.
- Enter the bill-of-lading or Federal Express airbill number under "Remarks," in the bottom right corner, if appropriate.
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in the appropriate sample shipping package. Retain the pink copy with field records.
- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment G is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals are provided by ZPMO on an as-needed basis.
- Place the seal across the shipping container opening so that it would be broken if the container is opened.
- Complete other carrier-required shipping papers.

The custody record is completed using black waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the sample container (enclosed with other documentation in a plastic zip-lock bag). As long as custody forms are sealed inside the sample container and the custody seals are intact, commercial carriers are not required to sign off on the custody form.

If sent by mail, the package will be registered with return receipt requested. If sent by common carrier or air freight, proper documentation must be maintained.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

### 5.3.3 Receipt for Samples Form

Whenever samples are split with a private party or government agency, a separate Receipt for Samples Record Form is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the party or agency shall require the signature of a representative of the appropriate party acknowledging receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received by" space. When appropriate, as in the case where the representative is unavailable, the custody record shall contain a statement that the samples were delivered to the designated location at the designated time. This form must be completed and a copy given to the owner, operator, or agent-in-charge even if the offer for split samples is declined. The original is retained by the Field Operations Leader.

## 6.0 REFERENCES

U.S. EPA, 1984. User's Guide to the Contract Laboratory Program, Office of Emergency and Remedial Response, Washington, D.C.

## 7.0 ATTACHMENTS

Attachment A - Chain-of-Custody Record Form for use in Region I
Attachment B - Chain-of-Custody Record Form for use in Region II
Attachment C - Chain-of-Custody Record Form for use in Region III
Attachment D - Chain-of-Custody Record Form for use in Region IV
Attachment E - Sample Label
Attachment F - Sample Identification Tag
Attachment G - Chain-of-Custody Seal

## ATTACHMENT A
## CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION I
(Original is 8-1/2 by 11)

| | PROJECT NAME | | | | | NO. OF CON-TAINERS | REMARKS |
|---|---|---|---|---|---|---|---|
| SAMPLERS: *(Signature)* | | | | | | | |
| STA. NO. | DATE | TIME | COMP. | GRAB | STATION LOCATION | | |
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|---|---|---|---|---|---|
| Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* | Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* |
| Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* | Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* |
| Relinquished by: *(Signature)* | Date / Time | Received for Laboratory by: *(Signature)* | Date / Time | Remarks: | |

## ATTACHMENT B
## CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION II
(Original is 8 by 10-1/2)

# CHAIN OF CUSTODY RECORD

ENVIRONMENTAL PROTECTION AGENCY – REGION II
SURVEILLANCE & ANALYSIS DIVISION
EDISON, NEW JERSEY 08817

| Name of Unit and Address | | | | |
|---|---|---|---|---|
| Sample Number | Number of Containers | Description of Samples | | |
| | | | | |
| Person Assuming Responsibility for Samples | | | Time | Date |

| Sample Number | Relinquished By | Received By | Time | Date | Reason for Change of Custody |
|---|---|---|---|---|---|
| Sample Number | Relinquished By | Received By | Time | Date | Reason for Change of Custody |
| Sample Number | Relinquished By | Received By | Time | Date | Reason for Change of Custody |
| Sample Number | Relinquished By | Received By | Time | Date | Reason for Change of Custody |

**ATTACHMENT C**
**CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION III**
**(Original is 8-1/2 x 11-3/4")**

**ENVIRONMENTAL PROTECTION AGENCY**
Office of Enforcement

**REGION 3**
Curtis Bldg., 6th & Walnut Sts.
Philadelphia, Pennsylvania 19106

## CHAIN OF CUSTODY RECORD

| PROJ. NO. | PROJECT NAME | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLERS: *(Signature)* | | | | | | | NO. OF CON-TAINERS | | | | | | | | REMARKS |
| STA. NO. | DATE | TIME | COMP. | GRAB | STATION LOCATION | | | | | | | | | | |
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| Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* | Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* |
|---|---|---|---|---|---|
| Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* | Relinquished by: *(Signature)* | Date / Time | Received by: *(Signature)* |
| Relinquished by: *(Signature)* | Date / Time | Received for Laboratory by: *(Signature)* | Date / Time | Remarks | |

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

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# ATTACHMENT D
## CHAIN-OF-CUSTODY RECORD FORM FOR USE IN REGION IV
(Original is 8-1/2 by 14)

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION 4

**CHAIN OF CUSTODY RECORD**

ENVIRONMENTAL SERVICES DIVISION
COLLEGE STATION ROAD
ATHENS, GEORGIA 30613

PROJ. NO. | PROJECT NAME

SAMPLERS (Signature)

| STA NO | DATE | TIME | COMP. | GRAB | STATION LOCATION | NO. OF CONTAINERS | Water/Wastewater | | | | | | | | | | | | | | | | | | Soil/Sed | | | Sldg/Waste | Misc | REMARKS/TAG NUMBERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Gal G (Not Org) | Gal G (EP) | 40 ml vial (VOA) | Gal P (BOD, COD, TSS) | Pt G (oil&grease) | Pt G (metals, Hg) | Pt P (metals) | Pt P (S⁻²) | Pt P (TOC, COD) | Qt G (PAG or Pest) | ½ gal P (CN) | ½ gal P (Cl⁻, Fl⁻, SO₄) | Qt G (Not Org, EP) | 8 oz G (VOA) | Pt P (Inorg, Hg, CN, S⁻²) | 8 oz G (Not Org, VOA, Inorg, Hg, CN) | 8 oz G (EP, S⁻², F⁻) | | | | | | | |
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| Relinquished by: (Signature) | Date/Time | Received by: (Signature) | Relinquished by (Signature) | Date/Time | Received by (Signature) | Remarks |
|---|---|---|---|---|---|---|
| Relinquished by: (Signature) | Date/Time | Received by: (Signature) | Relinquished by (Signature) | Date/Time | Received by (Signature) | |

DISTRIBUTION Original and Pink copies accompany sample shipment to laboratory. Pink copy retained by laboratory. Yellow copy retained by samplers. Blue copy extra copy as needed

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## ATTACHMENT E
## SAMPLE LABEL

NUS CORPORATION PROJECT: _____

STATION LOCATION: _____

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

MEDIA: WATER ☐ SOIL ☐ SEDIMENT ☐ _____ ☐

CONCENTRATION: LOW ☐ MED ☐ HIGH ☐

TYPE: GRAB ☐ COMPOSITE ☐

| ANALYSIS | PRESERVATION |
|---|---|
| VOA ☐ BNA's ☐ | Cool to 4°C ☐ |
| PCB's ☐ PESTICIDES ☐ | $HNO_3$ to pH <2 ☐ |
| METALS: TOTAL ☐ DISSOLVED ☐ | NAOH to pH>12 ☐ |
| CYANIDE ☐ | _____ ☐ |
| _____ ☐ | |

Sampled by: _____

Case No.: _____ Traffic Report No.: _____

Remarks:

ACFILE: FORMS\BOTLABL

## ATTACHMENT F
## SAMPLE IDENTIFICATION TAG

☆ GPO 505-552

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

Designate: Grab / Comp.

Time

Month/Day/Year

Station No.

Project Code

Samplers (Signatures)

Station Location

**Preservative:**
Yes ☐ No ☐

**ANALYSES**

| | |
|---|---|
| BOD Anions<br>Solids (TSS) (TDS) (SS) | |
| COD, TOC, Nutrients | |
| Phenolics | |
| Mercury | |
| Metals | |
| Cyanide | |
| Oil and Grease | |
| Organics GC/MS | |
| Priority Pollutants | |
| Volatile Organics | |
| Pesticides | |
| Mutagenicity | |
| Bacteriology | |
| | |

Remarks:

| Tag No. | Lab Sample No. |
|---|---|
| 3 60966 | |

ATTACHMENT G
CHAIN-OF-CUSTODY SEAL

**CUSTODY SEAL**

**Date**

**Signature**

NUS CORPORATION

NUS CORPORATION

CUSTODY SEAL

Date

Signature

| NUS CORPORATION<br>ENVIRONMENTAL MANAGEMENT GROUP | STANDARD OPERATING PROCEDURES | Number SF-1.1 | Page 1 of 16 |
|---|---|---|---|
| | | Effective Date 05/04/90 | Revision 2 |
| | | Applicability EMG | |
| | | Prepared Earth Sciences | |
| Subject ONSITE WATER QUALITY TESTING | | Approved D. Senovich | |

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## 1.0 PURPOSE

This procedure describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO) Concentration
- Oxidation Reduction Potential
- Certain Dissolved Constituents Using Specific Ion Elements

## 2.0 SCOPE

This procedure is applicable for use in an on-site groundwater quality monitoring program to be conducted during a remedial investigation or site investigation program at a hazardous or non-hazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc. and are not, in general, subject to solution interferences from color, turbidity and colloidal material, or suspended matter.

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

## 3.0 GLOSSARY

### 3.1 pH MEASUREMENT

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

pH Paper - Paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution pH.

### 3.2 SPECIFIC CONDUCTANCE MEASUREMENT

Ohm - Standard unit of electrical resistance (R). A siemen (or umho) is the standard unit of electrical conductance, the inverse of the ohm

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's law, $E = IR$, where E is the potential difference, I is the current, and R is the resistance.

Conductance - The conductance of a conductor 1 centimeter long and 1 square centimeter in cross-sectional area. Conductivity and specific conductance are used synonymously.

### 3.3 TEMPERATURE MEASUREMENT

None.

### 3.4 DISSOLVED OXYGEN MEASUREMENT

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

### 3.5 OXIDATION-REDUCTION POTENTIAL MEASUREMENT

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

Reduction - The gaining of electrons by an atom or group of atoms and subsequent increase in negative charge.

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

### 3.6 SPECIFIC ION ELECTRODES MEASUREMENT

Specific Ion Electrode - An electrode which develops a potential difference across a membrane in response to the concentration differences for selected ions on either side of that membrane.

## 4.0 RESPONSIBILITIES

Site Manager - in consultation with the Project Geochemist, is responsible for determining which on-site water quality measurements can contribute to the RI, when these measurements shall be made, and the data quality objectives (DQOs) for these measurements. The Project Operations Plan (POP) shall contain details of type, frequency and locations of the desired measurements.

Project Geochemist - primarily responsible for determining the type, frequency and locations for on-site water quality measurements as presented in the POP and for interpreting the results, including determination of which measurements are unrepresentative.

Field Operations Leader - responsible for implementing the POP, and also for deciding under what field conditions a particular on-site measurement will be unrepresentative or unobtainable.

Field Samplers/Analysts - responsible for the actual analyses that take place, including calibration, quality control and recording of results, as well as for the care and maintenance of the equipment in the field.

## 5.0 GUIDELINES

### 5.1 MEASUREMENT OF pH

#### 5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH can also be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis, and specific techniques are not described.

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

#### 5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or basicity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to hydrogen ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

#### 5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Accumet 150 portable pH meter, or equivalent.
- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- pH indicator paper, such as Hydrion or Alkacid, to cover the pH range 2 through 12.
- Buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

### 5.1.4 Measurement Techniques for Field Determination of pH

1. pH Meter

The following procedure is used for measuring pH with a pH meter (Standardization is according to manufacturers instructions):

a. The instrument and batteries shall be checked and calibrated prior to initiation of the field effort.

b. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.

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

d. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

e. Immerse the electrode(s) in a pH-7 buffer solution.

f. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). Alternately, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.

g. Adjust the pH meter to read 7.0.

h. Remove the electrode(s) from the buffer and rinse well with demineralized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.

i. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

j. Read and record the pH of the solution, after adjusting the temperature compensator to the sample temperature. pH shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature.

k. Rinse the electrode(s) with deionized water.

l. Keep the electrode(s) immersed in deionized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

2. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

## 5.2 MEASUREMENT OF SPECIFIC CONDUCTANCE

### 5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

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

### 5.2.2 Principles of Equipment Operation

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

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

### 5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- YSI Model 33 portable conductivity, meter, or equivalent
- Probe for above meter

A variety of conductivity meters are available which may also be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirement of the sampling program.

### 5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturers instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Attachment A may be used for guidance.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity. Adjust the temperature setting to the sample temperature.
- Read and record the results in a field logbook or sample log sheet.

If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

Note that specific conductance is occasionally reported at temperatures other than ambient.

## 5.3 MEASUREMENT OF TEMPERATURE

### 5.3.1 General

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

### 5.3.2 Equipment

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

### 5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to manufacturer's recommendations with an approved thermometer before each measurement or group of closely spaced measurements.

## 5.4 MEASUREMENT OF DISSOLVED OXYGEN CONCENTRATION

### 5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The method monitoring discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and are free from interference caused by color, turbidity, colloidal material or suspended matter.

### 5.4.2 Principles of Equipment Operation

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

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

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not

easily depolarized from the indicating electrode. If the gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

### 5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor or equivalent.
- Dissolved oxygen/temperature probe for above monitor.
- Sufficient cable to allow the probe to contact the sample.

### 5.4.4 Measurement Techniques for Dissolved Oxygen Determination

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

- The equipment shall be calibrated and have its batteries checked in the laboratory before going to the field.

- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

- The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).

- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers placed in wells can be moved up and down.

- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.

- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

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

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

## 5.5 MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

### 5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendence of organic or inorganic compounds to exist in an oxidized state. The technique therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

### 5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and will be dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

### 5.5.3 Equipment

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

- Accumet 150 portable pH meter or equivalent, with a millivolt scale.
- Platinum electrode to fit above pH meter.
- Reference electrode such as a calomel, silver-silver chloride, or equivalent.

### 5.5.4 Measurement Techniques for Oxidation-Reduction Potential

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

- The equipment shall be calibrated and have its batteries checked before going to the field.

- Check that the platinum probe is clean and that the platinum bond or tip is unoxidized. If dirty, polish with emery paper or, if necessary, clean the electrode using aqua regia, nitric acid, or chromic acid, in accordance with manufacturer's instructions.

- Thoroughly rinse the electrode with demineralized water.

- Verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added, the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions. If the ORP does not respond as above when the caustic is added, the electrodes shall be cleaned and the above procedure repeated.

- After the assembly has been checked for sensitivity, wash the electrodes with three changes of water or by means of a flowing stream of water from a wash bottle. Place the sample in a clean glass beaker or sample cup and insert the electrodes. Set temperature

compensator throughout the measurement period. Read the millivolt potential of the solution, allowing sufficient time for the system to stabilize and reach temperature equilibrium. Measure successive portions of the sample until readings on two successive portions differ by no more than 10 mV. A system that is very slow to stabilize properly will not yield a meaningful ORP. Record all results in a field logbook, including ORP (to nearest 10 mV), sample temperature and pH at the time of measurement.

## 5.6 SPECIFIC ION ELECTRODE MEASUREMENTS

### 5.6.1 General

Use of specific ion electrodes can be beneficial in the field for determining the presence and concentration of dissolved inorganic species which may be associated with contaminant plumes or leachate. Thus, electrodes can be used for rapid screening of water quality and determination of water migration pathways.

This procedure provides generic information for specific ion electrodes commonly used in groundwater quality monitoring programs and describes the essential elements of a field investigation program. Analytical methods using some specific ion electrodes have not been approved by the USEPA. In addition, calibration procedures and solutions, interferences and conditions and requirements for use for various electrodes vary greatly. Consequently, review of manufacturer's literature is mandatory prior to use.

### 5.6.2 Principles of Equipment Operation

All specific ion electrode measurements involve the use of a reference electrode, a pH meter, and a specific ion electrode (SIE). When the SIE and the reference electrode are immersed in a solution of the ion to be measured, a potential difference is developed between the two electrodes. This potential can be measured by a pH meter and related to the concentration of the ion of interest through the use of standard solutions and calibration curves.

Several different types of SIEs are in use: glass, solid-state, liquid-liquid membrane, and gas-sensing. All of the electrodes function using an ion exchange process as the potential determining mechanism. Glass electrodes are used for pH measurement. The glass in the tip of the electrode actually acts as a semi-permeable membrane to allow solution. Solid-state electrodes replace the glass membrane with an ionically-conducting membrane, (but act in essentially the same manner) while liquid-liquid membrane electrodes have an organic liquid ion exchanger contained in the pores of a hydrophobic membrane. Maintenance of the conducting interface, in combination with a reference electrode, allows completion of the electrical circuit and subsequent measurement of the potential difference. Gas-sensing electrodes have a membrane that permits the passage of gas only, thus allowing for the measurement of gas concentration. Regardless of the mechanism involved in the electrode, most SIEs are easy to use under field conditions. The sensitivity and applicable concentration range for various membranes and electrodes will vary.

### 5.6.3 Equipment

The following equipment is required for performing quantitative analyses using a specific ion electrode:

- A pH meter with a millivolt scale, or equivalent.
- The specific ion electrode for the parameter to be measured. A partial list of ions which can be measured includes cyanide, sulfide, ammonia, lead, fluoride and chloride.
- A suitable reference electrode to go with the above SIE.

Specific electrodes for other ions have also been developed, but are not widely used for field investigation efforts at this time. Note that of the specific electrodes referenced above, only fluoride and ammonia have analytical methods approved by the U.S. EPA.

### 5.6.4 Measurement Techniques for Inorganic Ions Using Specific Ion Electrodes

Different types of electrodes are used in slightly different ways and are applicable for different concentration ranges. Following the manufacturer's instructions, the general steps given below are usually followed:

- Immerse the electrode in water for a suitable period of time prior to sample analysis.

- Standardize the electrode according to the manufacturer's instructions, including necessary chemical additions for ionic strength adjustment, etc. Standard solutions normally differ by factors of ten in concentration. Constant stirring is needed for accurate readings.

- Immerse the electrode in the sample. Allow the reading to stabilize and record the results in a site logbook. Stir the sample at the same rate as the standards. Air bubbles near the membrane shall be avoided, since this may cause interference in millivolt readings.

(NOTE: Each SIE has substances which interfere with proper measurement. These may be eliminated using pretreatment methods as detailed by the manufacturer. It is important to know if interferences are present so that suspect readings may be noted as such.)

- If the pH meter does not read out directly, plot millivolts versus concentration for the standards and then determine sample concentration.

## 6.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

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

## 7.0 ATTACHMENTS

Attachment A - Specific Conductance of KC1 Solutions at 25 degrees Centigrade

Attachment B - Variation of Dissolved Oxygen Concentration in Water as a a Function of Temperature and Salinity.

## ATTACHMENT A

### SPECIFIC CONDUCTANCE OF M KCl AT VARIOUS TEMPERATURES[1]

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

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

## ATTACHMENT B

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

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

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

| Temperature °C | Dissolved Oxygen mg/l | | | | | |
|---|---|---|---|---|---|---|
| | Chloride Concentration in Water | | | | | Difference/100 mg chloride |
| | 0 | 5,000 | 10,000 | 15,000 | 20,000 | |
| 25 | 8.4 | 8.0 | 7.6 | 7.2 | 6.7 | 0.008 |
| 26 | 8.2 | 7.8 | 7.4 | 7.0 | 6.6 | 0.008 |
| 27 | 8.1 | 7.7 | 7.3 | 6.9 | 6.5 | 0.008 |
| 28 | 7.9 | 7.5 | 7.1 | 6.8 | 6.4 | 0.008 |
| 29 | 7.8 | 7.4 | 7.0 | 6.6 | 6.3 | 0.008 |
| 30 | 7.6 | 7.3 | 6.9 | 6.5 | 6.1 | 0.008 |
| 31 | 7.5 | | | | | |
| 32 | 7.4 | | | | | |
| 33 | 7.3 | | | | | |
| 34 | 7.2 | | | | | |
| 35 | 7.1 | | | | | |
| 36 | 7.0 | | | | | |
| 37 | 6.9 | | | | | |
| 38 | 6.8 | | | | | |
| 39 | 6.7 | | | | | |
| 40 | 6.6 | | | | | |
| 41 | 6.5 | | | | | |
| 42 | 6.4 | | | | | |
| 43 | 6.3 | | | | | |
| 44 | 6.2 | | | | | |
| 45 | 6.1 | | | | | |
| 46 | 6.0 | | | | | |
| 47 | 5.9 | | | | | |
| 48 | 5.8 | | | | | |
| 49 | 5.7 | | | | | |
| 50 | 5.6 | | | | | |

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

| NUS CORPORATION<br>ENVIRONMENTAL MANAGEMENT GROUP | STANDARD OPERATING PROCEDURES | Number SF-1.2 | Page 1 of 10 |
|---|---|---|---|
| | | Effective Date 05/04/90 | Revision 2 |
| | | Applicability EMG | |
| | | Prepared Earth Sciences | |
| Subject SAMPLE PRESERVATION | | Approved D. Senovich | |

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## 1.0 PURPOSE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped offsite for chemical analysis.

## 2.0 SCOPE

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the quality of the sample prior to analysis.

Many water and soil samples are unstable, and therefore require preservation when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s) requiring analysis. While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s) and refrigeration/ freezing. Their purpose is to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

## 3.0 GLOSSARY

HCl - Hydrochloric Acid
$H_2SO_4$- Sulfuric Acid
$HNO_3$ - Nitric Acid
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing one gram-atom of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one gram-atom of H, is "one-normal," while a one molar solution of $H_2SO_4$ containing two gram-atoms of H, is "two-normal."

## 4.0 RESPONSIBILITIES

Field Operations Leader - retains overall responsibility for the proper storage and preservation of samples. During the actual collection of samples, the sampling technician(s) will be directly responsible for the bottling, preservation, labeling, and custody of the samples they collect until released to another party for storage or transport to the analytical laboratory.

## 5.0 PROCEDURES

### 5.1 SAMPLE CONTAINERS

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be determined is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then the container shall be plastic. Since container specification will depend on the analyte and sample matrix types (as indicated in Attachment A) duplicate samples shall be taken when both organic and inorganic analyses are required. Containers shall be kept in the

dark (to minimize biological or photooxidation/photolysis breakdown of constituent) until they reach the analytical laboratory. The sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (1 liter of water at 4°C expands by 15 ml if heated to 130°F/55°C), however, head space for volatile organic analyses shall be omitted.

For CLP laboratories, containers will be obtained through the CLP Sample Management Office. For Responsible party actions or non-CLP laboratories, the laboratory shall provide containers that have been cleaned according to U.S. EPA procedures. Sufficient lead time shall be allowed. Shipping containers for samples, consisting of sturdy ice chests, are provided by the laboratory of the remedial investigation contractor.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded; because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing Teflon liner (if required for the container) shall be discarded.

General sample container and sample volume requirements are listed in Attachment A. Specific container requirements are listed in Attachment B.

## 5.2 PRESERVATION TECHNIQUES

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the Field or added in the Field. In general, aqueous samples of low concentration organics (or soil samples of low or medium concentration organics) are cooled to 4°C. Medium concentration aqueous samples and high hazard organics sample are not preserved. Low concentration aqueous samples for metals are acidified with $HNO_3$, while medium concentration and high hazard aqueous metal samples are not preserved. Low or medium concentration soil samples for metals are cooled to 4°C while high hazard samples are not preserved.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

### 5.2.1 Addition of Acid ($H_2SO_4$, HCl, or $HNO_3$) or Base

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade and shall be diluted to the required concentration with double-distilled, deionized water in the laboratory, before Field sampling commences:

| Acid Base | Concentration | Normality | Amount for Acidification* |
|---|---|---|---|
| HCl | 1:1 dilution of concentrated HCl | 6N | 5-10 ml |
| $H_2SO_4$ | 1:1 dilution of concentrated $H_2SO_4$ | 18N | 2-5 ml |
| $HNO_3$ | Undiluted concentrated $HNO_3$ | 16N | 2-5 ml |
| NaOH | 400 grams solid NaOH in 870 ml water | 10N | 2 ml** |

* Amount of acid to add (at the specified strength) per liter of water to reduce the sample pH to less than 2, assuming that the water is initially at pH 7, and is poorly buffered and does not contain particulate matter.

** To raise pH of 1 liter of water to 12.

The approximate volumes needed to acidify one liter of neutral water to a pH of less than 2 (or raise the pH to 12) are shown in the last column of the above table. These volumes are only approximate; if the water is more alkaline, contains inorganic or organic buffers, or contains suspended particles, more acid may be required. The final pH must be checked using narrow-range pH paper.

Sample acidification or base addition shall proceed as follows:

- Check initial pH of sample with wide range (0-14) pH paper.
- Fill sample bottle to within 5-10 ml of final desired volume and add about 1/2 of estimated acid or base required, stir gently and check pH with medium range pH paper (pH 0-6 or pH 7.5-14, respectively).
- Add acid or base a few drops at a time while stirring gently. Check for final pH using narrow range (0-2.5 or 11-13, respectively) pH paper; when desired pH is reached, cap sample bottle and seal.

  Never dip pH paper into the sample; apply a drop of sample to the pH paper using the stirring rod.

### 5.2.2 Cyanide Preservation

Pre-sample preservation is required if oxidizing agents such as chlorine are suspected to be present. To test for oxidizing agents, place a drop of the sample on KI-starch paper; a blue color indicates the need for treatment. Add ascorbic acid to the sample, a few crystals at a time, until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 g of ascorbic acid for each liter of sample volume. Add NaOH solution to raise pH to greater than 12 as described in 5.2.1. If oxidizing agents are not suspected, add NaOH as directed.

### 5.2.3 Sulfide Preservation

Samples for sulfide analysis must be preserved by addition of 4 drops (0.2 ml) of 2N zinc acetate solution per 100 ml sample. The sample pH is then raised to 9 using NaOH. The 2N zinc acetate solution is made by dissolving 220 g of zinc acetate in 870 ml of distilled water to make 1 liter of solution.

### 5.2.4 Preservation of Organic Samples Containing Residual Chlorine

Some organic samples containing residual chlorine must be treated to remove this chlorine upon collection (See Attachment A). Test the samples for residual chlorine using EPA methods 330.4 or 330.5 (Field Test Kits are available for this purpose). If residual chlorine is present, add 0.008% sodium thiosulfate (80 mg per liter of sample).

### 5.2.5 Field Filtration

When the objective is to determine concentration of dissolved inorganic constituents in a water system, the sample must be filtered through a non-metallic 0.45 micron membrane filter immediately after collection. A filtration system is recommended if large quantities of samples must be filtered in the field. The filtration system shall consist of a Büchner funnel inserted into a single-hole rubber stopper, sized to form a seal when inserted into the top of a vacuum filter flask equipped with a single side arm. Heavy-wall Tygon tubing shall be attached to the single side arm of the vacuum filter flask and the suction port of a vacuum pump. The stem of the Büchner funnel shall extend below the level of the side arm of the vacuum filter flask to prevent any solvent from entering the tubing leading to the vacuum pump. Before filtration, the filter paper, which shall be of a size to lay flat on the funnel plate, shall be wetted with the solvent in order to "seal" it to the funnel. Slowly pour the solvent into the funnel and monitor the amount of solvent entering the vacuum filter flask. When the rate of solvent entering the flask is reduced to intermittent dripping and the added aliquot of solvent in the funnel has passed through the filter, the used filter paper shall be replaced with new filter paper. If the solvent contains a high percentage of suspended solids, a coarser-sized nonmetallic membrane filter may be used prior to usage of the 0.45 micron membrane filter. This "prefiltering" step may be necessary to expedite the filtration procedure. Discard the first 20 to 50 ml of filtrate from each sample to rinse the filter and filtration apparatus to minimize the risk of altering the composition of the samples by the filtering operation. For analysis of dissolved metals, the filtrate is collected in a suitable bottle (see Section 5.1) and is immediately acidified to pH 2.0 or less with nitric acid whose purity is consistent with the measurement to be made. Inorganic anionic constituents may be determined using a portion of the filtrate that has not been acidified.

Samples used for determining temperature, dissolved oxygen, Eh, and pH should not be filtered. Do not use vacuum filtering prior to determining carbonate and bicarbonate concentration because it removes dissolved carbon dioxide and exposes the sample to the atmosphere. Pressure filtration can be done using water pressure from the well. If gas pressure is required, use an inert gas such as argon or nitrogen.

Do not filter samples for analysis of volatile organic compounds. If samples are to be filtered for analyzing other dissolved organic constituents, use a glass-fiber or metal-membrane filter and collect the samples in a suitable container (see Section 5.1). Because most organic analyses require extraction of the entire sample, do not discard any of it. After filtering, the membrane containing the suspended fraction can be sealed in a glass container and analyzed separately as soon as practicable. Total recoverable inorganic constituents may be determined using a second, unfiltered sample collected at the same time as the sample for dissolved constituents.

## 6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. U.S. EPA-EMSL, Cincinnati, Ohio.

## 7.0 ATTACHMENTS

Attachment A - General Sample Container and Preservation Requirements CERCLA/RCRA Samples

Attachment B - Required Containers, Preservation Techniques, and Holding Times (3 sheets)

# ATTACHMENT A
## GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS CERCLA/RCRA SAMPLES

FT-7.06
REVISION 0

| | SAMPLE TYPE & CONCENTRATION | CONTAINER[1] | SAMPLE SIZE | PRESERVATION[2] | HOLDING TIME[2] |
|---|---|---|---|---|---|
| **WATER** | | | | | |
| Organics (GC & GC/MS) | VOA | borosilicate glass | 2 x 40 ml | Cool to 4°C | 7 days |
| | Extractables Low | amber glass | 2 x 2 l or 4 x 1 l | Cool to 4°C | 5 days to extraction 40 days after extraction |
| | Medium | wide-mouth glass | 4 x 32 oz | None | Same as above |
| Inorganics | Metals Low | high density (h.d.) polyethylene | 1 l | $HNO_3$ to pH ≤2 | 6 months (Hg-30 days) |
| | Medium | wide-mouth glass | 16 oz | None | 6 months |
| | Cyanide Low | h.d. polyethylene | 1 l | NaOH to pH >12 | 14 days |
| | Medium | wide-mouth glass | 16 oz | None | |
| Organic/Inorganic | High Hazard | 8 oz wide-mouth glass | 6 oz | None | 14 days |
| COD | -- | h.d. polyethylene | 0.5 l | $H_2SO_4$ to pH <2 | 28 days |
| TOC | -- | h.d. polyethylene | 0.5 l | HCl to pH <2 | 28 days |
| Oil & Grease | -- | glass | 1.0 l | $H_2SO_4$ to pH <2 | 28 days |
| Phenols | -- | h.d. polyethylene | 1.0 l | $H_2SO_4$ to pH <2 | 28 days |
| General Chemistry | -- | h.d. polyethylene | 1.0 l | None | --- |
| **SOIL** | | | | | |
| Organics (GC & GC/MS) | VOA | 2 x 120 ml (4 oz) wide-mouth glass | 240 ml | Cool to 4°C | 10 days |
| | Extractables Low/Medium | 8 oz or 2 x 4 oz (120 ml) wide-mouth glass | 6 oz | Cool to 4°C | 10 days to extraction 40 days after extraction |
| Inorganics | Low/Medium | 8 oz or 2 x 4 oz (120 ml) wide-mouth glass | 6 oz | Cool to 4°C | NA |
| Organic/Inorganic | High Hazard | 8 oz (120 ml) wide-mouth glass | 6 oz | None | NA |
| Dioxin | All | 4 oz (120 ml) wide-mouth glass | 4 oz | None | NA |
| EP Toxicity | All | 250 ml h.d. polyethylene | 200 grams | None | NA |
| **Air** | | | | | |
| Volatile Organics | Low Medium | Charcoal Tube 7 cm long, 6 mm OD, 4 mm ID | 100 l air | Cool to 4°C | NA |

1. All glass containers should have Teflon cap liners or septa.
2. See Attachment B.

SAMPLE CONTAINER AND PRESERVATION REQUIRMENTS CERCLA/RCRA SAMPLES

# ATTACHMENT B
## REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 1

| Parameter No./Name | Container(1) | Preservation(2,3) | Maximum Holding Time(4) |
|---|---|---|---|
| **INORGANIC TESTS:** | | | |
| Acidity | P,G | Cool, 4°C | 14 days |
| Alkalinity | P,G | Cool, 4°C | 14 days |
| Ammonia | P,G | Cool, 4°C, $H_2SO_4$ to pH 2 | 28 days |
| Biochemical Oxygen Demand | P,G | Cool, 4°C | 48 hours |
| Bromide | P,G | None required | 28 days |
| Biochemical Oxygen Demand, Carbonaceous | P,G | Cool, 4°C | 48 hours |
| Chemical Oxygen Demand | P,G | Cool, 4°C, $H_2SO_4$ to pH 2 | 28 days |
| Chloride | P,G | None required | 28 days |
| Chlorine, Total Residual | P,G | None required | Analyze immediately |
| Color | P,G | Cool, 4°C | 48 hours |
| Cyanide, Total and Amenable to Chlorination | P,G | Cool, 4°C, NaOH to pH 12, 0.6g ascorbic acid(5) | 14 days(6) |
| Fluoride | P | None required | 28 days |
| Hardness | P,G | $HNO_3$ to pH 2, $H_2SO_4$ to pH 2 | 6 months |
| Hydrogen Ion (pH) | P,G | None required | Analyze immediately |
| Kjeldahl and Organic Nitrogen | P,G | Cool, 4°C, $H_2SO_4$ to pH 2 | 28 days |
| Nitrate | P,G | Cool, 4°C | 48 hours |
| Nitrate-Nitrite | P,G | Cool, 4°C, $H_2SO_4$ to pH 2 | 28 days |
| Nitrite | P,G | Cool, 4°C | 48 hours |
| Oil and Grease | G | Cool, 4°C, $H_2SO_4$ to pH 2 | 28 days |
| Organic Carbon | P,G | Cool, 4°C, HCl or $H_2SO_4$ to pH 2 | 28 days |
| Orthophosphate | P,G | Filter immediately, Cool, 4°C | 48 hours |
| Oxygen, Dissolved-Probe | G Bottle and top | None required | Analyze immediately |
| Oxygen, Dissolved-Winkler | G Bottle and top | Fix on site and store in dark | 8 hours |
| Phenols | G | Cool, 4°C, $H_2SO_4$ to pH 2 | 28 days |
| Phosphorus (elemental) | G | Cool, 4°C | 48 hours |
| Phosphorus, Total | P,G | Cool, 4°C, $H_2SO_4$ to pH 2 | 28 days |
| Residue, Total | P,G | Cool, 4°C | 7 days |
| Residue, Filterable | P,G | Cool, 4°C | 48 hours |
| Residue, Nonfilterable (TSS) | P,G | Cool, 4°C | 7 days |
| Residue, Settleable | P,G | Cool, 4°C | 48 hours |
| Residue, Volatile | P,G | Cool, 4°C | 7 days |
| Silica | P | Cool, 4°C | 28 days |
| Specific Conductance | P,G | Cool, 4°C | 28 days |
| Sulfate | P,G | Cool, 4°C | 28 days |
| Sulfide | P,G | Cool, 4°C, add zinc acetate plus sodium hydroxide to pH 9 | 7 days |
| Sulfite | P,G | None required | Analyze immediately |
| Surfactants | P,G | Cool, 4°C | 48 hours |
| Temperature | P,G | None required | Analyze immediately |
| Turbidity | P,G | Cool, 4°C | 48 hours |
| **METALS:(7)** | | | |
| Chromium VI | P,G | Cool, 4°C | 24 hours |
| Mercury | P,G | $HNO_3$ to pH 2 | 28 days |
| Metals, except Chromium VI and Mercury | P,G | $HNO_3$ to pH 2 | 6 months |

# ATTACHMENT B
## REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

PAGE 2

| Parameter No./Name | Container(1) | Preservation(2,3) | Maximum Holding Time(4) |
|---|---|---|---|
| ORGANIC TESTS:(8) | | | |
| Purgeable Halocarbons | G, Teflon-lined septum | Cool, 4°C, 0.008% $Na_2S_2O_3$(5) | 14 days |
| Purgeable Aromatic Hydrocarbons | G, Teflon-lined septum | Cool, 4°C, 0.008% $Na_2S_2O_3$(5) HCl to pH 2(9) | 14 days |
| Acrolein and Acrylonitrile | G, Teflon-lined septum | Cool, 4°C, 0.008% $Na_2S_2O_3$(5) adjust pH to 4-5(10) | 14 days |
| Phenols(11) | G, Teflon-lined cap | Cool, 4°C, 0.008% $Na_2S_2O_3$(5) | 7 days until extraction, 40 days after extraction |
| Benzidines(11) | G, Teflon-lined cap | Cool, 4°C, 0.008% $Na_2S_2O_3$(5) | 7 days until extraction(13) |
| Phthalate Esters(11) | G, Teflon-lined cap | Cool, 4°C | 7 days until extraction, 40 days after extraction |
| Nitrosamines(11,14) | G, Teflon-lined cap | Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$(5) | 7 days until extraction, 40 days after extraction |
| PCBs(11) Acrylonitrile | G, Teflon-lined cap | Cool, 4°C | 7 days until extraction, 40 days after extraction |
| Nitroaromatics and Isophorone(11) | G, Teflon-lined cap | Cool, 4°C, 0.008% $Na_2S_2O_3$(5), store in dark | 7 days until extraction, 40 days after extraction |
| Polynuclear Aromatic Hydrocarbons(11) | G, Teflon-lined cap | Cool, 4°C, 0.008% $Na_2S_2O_3$(5), store in dark | 7 days until extraction, 40 days after extraction |
| Haloethers(11) | G, Teflon-lined cap | Cool, 4°C, 0.008% $Na_2S_2O_3$(5) | 7 days until extraction, 40 days after extraction |
| Chlorinated Hydrocarbons(11) | G, Teflon-lined cap | Cool, 4°C | 7 days until extraction, 40 days after extraction |
| TCDD(11) | G, Teflon-lined cap | Cool, 4°C, 0.008% $Na_2S_2O_3$(5) | 7 days until extraction, 40 days after extraction |
| PESTICIDES TESTS: | | | |
| Pesticides(11) | G, Teflon-lined cap | Cool, 4°C, pH 5-9(15) | 7 days until extraction, 40 days after extraction |
| RADIOLOGICAL TESTS: | | | |
| 1-3 Alpha, beta and radium | P, G | $HNO_3$ to pH 2 | 6 months |

**TABLE 1 Notes**

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the ime of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at ·° until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation zardous Materials Regulations (49 CFR Part 172).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis 1 still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the ic types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator.

(5) Should only be used in the presence of residual chlorine.

## ATTACHMENT B
## REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES



(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).

(12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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|---|---|---|---|
| | | Effective Date 05/04/90 | Revision 1 |
| | | Applicability EMG | |
| | | Prepared Earth Sciences | |
| Subject DECONTAMINATION OF CHEMICAL SAMPLING AND FIELD ANALYTICAL EQUIPMENT | | Approved D. Senovich | |

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**7.0 RECORDS**

## 1.0 PURPOSE

The purpose of these procedures is to provide a general methodology, protocol, and reference information on the proper decontamination procedures to be used on chemical sampling and field analytical equipment.

## 2.0 SCOPE

This procedure addresses chemical sampling and field analytical equipment only, and should be consulted when equipment decontamination procedures are being developed as part of project-specific plans.

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Site Manager - responsible for ensuring that project-specific plans and the implementation of field investigations are in compliance with these guidelines.

Field Operations Leader - responsible for ensuring that decontamination procedures for all chemical sampling and field analytical equipment are programmed prior to the actual field effort and that personnel required to accomplish the task have been briefed and trained to execute the task.

## 5.0 PROCEDURES

In order to assure that chemical analysis results are reflective of the actual concentrations present at sampling locations, chemical sampling and field analysis equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sample points) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sample points and the transfer of contamination offsite.

This procedure incorporates only those aspects of decontamination not addressed in other procedures. Specifically it incorporates those items involved in decontamination of chemical sampling and field analytical equipment.

### 5.1 ACCESS FOR SAMPLING

#### 5.1.1 Bailers and Bailing Line

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

Before the initial sampling and after each succeeding sampling point, the bailer must be decontaminated. The following steps should be followed if sampling for organic contaminants:

- Potable water rinse
- Alconox or Liquinox detergent wash
- Scrubbing of the line and bailer with a scrub brush may be required if the sample point if heavily contaminated with heavy or extremely viscous compounds
- Potable water rinse
- Rinse with 10 percent nitric acid solution*
- Deionized water rinse
- Acetone or methanol rinse
- Hexane rinse**
- Distilled/Deionized water rinse
- Air dry

If sampling for organics only, the nitric acid, acetone, methanol, and hexane rinses may be omitted. Contract-specific requirements may permit alternative procedures.

Braided nylon or polypropylene lines may be used with a bailer, however, the same line must not come in contact with the sample medium, otherwise, the line must be discarded in an approved receptacle and replaced. Prior to use, the bailer should be wrapped in aluminum foil or polyethylene sheeting.

### 5.1.2 Sampling Pumps

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

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

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

---

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

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

### 5.1.3 Filtering Equipment

Part of the sampling plan may incorporate the filtering of groundwater samples, and subsequent preservation. This should occur as soon after sample retrieval as possible; preferably in the field as soon as the sample is obtained. To this end, three basic filtration systems are most commonly used - the in-line disposable Teflon filter, the inert gas over-pressure filtration system, and the vacuum filtration system.

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

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

## 5.2 FIELD ANALYTICAL EQUIPMENT

### 5.2.1 Water Level Indicators

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

- Rinse with potable water
- Rinse with deionized water
- Acetone or methanol rinse
- Rinse with deionized water

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

### 5.2.2 Probes

Probes, e.g., pH or specific ion electrodes, geophysical probes, or thermometers which would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise; in those cases, the methods of decontamination must be clearly described in the FSAP. Probes that contact a volume of groundwater not used for laboratory analyses can be rinsed with deionized water. For probes which make no direct contact, e.g., OVA equipment, the probe will be wiped with clean paper-towels or cloth wetted with alcohol.

## 6.0 REFERENCES

None.

## 7.0 RECORDS

None.

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## 1.0 PURPOSE

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

## 2.0 SCOPE

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

## 3.0 GLOSSARY

None.

## 4.0 RESPONSIBILITIES

Site Geologist - Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used onsite the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

## 5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

### 5.1 MATERIALS NEEDED

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute HCl
- Ruler (marked in tenths and hundreths of feet)
- Hand Lens

### 5.2 CLASSIFICATION OF SOILS

All data shall be written directly on the boring log (Exhibit 4-1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

### 5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Exhibit 4-2. This method of classification identifies soil types on the basis of grain size and cohesiveness.

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

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

### 5.2.2 Color

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

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

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

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

### 5.2.3 Relative Density and Consistency

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

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

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

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

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

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

| Consistency | Unc. Compressive Str. Tons/Square Foot | Standard Penetration Resistance (Blows per Foot) | Field Identification Methods |
|---|---|---|---|
| Very soft | Less than 0.25 | 0 to 2 | Easily penetrated several inches by fist |
| Soft | 0.25 to 0.50 | 2 to 4 | Easily penetrated several inches by thumb |
| Medium stiff | 0.50 to 1.0 | 4 to 8 | Can be penetrated several inches by thumb |
| Very stiff | 1.0 to 2.0 | 8 to 15 | Readily indented by thumb |
| Hard | 2.0 to 4.0 | 15 to 30 | Readily indented by thumbnail |
| Hard | More than 4.0 | Over 30 | Indented with difficulty by thumbnail |

### 5.2.4 Weight Percentages

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

| Terms of Identifying Proportion of the Component | Defining Range of Percentages by Weight |
| --- | --- |
| trace | 0 - 10 percent |
| some | 11 - 30 percent |
| and or adjective form of the soil type (e.g., "sandy") | 31 - 50 percent |

Examples:

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

### 5.2.5 Moisture

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

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

### 5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Exhibit 4-4.

### 5.2.7 Texture/Fabric/Bedding

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

### 5.2.8 Summary of Soil Classification

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

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

## 5.3 CLASSIFICATION OF ROCKS

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

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

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

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

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

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

- Coal - Rock consisting mainly of organic remains.

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

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

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

### 5.3.1 Rock Type

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

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

### 5.3.2 Color

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

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

### 5.3.3 Bedding Thickness

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

### 5.3.4 Hardness

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

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

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

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

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

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

### 5.3.5 Fracturing

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

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

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

Method of Calculating RQD
(After Deere, 1964)

RQD % = r/l x 100

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

l = Total length of the coring run.

### 5.3.6 Weathering

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

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

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

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

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

### 5.3.7 Other Characteristics

The following items shall be included in the rock description:

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

- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

### 5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inch or less), probably continuous layer.

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

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

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

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

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

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

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

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

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

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

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

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

## 5.4 ABBREVIATIONS

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

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

## 5.5 BORING LOGS AND DOCUMENTATION

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

### 5.5.1 Soil Classification

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

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

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

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

- Enter color of the material in the appropriate column.

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

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

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

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

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

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

  - Angularity - describe angularity of coarse grained particles using Angular, Subangular, Subrounded, Rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

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

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak or strong.

- Additional comments:

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

  - Indicate odor and HNu or OVA reading if applicable.

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

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

  - Vertical lines shall be drawn (as shown in Exhibit 4.6) in columns 5 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

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

### 5.5.2 Rock Classification

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

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

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

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

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

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

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

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

- Remarks at the bottom of Boring Log shall include:

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

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

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

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

### 5.5.3 Classification of Soil and Rock from Drill Cuttings

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

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

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

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

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

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

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split barrel and rock core sampling methods be used at selected boring locations during the field investigation to

provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

## 5.6 REVIEW

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs
- Checking for conformance to the guideline
- Checking to see that all information is entered in their respective columns and spaces

## 6.0 REFERENCES

Unified Soil Classification System (USCS)

ASTM D2488, 1985

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

## 7.0 RECORDS

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

## EXHIBIT 4-1

***BORING LOG*** ***NUS CORPORATION***

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

| SAMPLE NO. & TYPE OR RQD | DEPTH (ft.) OR RUN NO. | BLOWS/ 6" OR RQD (%) | SAMPLE RECOVERY /SAMPLE LENGTH | LITHOLOGY CHANGE (Depth,ft.) OR SCREENED INTERVAL | MATERIAL DESCRIPTION | | | USCS OR ROCK | BROKENNESS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | | | |
| | | | | | | | | | | |
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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

| | FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3" & basing fractions on estimated weights) | | | GROUP SYMBOL | TYPICAL NAMES |
|---|---|---|---|---|---|
| | Identification procedures on fraction smaller than No. 40 sieve size | | | | |
| | DRY STRENGTH (Crushing Characteristics) | DILATANCY (Reaction to Shaking) | TOUGHNESS (Consistency Near Plastic Limit) | | |
| SILTS & CLAYS Liquid limit < 50 | None to slight | Quick to slow | None | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity |
| | Medium to high | None to very slow | Medium | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | Slight to medium | Slow | Slight | OL | Organic silts and organic silt-clays of low plasticity |
| SILTS & CLAYS Liquid limit > 50 | Slight to medium | Slow to none | Slight to medium | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts |
| | High to very high | None | High | CH | Inorganic clays of high plasticity, fat clays |
| | Medium to high | None to very slow | Slight to medium | OH | Organic clays of medium to high plasticity |
| HIGHLY ORGANIC SOILS | Readily identified by color, odor, spongy feel and frequently by fibrous texture. | | | Pt | Peat and other organic soils |

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

## DENSITY OF GRANULAR SOILS

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

## CONSISTENCY OF COHESIVE SOILS

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

# ROCK TERMS

## ROCK HARDNESS (FROM CORE SAMPLES)

| DESCRIPTIVE TERMS | SCREWDRIVER OR KNIFE EFFECTS | HAMMER EFFECTS |
|---|---|---|
| Soft | Easily gouged | Crushes when pressed with hammer |
| Medium soft | Can be gouged | Breaks (one blow) Crumbly edges |
| Medium hard | Can be scratched | Breaks (one blow) Sharp edges |
| Hard | Cannot be scratched | Breaks conchoidally (several blows) Sharp edges |

## ROCK BROKENNESS

| DESCRIPTIVE TERMS | ABBREVIATION | SPACING |
|---|---|---|
| Very broken | (V. Br.) | 0 - 2" |
| Broken | (Br.) | 2" - 1' |
| Blocky | (Bl.) | 1' - 3' |
| Massive | (M.) | 3' - 10' |

## LEGEND

**SOIL SAMPLES - TYPES**

S - 2" O.D. Split Barrel Sample
ST - 3" O.D. Undisturbed Sample
O - Other Samples, Specify in Remarks

**ROCK SAMPLES - TYPES**

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

**WATER LEVELS**

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

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

EXHIBIT 4-2

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: WL 26.35 - TPVC 10-16-87
(Date, Time & Conditions)

| 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 UNCONSOLIDATED USCS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| S-1 | 0.0 | 3/6 | 1.5/1.5 | | STIFF | BRN | CLAYEY SILT - TR SHALE | ML | 0-6" TOPSOIL MOIST 0PPM |
| | 1.5 | 6 | | | | | FRAG - TR ORG. | | RESIDUAL SOIL. |
| | 5.0 | | | | | | | | |
| S-2 | 6.0 | 11/100/.5 | 0.8/1.0 | 5.5/6.0 | M. SOFT | GRAY BRN | DEC SHALE AND SILT | VBR | DAMP 0PPM |
| | | | | | TO | | | | REFUSAL @ 6' 5.5 TOP OF DEC ROCK |
| | | | | | M. HARD | | | | |
| | | | | | | | | | AUGERED TO 15' W/SOLID STEM AUG. |
| | | | | | | | | | CUTTING MOIST @ ≈8' WATER @ 11'± |
| | | | | | | | | | WL @ 12:10 PM WAS ≈ 9' FROM GS. |
| | | | | | | | | | SET 4" PVC CAS. @ 15.0' |
| 9-21 | 15.0 | | | | | | | | |
| 9-22 | | | | | M. HARD | BRN GRAY | SILTY SHALE - FEW | VBR | SEVERAL 0 PPM |
| | | | | | | | QUARTZ PCS | | Fe STAINED JOINTS ON CORE THRUOUT RUN. JOINTS AND BREAKS ARE HORIZ TO LO ∠. W/ VUGS ON LOWER PORTION 23 TO 25 OF CORE |
| | 0.9/10.0 | ① | 0.9/10 | 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: S.J. 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 1.0 & JNTS |
| | | | | | | | | (SILTSTONE) | | ≈26 TO 27 2-VERT |
| | | | | | | | | - FEW QUARTZ | | JOINTS. IRON STAINS ON JNTS |
| | | | | | | | | SEAMS | | ROCK BECOMES AND BREAKS MORE LIKE |
| | | | | | | | | | | A SILTSTONE WITH DEPTH. |
| | 9/10.0 | 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.) | MATERIAL DESCRIPTION* SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 1.9/10.0 | 4 | 19%/0 | 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%/0 | 1.8/10.0 | | | | | | |
| | 65.0 | | | | | | | | |
| | | | | 66 | | | | | |
| | | | | | | | | | 68.0 - DRILLER NOTED SOFT AREA - LOSS OF 1/3 OF WATER - CHANGE IN COLOR OF DRILL WATER TO YELLOW BROWN |
| 0/0 | 6 | 0%/0 | 1.3/10.0 | | | | | | |
| | | | | | | | | | POOR RECOVERY |
| | | | | | | | | | FEW CALCAREOUS ZONES. |
| | 75.0 | | | 76 | | | | | |

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

BORING MW 3A

PAGE 3 OF 3

* See Legend on Back

## EXHIBIT 4-6

**BORING LOG** — **NUS CORPORATION**

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

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

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

SAMPLES TAKEN USING 140 lb WT AND 30 INCH DROP.

BORING MW 013

PAGE 1 OF 4

**BORING LOG** — **NUS CORPORATION**

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

| SAMPLE NO. & TYPE OR RQD | DEPTH (ft.) OR RUN NO | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREEN INT | MATERIAL DESCRIPTION: SOIL DENSITY-CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS (HNU) |
|---|---|---|---|---|---|---|---|---|---|
| S-6 | 25.0 | 6 / 17 | 1.1/1.5 | | DENSE | OLIVE BLUE | SILTY SAND - SOME | GM | WET 0PPM |
| | 26.5 | 30 | | | | GRAY | GRAVEL - TR CLAY | | C.S. IS FRIABLE FIRST CHANGE IN |
| | | | | | | | TR. SS. FRAG | | COLOR. NOT ENOUGH CLAY TO BE CONFINING |
| | | | | | | | | | NOTE: MAY SET ZONE 2 |
| 7/7 | 30.0 | | | | | MOTTLED | | | CASING @ 28' |
| 7/8 S-7 | | 17 / 27 | 1.4/1.5 | | V. DENSE | BRN BLUE GRAY | SILTY SAND - SOME GRAVEL | SM/GM | MOIST → WET (OPPM) |
| | 31.5 | 36 | | | | | TR SS. FRAG | | CONSISTOR IS BLUE GRAY & FRIABLE. |
| | | | | | | | TR CLAY | | SUBROUNDED GRAVEL |
| | | | | | | | | | NOT MUCH CLAY - BUT MAY BE SEMI-CONFINING. |
| | 35.0 | | | | | | | | |
| S-8 | 35.9 | 30 / 50/4 | 0.7/0.9 | | V. DENSE | BLUE GRAY | SILTY F. TO C. SAND - | SM/ | MOIST → WET (OPPM) |
| | | | | | | | SOME GRAVEL | GM | V. SL. TR. CLAY - LESS |
| | | | | | | | TR. SS. FRAG. | | THAN S-7 1" Φ 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 | HOLDS 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" Φ SIZE - HOLDS TOGETHER WHEN SQUEEZED |
| | | | | | | | CLAY | | BUT NOT COHESIVE CLASSIFICATION |
| | | | | | | | | | SLOW DRILLING TO 50' |

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

BORING MW013

PAGE 2 OF 4

**BORING LOG** — **NUS CORPORATION**

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

| | SAMPLE NO. & TYPE or RQD | DEPTH (ft.) or RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) or SCREEN INT | MATERIAL DESCRIPTION: SOIL DENSITY/CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | ROCK & SOIL USCS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | S-11 | 50.0 | 15 / 41 | 1.0/1.3 | | V. DENSE | MOTTLED BLUE | SILTY SAND - SOME GR. | SM | MOIST - (OPPM) |
| | | 51.3 | 50/3 | | | | ERTH 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 | SC | MOIST → WET (OPPM) |
| | | 56.5 | 26 | | | | | SOME GRAVEL | | 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 | SC / GW | MOIST → WET (OPPM) |
| | | | | | | | | GRAVEL | | NOT AS MUCH CLAY AS S-12 BUT VERY COMPACT. SUBROUNDED GRAINS |
| | | | | | | | | | | SET CAS. @ 60'. |
| | | 65.0 | | | | | | | | |
| 7/13 | S-14 | 65.8 | 37 / 50/.3 | 0.7/0.8 | | V. DENSE | BRN ORANG | SILTY SAND - SOME GR. | SM / GW | MOIST (OPPM) |
| | | | | | | | | AND ROCK FRAG - | | MORE CLAY TOWARDS TOP OF SAMPLE |
| | | | | | 68.0 | | | TR. CLAY | | MAX 3/4" Φ SIZE |
| | | | | | | | YELLOW BRN | | | COLOR CHANGE AT ≈ 68' MORE SAND PER |
| | | 70.0 | | | | | | | | DRILLER - BOTTOM OF SEMI 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
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**BORING LOG** — **NUS CORPORATION**

PROJECT: WESTLINE SITE — BORING NO.: MW013
PROJECT NO.: 437Y — DATE: 7-13-87 / 7-14-87 — DRILLER: B. ERICSON
ELEVATION: — FIELD GEOLOGIST: 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 SCR. INT | MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | BROKENNESS | Rock or USCS | REMARKS (HNU) |
|---|---|---|---|---|---|---|---|---|---|---|
| S-16 | 75.0 | 28 50/.5 | 0.9/1.0 | | V DENSE | GRAY ORANG BRN | FINE TO C. CLAYEY SAND - SOME | | GC | 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 PC. |
| | 80.0 | | | | | | | | | NO SAMPLE @ 80' - |
| | | | | | | | | | | DECIDED TO GO TO 85'. |
| | 85.0 | 50/.4 | 0.4/0.4 | | V. DENSE | GRAY ORANG. BRN | SILTY F. TO C. SAND - SOME | | GW | WET (0PPM) |
| S-17 | 85.4 | | | 85 | | | GRAVEL - TR | | | SUBROUNDED GRAINS |
| | | | | | | | S.S. FRAG - TR | | | V. SL TR CLAY - WILL |
| | | | | | | | CLAY | | | SET SCREEN ≈ 75' TO 85' IN THIS |
| | | | | | | | | | | BORING. |
| | | | | | | | BOTM OF HOLE @ 85.0' | | | |

REMARKS S-17 @ 2:20 PM 7-14-87 - METHOD BEGINS 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<br>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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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.

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- 5.3 DATA ANALYSIS

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## 1.0 PURPOSE

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

## 2.0 SCOPE

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

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

## 3.0 GLOSSARY

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

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

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

## 4.0 RESPONSIBILITIES

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

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

## 5.0 PROCEDURES

### 5.1 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN WELLS

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

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

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

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

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

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

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

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

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

## 5.2 IN-SITU HYDRAULIC CONDUCTIVITY TESTING IN BORINGS

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

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

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

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

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

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

## 5.3 DATA ANALYSIS

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

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

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

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

## 6.0 REFERENCES

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

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

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

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

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

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

## 7.0 RECORDS

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

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

## ATTACHMENT A
## HYDRUALIC CONDUCTIVITY TESTING DATA SHEET

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

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

| TIME | ELAPSED TIME (min. or sec.) | MEASURED DEPTH TO WATER (ft.) | CORRECTION | DEPTH TO WATER (ft.) | DRAWDOWN OR HEAD (ft.) | REMARKS |
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|---|---|---|---|
| | | Effective Date 05/04/90 | Revision 1 |
| | | Applicability EMG | |
| | | Prepared Earth Sciences | |
| Subject MAGNETIC AND METAL DETECTION SURVEYS | | Approved D. Senovich | |

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## 1.0 PURPOSE

The purpose of this guideline is to provide a general description of, and technical management guidance on, the use of Magnetic and Metal Detection Surveys for site investigations.

## 2.0 SCOPE

This guideline provides a description of the principles of operation, instrumentation, applicability and implementability of standard geophysical methods used during site investigations to determine site features related to magnetic anomalies and buried metal. The document is intended to be used by the site manager (SM), RI leader, Field Operations Leader, or site geologist to 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 subject geophysical methods requires inclusion of project-specific, site-specific, and subcontractor-specific information prior to development of detailed operating procedures, during both planning and execution.

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

Magnetic Susceptibility -- Property of a material corresponding to its ability to distort an applied magnetic field.

Magnetometer -- A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey -- A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal detection -- A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Magnetometry -- The science of measuring variations in the earth's magnetic field.

## 4.0 RESPONSIBILITIES

Site Manager -- responsible for scoping the magnetic or metal detection surveys during development of the Work Plan with the help of the RI leader, site geologist, and site geophysicist.

Site Geophysicist -- central role in determining the technique used for providing necessary data. Field work for these surveys is supervised by the site geophysicist, with support from geophysical technical specialists and other personnel as needed. Data reduction and interpretation are performed by the site geophysicist or technical specialists.

## 5.0 PROCEDURES

## 5.1 DESCRIPTION OF METHODS

### 5.1.1 Theory and Principles of Operation

**Magnetometry**

Materials subject to a magnetic field will develop an induced magnetization, proportional to the applied magnetic field and the magnetic susceptibility of the material.

Induced magnetization in an object produces a local magnetic field which either reinforces (positive magnetic susceptibility) or reduces (negative susceptibility) the external applied field. The variations in an otherwise homogenous field caused by the presence of the object is called a magnetic anomaly, and observations of such anomalies can be used to infer the presence of magnetic objects.

Because there are numerous factors that affect magnetic fields there is no unique interpretation of a set of magnetometry data. Conversely, there is no unique magnetic anomaly produced by a particular kind of buried object. Factors that influence the response of a magnetometer to buried objects include the size, shape, depth, orientation, and magnetic susceptibility of the buried material, and permanent magnetometers such that many objects of interest at hazardous waste sites (particularly buried ferromagnetic materials such as drums, tanks, pipes and iron scrap) are detectable. While the location of ferromagnetic material can be detected to the precision of the survey, difficulties may be encountered in interpreting and attempting to identify the source of magnetic anomalies.

**Metal Detection**

When a radio frequency electromagnetic field generated by a transmitter coil encounters a highly conductive object such as metal (not necessarily ferromagnetic), alternating currents are induced in the object that, in turn, generate alternating secondary magnetic fields that are detected as alternating voltages by a receiver coil. The presence of the metal object effectively "couples" the transmitter and receiver coils, which otherwise are oriented so that little or no coupling exists. The principles of metal detector operation are very similar to those associated with electromagnetic induction instruments.

A number of factors influence the response of a metal detector. The receiver response increases with the size and surface area, and decreases with the depth of a buried object. Factors such as soil properties and object shape complicate detectability and interpretation. Certain shapes, such as elongated metal rods, are difficult to detect. Iron minerals and conductive fluids will affect the detector response in much the same manner as a target of interest. Generally, metal detectors show greater response to smaller nearby targets than to larger targets at greater depth, and the presence of widespread metallic debris at a site can interfere with attempts to detect buried drums and other objects.

### 5.1.2 General Applicability

**Magnetic Surveys (Magnetometry)**

Applications of magnetic surveys at hazardous waste sites center on confirming the presence (or absence) and location of buried ferromagnetic objects. Location of buried waste containers such as drums or tanks and surveying of proposed drill sites to detect interfering pipes, cables or tanks are

two important applications. Typically, a single 55-gallon drum can be detected at distances of up to 3 meters and large drum deposits or large tanks can be detected at distances of 12 meters or more.

Magnetic surveys can more readily detect metallic masses than identify or characterize targets. Calculations of the mass or size of detected objects generally yield only approximate results.

Magnetic surveys may be impractical in areas where metal pipes, fences, railroad tracks, metal buildings, and other ferrous metal artifacts are abundant. However, proper selection of equipment and survey techniques can often alleviate some of these problems.

**Metal Detection**

Metal detectors (MDs) can be used for locating buried metallic containers of various sizes; defining the boundaries of trenches containing metallic containers; locating buried metallic storage tanks; locating buried metallic pipes; avoiding buried utilities when drilling or trenching; or locating utility trenches which may provide a permeable pathway for contaminants.

The detection range of a MD is relatively short. Its sensitive areas are focused directly above and below the coil providing good definition of object location. Quart-sized metal objects can be detected at a distance of about 1 meter; objects the size of a 55 gallon drum can be detected up to 3 meters; and massive piles of metals can be detected at depths of 3 to 6 meters. Deeper objects are difficult to detect with an MD. Although most MDs are operated on foot, some can be vehicle-mounted if desired.

### 5.1.3 Instrumentation

**Magnetometers**

Two types of magnetometers, the fluxgate and proton precession magnetometers, are commonly used at hazardous waste sites. The fluxgate magnetometer uses an iron core of high magnetic susceptibility as a sensor. The amount of coiled electrical current necessary to induce magnetic saturation of the rod is directly dependent upon, and thus measures, the strength of the ambient magnetic field. In a proton precession magnetometer a strong magnetic field is applied to a bottle or proton-rich fluid (e.g., kerosene) that realigns the protons. The field is then turned off and the frequency of the signal generated by the protons as they realign themselves ("precess") to the earth's magnetic field is dependent upon and measures the strength of the field at that point. Some magnetometers, such as the fluxgate, are extremely sensitive to orientation during measurement. In order to alleviate this problem, two sensors are connected by a rigid pole to form a "gradiometer" that measures only a certain directional component of the earth's magnetic field. These gradiometers are commonly used at hazardous waste sites.

The type of magnetometer best suited for a particular site investigation depends upon characteristics of that site and should be chosen by a person familiar with the different instruments available. Proton precession magnetometer, for example, while very useful in many situations, will cease to function in an area with high magnetic gradients such as a junkyard or near a steel bridge.

Different instruments have different levels of sensitivity. Whereas in some cases, high sensitivity may be desired to detect deeply buried objects, in other instances, a low sensitivity instrument may be desired to reduce the effects of "noise" from nearby fences or cars. Furthermore, the size of the survey area and the resolution required will determine whether the magnetometer used is hand-held for stationary measurements or a vehicle-mounted continuous sensor model.

**Metal Detectors (MDs)**

Three general classes of metal detectors are commonly used in hazardous waste site studies: pipeline/cable locators, conventional "treasure hunter" detectors and specialized detectors. The pipeline/cable detectors are commonly used by EPA field investigation teams. They do not respond to small objects like soda cans. Although most of the "treasure hunter" type detectors are used for locating coin-sized objects, some can be fitted with larger sensor coils suitable for detection of larger objects at greater depths. Some of these models also can operate with adverse soil conditions such as high iron content. Specialized detectors are also available to operate to greater depths, over a wide sweep area, operate continuously, cope with special field problems, or operate while vehicle-mounted. These special MDs require an experienced operator and are not commonly available.

## 5.2 DATA ACQUISITION

### 5.2.1 Field Procedures

**Magnetics**

Magnetic measurements are generally made in a cross-grid pattern, or if a continuous sensor is used, in a series of parallel lines across the survey area. The desired resolution (reconnaissance or high density) and the size and depth of the objects sought, determines the spacing of measurement stations or survey lines. Because of the phenomenon of temporal magnetic drift, a magnetic survey must include a base station where magnetic measurements are made at regular intervals. These base station readings are later used to correct that survey data for temporal differences due to drift. If the survey area permits, surveys are often conducted in a loop, the base station forming the end and starting points.

Special care must be taken with handling of the magnetometer during use. The operator must not take measurements with the sensor near ferromagnetic objects such as belt buckles or steel-toed boots. The orientation of the magnetometer and its height from the ground must also be carefully controlled during operation. Recorded data must be annotated with station locations to allow construction of a site magnetic map.

**Metal Detector**

Surveys with metal detectors are similar in planning to those with magnetometers. A grid pattern of evenly spaced parallel lines is used. Desired resolution and the size of objects determine spacing. In some cases, elevating the MD a few feet off the ground may help to eliminate noise from small surface objects. An experienced operator is recommended. Recorded data must be annotated with station locations to allow construction of a site metal detection map.

### 5.2.2 Data Format

**Magnetics**

The output of a magnetometer is a numerical value (in gausses) of the intensity of the earth's magnetic field at a location. It may be displayed electronically or printed on a strip chart depending on the instrument used. Because the object of a magnetic survey is generally to complete a map of the survey area, each magnetic reading must be coupled with a record of its precise location.

The times of each reading must also be recorded to allow temporal drift connection. Some recent proton magnetometers include microprocessors for recording information on readings, locations, and times in one memory for playback at the survey's completion.

Metal Detection

The data provided by a metal detector is less quantitative than that of a magnetometer. The MD signal strength may vary (depending on the instrument) with object depth, size and shape, but this signal does not translate into a quantity such as field strength. It merely indicates the presence of a metal object. This on/off type of signal is useful because it can indicate the boundaries of a metal-bearing zone more clearly than some quantitative data such as magnetometer recordings.

## 5.3 DATA INTERPRETATION

### 5.3.1 Magnetics

#### 5.3.1.1 Correction of Diurnal Variations

Corrections for diurnal variations are made by plotting base station readings on a time-versus-total-field graph; total-field values for times in between actual readings are interpolated. A datum value for total field is chosen, and the differences ($\Delta T$) between the base station total-field reading and the datum value can be determined for any time during the survey. The corrected total-field reading for the survey data is obtained by adding $\Delta T$ to the total-field reading.

#### 5.3.1.2 Depth Estimates from Total Field

The width of a magnetic anomaly is proportional to the depth (or distance) of the source from the magnetometer sensor; the deeper the source, the broader the anomaly. This relationship is of primary importance in interpreting the results of a magnetic survey. The proportion between the width of an anomaly and the depth of the source is a function of the fall-off rate, or the variation of anomaly amplitude with distance(d). For a dipole, the total-field anomaly amplitude varies as $1/d^3$, and for a monopole as $1/d^2$. In actual practice, source orientation and other factors may result in fall-off rates from $1/d$ to $1/d^3$. The shape of the magnetic profile of an anomaly and knowledge of the source object help in selecting the proper fall-off rate for depth estimation. A range of depths determined from several fall-off rates may be the most appropriate way to present depth estimates.

In general the anomaly width is on the order of one to three times the depth of the source. Thus, for an anomaly with a width of 100 feet, the source probably lies between 30 and 100 feet deep (or distant). Several methods, including the half-width rule and the slope technique, can be used to estimate source depths from total field profiles.

#### 5.3.1.3 Half-Width Rule

The half-width ($x_{1/2}$) of an anomaly on a total field profile is the horizontal distance between the principal maximum (or minimum) of the anomaly (assumed to be over the center of the source) and the point where the total field value is exactly one-half of the principal maximum (Figure 3.2-1). A profile that is used for depth estimation by using the half-width rule should be oriented perpendicular to the long axis of the anomaly to give the narrowest profile. This rule is valid only for forms such as spheres, cylinders, and other simple shapes. For example, a single upright 55-gallon steel drum can be approximated as a vertical cylinder (monopole) and the depth (d) = $1.3\,x_{1/2}$. A buried trench filled with drums can be approximated by a horizontal cylinder, where $d = 2\,x_{1/2}$.

#### 5.3.1.4 Slope Techniques

Depth of the source can be estimated using the slope of the anomaly at the inflection points of the profile. The horizontal extent ($X_z$) of the "straight" portion of the slope is determined as shown in Figure 3.2-1. The depth is then estimated by the equation,

$$d = KX_z \, where \, 0.5 < K < 1.5$$

### 5.3.2 Metal Detection

Very little interpretation is necessary for Metal Detection surveys performed to provide qualitative data on the presence of metallic objects in the survey area, as a precursor to more detailed subsequent geophysical surveys. For these cases, the positive audible responses or meter deflections are recorded on site grid maps and no further processing or interpretation is made. More detailed metal detection surveys using strip-chart or magnetic tape recording are possible. Typically, data is plotted on site grid maps following computer processing. Corrections for nonlinearities and smoothing of the data to eliminate small-target responses can be accomplished.

## 5.4 APPLICATIONS MANAGEMENT

### 5.4.1 Prerequisites

As described in Section 5.1.2, appropriate planning of magnetic and metal detection surveys requires at least a basic understanding of general site features and geohydrologic characteristics, as well as the probable variability in conditions. The Work Plan should describe, in as much detail as possible, the known site conditions which may affect the measurements, and the objectives of proposed survey efforts. The type and degree of data interpretation and the desired format for data presentation should be specified if possible.

### 5.4.2 Work Planning and Scheduling

Magnetic and metal detection surveys may be performed concurrently with field geotechnical investigations, in which case on-site interpretation of data may provide real-time guidance for well drilling activities. Ideally, however, these geophysical surveys should be conducted in advance, allowing sufficient time for data interpretation and use of the results in planning other field exercises.

The time and effort required by these geophysical surveys vary greatly depending on the site-specific objectives and site conditions. Typically, from two to ten acres can be covered by metal detection and from one-half to two acres can be covered by magnetic survey per day by a two-person team. Data reduction and interpretation will require at least an equivalent amount of time to the field work. Weather conditions, terrain, and obstructive site features cause considerable variability in these estimates.

## 5.5 CALIBRATION

### 5.5.1 Magnetic Survey

Magnetometer readings should be compared regularly to readings of a reference base station magnetometer; this procedure is necessary if corrections are to be made for changes in the earth's magnetic field over time.

**Daily Quality Control**

All data sets should be accompanied by quality control data that indicates the level of quality of each individual data point. Periodically, replicate measurements should be made so that measurement precision can be established. This procedure also requires corrections for variations in the earth's magnetic field with time. Each data set should be referenced to the most recent calibrations. All data obtained prior to a calibration requiring significant changes in instrument controls is suspect, and the measurements should be repeated or otherwise validated. Data should be preliminarily reduced and plotted during the field program to determine the overall quality of the data and whether the survey results are consistent with the site conceptualization. Data points representing discontinuities in the curves should be validated by repetition and, if necessary, a fine grid of measurements made to determine whether the anomaly represents a site feature of interest, a spurious reading, or an obstructive interference.

### 5.5.2 Metal Detection

**Calibration**

Metal detectors normally are not calibrated, and only relative response is of interest. Periodically, the sensitivity should be checked by nulling the instrument at a fixed location known to be free of metal, and adjusting the gain to provide a proper response over a known target.

**Daily Quality Control**

Metal detector data should be accompanied by sufficient quality control data to verify that the instrument was operating properly. Occasional repetitive measurements and a log of the sensitivity adjustments usually suffice for this purpose.

## 6.0 REFERENCES

Good discussions of various geophysical survey techniques and applications are found in the following references:

Benson, R. C., R. A. Glaccum and M. R. Noel, 1982. Geophysical Techniques for Sensing Buried Wastes and Waste Migration, Technos, Inc., Miami, Florida, Contract No. 68-03-3050, U.S. EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

Costello, R. L., 1980. Identification and Description of Geophysical Techniques, Report No. DRXTH-TE-CR-80084, U. S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland; Defense Technical Information System Number ADA 123939.

McKown, G. L., G. A. Sandness and G. W. Dawson, 1980. Detection and Identification of Buried Waste and Munitions, Proceedings of the 11th American Defense Preparedness Association Environmental Systems Symposium, Arlington, Virginia, 1980.

## 7.0 RECORDS

None.

# Standard Method for PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

*This method has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.*

## 1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

## 2. Applicable Documents

2.1 *ASTM Standards:*

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

## 3. Descriptions of Terms Specific to This Standard

3.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 *N-value*—the blow-count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9 $\Delta N$—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 *number of rope turns*—the total contact angle between the rope and the cathead at the

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Sept. 11, 1984. Published November 1984. Originally published as D 1586 - 58 T. Last previous edition D 1586 - 67 (1974).

[2] Annual Book of ASTM Standards, Vol 04.08.

beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

## 4. Significance and Use

4.1 This method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

## 5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

NOTE 1—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

## 6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

## 7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance", or the "N-value". If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb

(63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

## 8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job.

8.1.2 Names of crew.

8.1.3 Type and make of drilling machine.

8.1.4 Weather conditions.

8.1.5 Date and time of start and finish of boring.

8.1.6 Boring number and location (station and coordinates, if available and applicable).

8.1.7 Surface elevation, if available.

8.1.8 Method of advancing and cleaning the boring.

8.1.9 Method of keeping boring open.

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made.

8.1.11 Location of strata changes.

8.1.12 Size of casing, depth of cased portion of boring.

8.1.13 Equipment and method of driving sampler.

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners).

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number.

8.2.2 Description of soil.

8.2.3 Strata changes within sample.

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

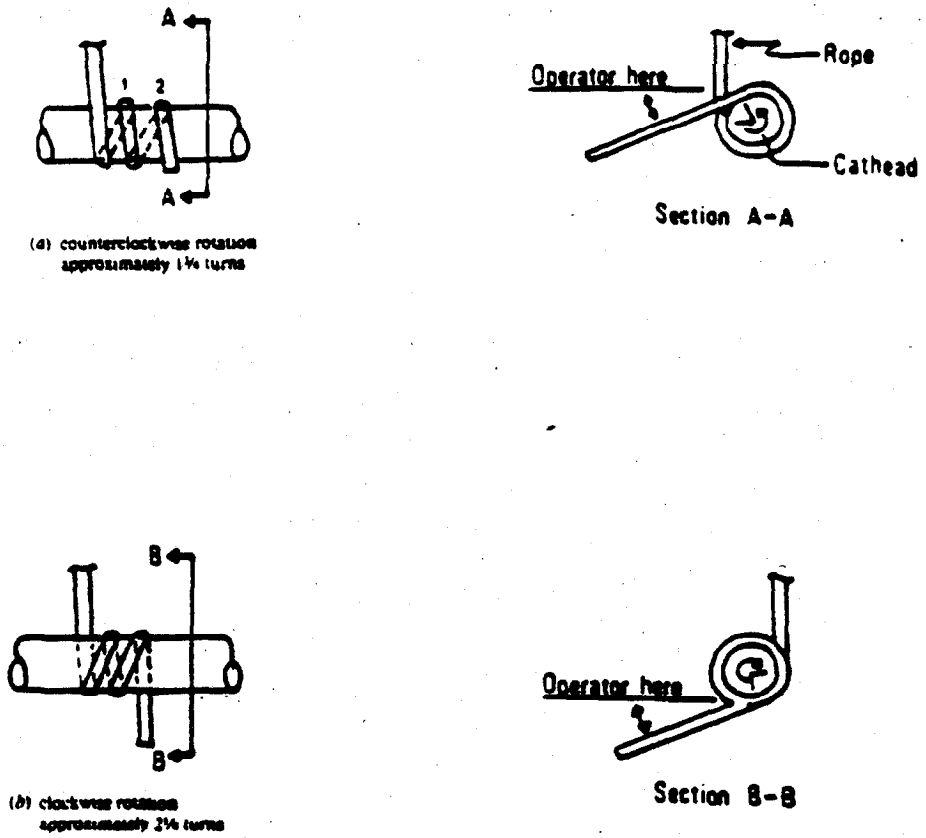
## 9. Precision and Bias

9.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values

obtained between operator-drill rig systems.

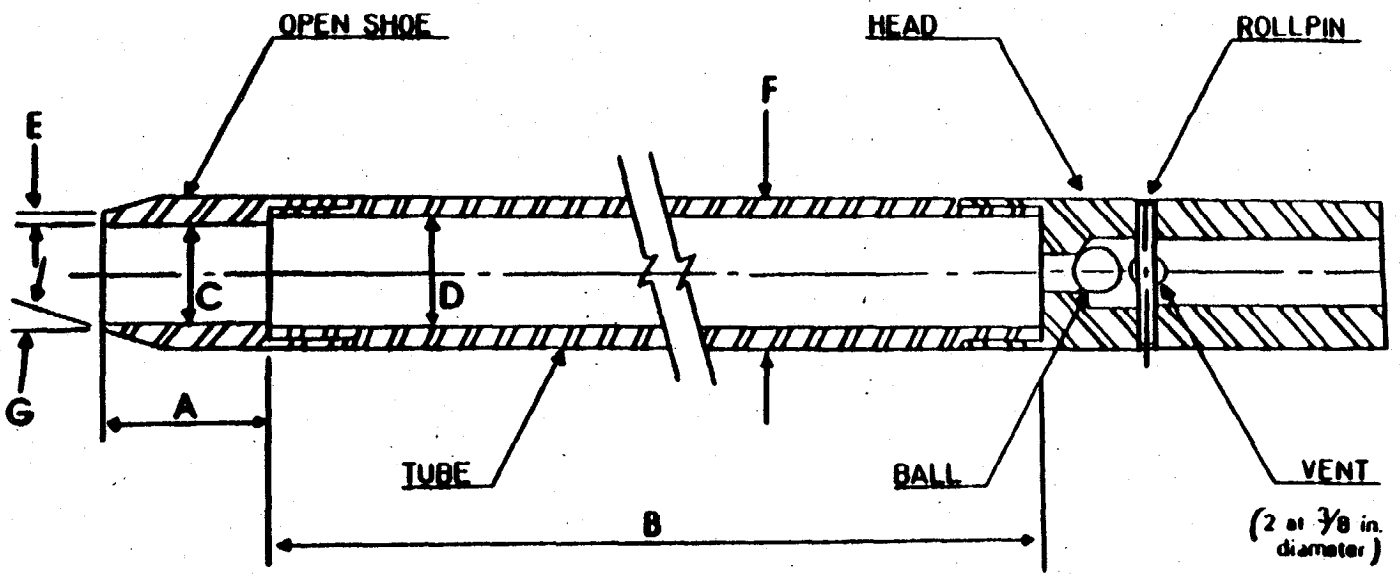
9.3 The variability in N-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting N on the basis of comparative energies. A method for energy measurement and N-value adjustment is currently under development.




(a) counterclockwise rotation approximately 1¾ turns

(b) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead




A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.0005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.005 − 0.000 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.100 ± 0.002 in. (2.54 ± 0.25 mm)
F = 2.000 ± 0.005 − 0.000 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

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

FIG. 2 Split-Barrel Sampler

*The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.*

# APPENDIX C
# SAMPLE SHIPPING PROCEDURES

## C.1 INTRODUCTION

Samples collected during field investigations or in response to a hazardous materials incident must be classified by the project leader, prior to shipping by air, as either environmental or hazardous material samples. In general, environmental samples include drinking water, ambient ground and surface water, background/control soils, sediment, treated municipal and industrial wastewater effluents, biological specimens or any samples not expected to be contaminated with high levels of hazardous materials. The shipment of samples designated as environmental samples are not regulated by the U. S. Department of Transportation (US-DOT). However, these samples must be transported in such a manner as to preserve their integrity.

Samples collected from process wastewater streams, drums, bulk storage tanks, or soil, sediment, or water samples from areas suspected of being highly contaminated may need to be shipped as a hazardous material. Regulations for packing, marking, labeling and shipping of hazardous materials and wastes are promulgated by the US-DOT and are described in the Code of Federal Regulations (49 CFR 171 through 177). The guidance for complying with US-DOT regulations in shipping environmental laboratory samples is given in the "National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples" (1). Additional guidance is given in a letter to M. D. Lair, P.E., from Thomas J. Charlton, P.E., Chief Standards Division, Office of Hazardous Materials Regulation, Materials Transportation Bureau, US-DOT (2). The transportation of hazardous materials by EPA personnel is covered by EPA Order 1000.18. It is the responsibility of the field project leader to insure that samples classified as hazardous materials are shipped in accordance with these regulations.

## C.2 SHIPMENT OF ENVIRONMENTAL SAMPLES

Samples collected by Branch personnel and designated by the project leader as environmental samples shall be shipped using the method described below. However, if the environmental samples are preserved, the amount of preservative must not exceed the amounts indicated in Table 1. If the amount of preservative added to a sample exceeds that listed in Table 1, then that sample may be considered a hazardous material and shall be shipped in accordance with procedures described in 49 CFR 171 through 177. In addition, the shipment of pre-preserved sample containers or bottles of preservatives (i.e., NaOH pellets, HCl, etc.) which are designated as hazardous under the US-DOT, Hazardous Materials Tables, 49 CFR 172.101, must be shipped pursuant to the appropriate US-DOT regulations. The shipment of nitric acid is forbidden on all aircraft.

Environmental samples shall be packed prior to shipment by air using the following procedures:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber tape. Line the cooler with a large heavy duty plastic bag.

2. Allow sufficient outage (ullage) in all bottles (except VOA's) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

3. Be sure the lids on all bottles are tight (will not leak) and then secure the lid to the bottle with tape (preferably plastic electrical tape) to insure the lid will not vibrate loose during transport.

4. Place all bottles in separate and appropriately sized polyethylene bags and seal the bags with tape (preferably plastic electrical tape).

5. Place four to six VOA vials in a quart metal can and then fill the can with vermiculite.

6. Place two to four inches of vermiculite in the bottom of the cooler and then place the bottles and cans in the cooler with sufficient space to allow for the addition of more vermiculite between the bottles and cans.

7. Put "blue ice" (or ice that has been placed in heavy duty polyethylene bags and properly sealed) on top of or between the samples. Fill all remaining space between the bottles or cans with vermiculite. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).

8. Place chain-of-custody and applicable CLP Traffic Report Forms into the cooler and then close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. The chain-of-custody seals should be affixed to the top and sides of the cooler so that the cooler cannot be opened without breaking the seal.

9. The shipping containers must be marked "THIS END UP," and arrow labels which indicate the proper upward position of the container should be affixed to the container. A label containing the name and address of the shipper shall be placed on the outside of the container. Labels used in the shipment of hazardous materials (such as Cargo Only Aircraft, Flammable Solids, etc.) are not permitted to be on the outside of the container used to transport environmental samples and shall not be used.

TABLE 1
CHEMICALS LISTED IN THE HAZARDOUS MATERIALS TABLE (49 CFR 172.101)
USED BY ESD FOR PRESERVING SAMPLES

| Preservative | Sample Type/ Parameter | pH Recommendation | Quantity of Preservative Added Per Liter | Wt. % of Preservative |
|---|---|---|---|---|
| HCl | Volatile Organic Analysis | <2 - ≥1 | 4 drops conc. HCl/40 ml | 0.22% (2) |
| $HgCl_2$ | Nitrogen Species | N.A. | 40 mg | 0.004% (1) |
| $HNO_3$ | Metals, Hardness | <2 - ≥1 | 5 ml of conc. (70%) | 0.35% (1) |
| $H_2SO_4$ | Nitrogen Species<br>COD, Oil & Grease,<br>P (hydrolyzable)<br>Organic Carbon, Phenols | <2 - ≥1 | 2 ml of 36N | 0.35% (1) |
| NaOH | Cyanides, Sulfides | >12 - ≤13 | 2 ml of 10N | 0.080% (1) |
| Freezing* 0°C (Dry Ice) | Biological - Fish & Shellfish Tissue | N.A. | N.A. | N.A. |

* - Dry ice is classified as a ORM-A hazard by DOT. There is no labeling requirement for samples preserved with dry ice, but each package must be plainly and durably marked on at least one side or edge with the designation "ORM-A." The package should also be marked "Dry Ice" or "Carbon Dioxide, Solid" and "Frozen Diagnostic Specimens." Samples must be packaged in accordance with the requirements of 49 CFR 173.615 and advance arrangements must be made between the shipper and each carrier.

N.A. - Not applicable.

## C.3 SHIPMENT OF HAZARDOUS MATERIALS SAMPLES

### C.3.1 Definitions

The field project leader is responsible for determining if samples collected during a specific field investigation should be classified as hazardous materials. If a sample is collected of a known substance that is listed in the Hazardous Materials Table, 49 CFR 172.101, then that sample must be identified, packaged, marked, labeled, and shipped according to the specified instructions listed for that material. However, if the composition of collected samples are unknown, the project leader must select the appropriate transportation category in accordance with the US-DOT Hazardous Materials Classification (Table 2). In addition, 49 CFR 172.402, Item H, states a material (sample) for which a reasonable doubt exists as to its class and labeling requirements, and for which a sample must be transported for laboratory analysis, may be labeled according to the shipper's tentative class assignment based upon:

- Defining criteria (i.e., definitions of Flammable Liquid, Poison B, etc.),
- The hazard precedence prescribed in 49 CFR 173.2 (Table 2), or
- The shipper's knowledge of the material.

The project leader can utilize data obtained from a photoionization detector or organic vapor analyzer, explosimeter, or radiation survey instruments, as well as pH meter/paper, to help categorize the sample. In general, samples of unknown hazardous materials collected by Branch personnel will be categorized as a Flammable Liquid, Flammable Solid, Corrosive Material, or Poison B. The proper packing, marking, labeling, and shipping procedures for a sample falling into one of these four categories is listed in the Hazardous Materials Table 49 CFR 172.101. It is unlikely that a sample collected by Branch personnel will be classified as a "Poison A." In the event a sample is collected that meets the DOT definition for a "Poison A" (i.e., poisonous gases or liquids of such a nature that a small amount of the gas or vapor of the liquid, mixed with air is dangerous to life - 49 CFR 173.326), that sample shall not be shipped by air cargo. The DOT definitions for Flammable Liquid, Flammable Solid, Corrosive Material, and Poison B are:

#### C.3.1.1 Flammable Liquid 49 CFR 173.115

1. A flammable liquid means any liquid having a flash point below 100°F (37.8°C) with the following exceptions:

   (a) Any liquid meeting one of the definitions specified in 49 CFR 173.300.

   (b) Any mixture having one component or more with a flash point of 100°F (37.8°C) or higher, that makes up at least 99 percent of the total volume of the mixture.

C.3.1.2 Flammable Solid 49 CFR 173.150

"Flammable Solid" is any solid material, other than one classed as an explosive, which, under conditions normally incident to transportation, is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard. Included in this class are spontaneously combustible and water-reactive materials.

C.3.1.3 Corrosive Material 49 CFR 173.240

1. A corrosive material is a liquid or solid that causes viable destruction or irreversible alterations in human skin tissue at the site of contact, or in the case of leakage from its packaging, a liquid that has a severe corrosion rate on steel.

   (a) A material is considered to be destructive or to cause irreversible alteration in human skin tissue if when tested on the intact skin of the albino rabbit by the technique described in Appendix A to this part, the structure of the tissue at the site of contact is destroyed or changed irreversibly after an exposure period of four hours or less.

   (b) A liquid is considered to have a severe corrosion rate if its corrosion rate exceeds 0.250 inch per year (IPY) on steel (SAE 1020) at a test temperature of 130°F. An acceptable test is described in NACE Standard TM-01-69.

2. If human experience or other data indicate that the hazard of a material is greater or less than indicated by the results of the tests specified in paragraph (a) of this section, the Department may revise its classification or make the material subject to the requirements of Parts 170-189 of this subchapter.

C.3.1.4 Poison B 49 CFR 173.343

1. Class B poisons are those substances, liquid or solid (including pastes and semisolids), other than Class A poisons or irritating materials, which are known to be so toxic to man as to afford a hazard to health during transportation, or which, in the absence of adequate data on human toxicity, are presumed to be toxic to man because they fall within any one of the following categories when tested on laboratory animals:

   (a) Oral Toxicity -- Those which produce death within 48 hours in half or more than half of a group of ten or more white laboratory rats weighing 200 to 300 grams at a single dose of 50 milligrams or less per kilogram of body weight, when administered orally.

(b) Toxicity of Inhalation -- Those which produce death within 48 hours in half or more than half of a group of ten or more white laboratory rats weighing 200 to 300 grams, when inhaled continuously for a period of one hour or less at a concentration of 2 milligrams or less per liter of vapor, mist, or dust, provided such concentration is likely to be encountered by man when the chemical product is used in any reasonable foreseeable manner.

(c) Toxicity by Skin Absorption -- Those which produce death within 48 hours in half or more than half of a group of ten or more rabbits tested at a dosage of 200 milligrams or less per kilogram body weight, when administered by continuous contact with the bare skin for 24 hours or less.

2. The foregoing categories shall not apply if the physical characteristics or the probable hazards to humans as shown by experience indicate that the substances will not cause serious sickness or death. Neither the display of danger or warning labels pertaining to use nor the toxicity tests set forth above shall prejudice or prohibit the exemption of any substances from the provisions of Parts 170-189 of this chapter.

C.3.2 Shipping Procedures

The Branch shipping procedures for samples categorized as a limited quantity Flammable Liquid, Flammable Solid, Poison B, or Corrosive Liquid are described below. (Limited quantities for Flammable Liquid, Flammable Solid, Poison B, and Corrosive Liquid are defined in 49 CFR Section 173.118, 173.153, 173.345, and 173.244, respectively). If larger quantities of a sample are required to be shipped than those listed (i.e., more than an 8-ounce container/sample or as specified below) then the limited quantity shipping procedures may not apply, and the project leader shall refer to the US-DOT regulations for the proper shipping procedures.

C.3.2.1 Flammable Solid or Flammable Liquid

1. Collect sample in an 8-ounce glass container (or see Appendix A to determine the appropriate containers). Allow sufficient ullage (approximately 10 percent by volume) so container is not liquid full at 130°F. If collecting a solid material, the container plus contents shall not exceed one pound net weight.

2. Attach properly completed Sample Tag (see Section 3) to sample container.

3. Be sure the lids on all bottles are tight (will not leak) and then secure the lid to the bottle with tape (preferably plastic electrical tape). Place a custody seal across the lid of the sample container and place the container in a 2-mil-thick (or thicker) polyethylene bag, one sample per bag. Seal the bag with tape (preferably plastic electrical tape). Tags should be positioned to enable them to be read through bag.

4. Place sealed bag inside a metal can with incombustible, absorbent cushioning material (e.g., vermiculite or diatomaceous earth) to prevent breakage (one bag per can). Pressure-close the can and use clips, tape, or other positive means to hold the lid securely, tightly, and effectively.

5. Mark and label the container as indicated in No. 8 below.

6. Place one or more metal cans surrounded with incombustible packaging material for stability during transport, into a strong outside container, such as a metal picnic cooler or a fiberboard box.

7. Mark and label the outside shipping container and complete shipping papers as described below.

8. Marking and Labeling: Use abbreviations only where specified. Place the following information on the shipping container, either hand printed or in label form: laboratory name and address and "Flammable Liquid, N.O.S.," UN 1993 or "Flammable Solid, N.O.S.," UN 1325. Place the following labels on the outside of the container.

   "Cargo Aircraft Only"; "Flammable Liquid"; if not liquid, "Flammable Solid" ("Dangerous When Wet" label should be used if the solid has not been exposed to wet environment).

   NOTE: If the cans are placed in an exterior container, both that container and inside cans must have the same markings and labels as above. "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" should also be marked on the top of the exterior container, and upward pointing arrows should be placed on all four sides of the exterior container.

   Shipping Papers: Use abbreviations only where specified below.

   Complete the carrier-provided Bill of Lading and sign the certification statement (if carrier does not provide, use standard industry form) with 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, as appropriate); "Cargo Aircraft Only"; "Limited Quantity" or Ltd. Qty."; "Laboratory Samples"; "Net Weight _____" or "Net Volume _____" (of hazardous contents), by item, if more than one metal can is inside an exterior container. The net weight or net volume must be placed just before or just after the "Flammable Liquid, N.O.S." or "Flammable Solid, N.O.S."

A Chain-of-Custody Record form (see Section 3) should also be properly executed and included in the exterior container.

9. A team member must accompany shipping container(s) to the transport carrier and, if required, open outside container(s) for air freight inspection.

C.3.2.2 Flammable Liquid, Multi Class or Single Class, Greater Than One Pint Containers; or Poison B, Liquid; or Poison B, Solid. (Note: Package requirement for multiclass flammable liquids also meets the requirements for Poison B liquids and solids.)

1. Collect sample in an 8-ounce glass container (or see Appendix A to determine the appropriate containers). Allow sufficient ullage (approximately 10 percent by volume) so container is not liquid full at 130°F. If collecting a solid material, the container plus contents shall not exceed five pounds net weight.

2. Attach properly completed sample tag (see Section 3) to sample container.

3. Be sure the lids on all bottles are tight (will not leak) and then secure the lid to the bottles with tape (preferably plastic electrical tape). Place a custody seal across the lid of the sample container and place the container in a 2-mil-thick (or thicker) polyethylene bag (one sample per bag). Seal the bag with tape (preferably plastic electrical tape). Tags should be positioned to enable them to be read through bag.

4. Place sealed bag inside a one-quart metal can with incombustible, absorbent cushioning material (e.g., vermiculite or diatomaceous earth) to prevent breakage (one bag per can). Pressure-close the can and use clips, tape, or other positive means to hold the lid securely, tightly, and effectively.

5. Mark and label the container as indicated in No. 8 below.

6. Place the one-quart metal can or cans in a DOT 12B fiberboard box using styrofoam headers to avoid movement of the can/cans. Specially designed boxes which provide an exact fit for the can/cans and headers must be used.

7. Mark and label the outside container and complete shipping papers as described below.

8. Place the following information on the metal can (or bottle) and exterior shipping container, either hand printed or in label form; laboratory name and address and proper shipping name (i.e., "Poison B, Liquid, N.O.S" UN 2810, etc.). Place the following labels on the outside of the metal can (or bottle) and the exterior container:

   "Cargo Aircraft Only"; proper label for hazard class (i.e., "Poison" UN 2810, etc.). "Dangerous When Wet" label should be used if the solid has not been exposed to a wet environment.

Note: "Laboratory Samples" and "THIS SIDE UP" or "THIS END UP" should also be marked on the top of the exterior container and upward pointing arrows should be placed on all four sides of the exterior container.

Shipping Papers: Use abbreviations only where specified below.

Complete the carrier-provided Bill of Lading and sign the certification statement (if carrier does not provide, use standard industry form) with the following information in the order listed. One form may be used for more than one exterior container.

Proper shipping name ("Poison B, Liquid, N.O.S." UN 2810, etc.). "Cargo Aircraft Only"; "Laboratory Samples"; "Net Weight _____" or "Net Volume _____" (of hazardous contents), by item, if more than one metal can is inside an exterior container. The net weight or net volume must be placed just before or just after the proper shipping name.

A Chain-of-Custody Record form (see Section 3) should also be properly executed, and included in the exterior container.

9. A team member must accompany shipping container(s) to the transport carrier and, if required, open outside container(s) for freight inspection.

When containers greater than 8-ounce capacity must be shipped, the above procedures will be used with the following modifications:

1. One-gallon or smaller glass or plastic containers will be used to collect the sample (see Appendix B to determine the proper container).

2. The container will then be placed directly into a DOT 15A wooden box (not more than two containers to each box), separated with foam or styrofoam padding and the remainder of the box filled with incombustible, absorbent cushioning material (e.g., vermiculite or diatomaceous earth).

(Note: If a sample is designated as a Poison B material and shipped by Federal Express, it must be packed in accordance with the exemption packing procedures as shown in the example given in Exhibit A.)

C.3.2.3 Corrosive Liquid/Corrosive Solid

1. Collect sample in an 8-ounce glass container (see Appendix A to determine the appropriate containers). Allow sufficient ullage (approximately 10 percent by volume) so container is not liquid full at 130°F. If collecting a solid material, the container plus contents shall not exceed one pound net weight.

2. Attach properly completed sample tag (see Section 3) to sample container.