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**REMEDIAL INVESTIGATION/FEASIBILITY STUDY
PROJECT PLANS**

**OPERABLE UNIT NO. 17 (SITES 90, 91, and 92)
MCB CAMP LEJEUNE, NORTH CAROLINA**

CONTRACT TASK ORDER 0344

DECEMBER 5, 1996

Prepared For:

**DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
*Norfolk, Virginia***

Under the:

**LANTDIV CLEAN Program
Contract N62470-89-D-4814**

Prepared By:

**BAKER ENVIRONMENTAL, INC.
*Coraopolis, Pennsylvania***

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	applicable or relevant and appropriate requirements
AST	above ground storage tank
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRA	baseline risk assessment
BTEX	benzene, toluene, ethylbenzene, xylenes
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
COPC	Contaminants of Potential Concern
DOD	Department of the Defense
DoN	Department of the Navy
DQO	Data Quality Objective
EDI	Estimated Daily Intake
EMD	Environmental Management Division (Camp Lejeune)
ESE	Environmental Science and Engineering, Inc.
°F	degrees Fahrenheit
FFA	Federal Facilities Agreement
FFSG	Force Service Support Group
FMF	Fleet Marine Force
FMFLANT	Fleet Marine Force Atlantic
FSAP	Field Sampling and Analysis Plan
gpm	gallons per minute
GRO	Gasoline Range Organics
GSRA	Greater Sandy Run Area
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HP	hydropunch
HQ	hazard quotient
IAS	Initial Assessment Study
IDW	Investigative Derived Waste
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LANTDIV	Naval Facilities Engineering Command, Atlantic Division

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

µg/L	micrograms per liter
µg/kg	micrograms per kilogram
MAGTF	Marine Air Ground Task Force
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
mgd	million gallons per day
NACIP	Navy Assessment and Control of Installation Pollutants
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCWQS	North Carolina Water Quality Standard
NEESA	Navy Energy and Environmental Support Activity
NPL	National Priorities List
NREA	Natural Resources and Environmental Affairs
OU	operable unit
PA/SI	Preliminary Assessment/Site Inspection
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCE	Tetrachloroethylene
PRGs	Preliminary Remediation Goals
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAB	Restoration Advisory Board
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	Remediation Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Management
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SOW	Statement of Work
SVOC	Semivolatile Compounds
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure
TDS	total dissolved solids
TOC	total organic carbon

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TPH	total petroleum hydrocarbon
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Society
UST	Underground Storage Tank
VOC	volatile organic compound
WOE	weight-of-evidence

1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) National Priorities List (NPL) effective November 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, the United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (NC DEHNR), the United States Department of the Navy (DoN) and the Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the MCB are thoroughly investigated, and that appropriate CERCLA response and Resource Conservation Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect the public health and welfare, and the environment (MCB Camp Lejeune FFA, 1989).

The scope of the FFA included the implementation of a remedial investigation/feasibility study (RI/FS) at 18 Operable Units (OUs) and 42 sites across MCB Camp Lejeune. Figure 1-1 presents the locations of all the OUs at MCB Camp Lejeune. RIs will be implemented at these OUs to determine fully the nature and extent of the threat to the public health and welfare or to the environment caused by the release and threatened release of hazardous substances, pollutants, contaminants or constituents at the site and to establish requirements for the performance of FSs. Feasibility studies will be conducted to identify, evaluate, and select alternatives for the appropriate CERCLA responses to prevent, mitigate, or abate the release or threatened release of hazardous substances, pollutants, contaminants, or constituents at the site in accordance with CERCLA/Superfund Amendments and Reauthorization Act of 1986 (SARA) and applicable State law (FFA, 1989).

This RI/FS Work Plan addresses OU No. 17 - Site 90 (BB-9), Site 91(BB-54), and Site 92 (BB-46). Photos of the sites are presented in Appendix A. This RI/FS is planned to be conducted in two phases if necessary. Phase I includes the installation and sampling of temporary shallow and intermediate monitoring wells along with sampling selected existing permanent monitoring wells. The Phase I findings will be evaluated to determine the data needs for Phase II. Potential data needs may include additional monitoring wells, groundwater or soil samples to complete the delineation of contamination, evaluate treatment alternatives, or model contaminant migration and transport.

1.1 Objective of the RI/FS Work Plan

The objective of this RI/FS Work Plan is to identify the tasks required to implement an RI/FS for Sites 90, 91, and 92 at MCB Camp Lejeune. The various studies or investigations required to collect appropriate data are described in this Work Plan. In addition, the Work Plan documents the scope and objectives of the individual Phase I site evaluation activities, and serves as a tool for assigning responsibilities and establishing the project schedule and cost. The preparation and contents of the RI/FS Work Plan are based on the scoping process, which is described below.

1.2 RI/FS Evaluation Scoping

Scoping is the initial planning stage of the RI/FS and site remediation. The results or outcome of the scoping process is documented in the RI/FS Work Plan. Scoping begins once the background information is reviewed and evaluated, and consists of the following activities:

- Preliminary assessment, based on readily available information, to identify the source and nature of the release or threatened release and to assess the threat to public health, the magnitude of the threat, and the factors necessary to determine the need for a removal action.
- Identifying any potential interim action which may need to be undertaken early in the program to mitigate potential threats to the public health and environment.
- Identifying potential contaminant migration pathways.
- Identifying contaminants of potential concern.
- Identifying potential Federal and State Applicable or Relevant and Appropriate Requirements (ARARs).
- Define the optimum sequence of investigation activities.
- Identifying the sampling strategies for the collection of data.
- Determining the type, amount, and data quality objectives (DQOs) to assess human health and environmental risks.
- Identifying potential technologies/alternatives for mitigating site problems.
- Identifying the remedial alternatives suitable to site conditions.

The background information available to this process included a number of existing environmental assessment reports, which are identified in Section 7.0 (References), and information collected during site visits.

As part of the scoping process, Baker prepared a Sample Strategy Plan in September 1996 which was submitted to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), MCB Camp Lejeune, USEPA Region IV, and the NC DEHNR. A conference call was held between Baker and the above parties to discuss the proposed Sample Strategy Plan, and to obtain technical and administrative input for conducting the site evaluation.

1.3 RI/FS Work Plan Format

The following elements are presented in this RI/FS Work Plan.

- Section 2 - Background and Setting
- Section 3 - RI/FS Evaluation Data Quality and Sampling Objectives
- Section 4 - RI/FS Evaluation Tasks
- Section 5 - Project Staffing
- Section 6 - Project Schedule
- Section 7 - References

Section 2 documents the evaluation of background information, along with the location and setting of the site. The purpose of this section is to define the physical and known environmental characteristics of the site. This section focuses on identifying potential and/or confirmed contaminant

migration pathways, identifying potential (or known) impacts to public health and environment, listing Federal or State standards and criteria.

Section 3 defines site-specific data quality and sampling objectives. Data or information deemed necessary to identify migration pathways, assess environmental and human health risks, or evaluate and select alternative technologies are presented in this section. This data may consist of chemical analyses, hydrogeologic information, or engineering analyses. The collection methods for obtaining this information also are identified and described in general terms [more detailed descriptions of the field investigation activities are documented in the Field Sampling and Analysis Plan (FSAP)].

Section 4 identifies and describes the tasks and field investigation activities that will be implemented to complete the RI/FS at the site in terms of meeting the site-specific objectives. These tasks generally follow the description of tasks identified in EPA's RI/FS Guidance Document (OSWER Directive 955.3-01).

Section 5 discusses project staffing for implementing the RI/FS. The RI/FS project plan schedule is provided in Section 6. References used in developing the RI/FS Work Plan are provided in Section 7.

2.0 BACKGROUND AND SETTING

The purpose of this section is to summarize and evaluate existing information pertaining to MCB Camp Lejeune, OU 17 (Sites 90, 91, and 92). The analysis of existing information will serve to provide an understanding of the nature and extent of contamination in order to aid in the site evaluation tasks. The current understanding of the physical setting of the site, the history of the site, and the existing information related to previous environmental investigative activities are described herein.

This section specifically addresses the location and setting of the site, historical events associated with past usage or disposal activities, topography and surface drainage, regional geology and hydrogeology, site-specific geology and hydrogeology, surface water hydrology, climatology, natural resources and ecological features, and land use.

Additional background information is presented in the following documents:

- Initial Assessment Study (IAS) of Marine Corps Base Camp Lejeune, North Carolina (Water and Air Research, 1983)
- Final Site Summary Report, Marine Corps Base, Camp Lejeune (Environmental Science and Engineering, Inc. [ESE], 1990)
- Hydrogeology of Aquifers in Cretaceous and Younger Rocks in the Vicinity of Onslow and Southern Jones Counties, North Carolina (Lyke, 1990)
- Continuous Seismic Reflection Profiling of Hydrogeologic Features Beneath New River, Camp Lejeune, North Carolina (Cardinell, 1990)
- Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina (Harned, 1989)
- Three Well Site Check, UST BB-46 Marine Corps Base, Camp Lejeune, North Carolina (R.E. Wright Associates, Inc., November 1994)
- Leaking Underground Storage Tank Comprehensive Site Assessment Building BB-51 (Richard Catlin and Associates, Inc., September 1994)
- Leaking Underground Storage Tank Comprehensive Site Assessment Building BB-9 (Richard Catlin and Associates, Inc., December 1994)

2.1 MCB Camp Lejeune, North Carolina

This section provides an overview of the physical features associated with MCB Camp Lejeune, North Carolina.

2.1.1 Location and Setting

MCB Camp Lejeune is located within the Coastal Plain Physiographic Province. It is located in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The facility covers approximately 236 square miles. This includes the recent

acquisition of approximately 64 square miles west of the facility within the Greater Sandy Run Area of the county. The military reservation is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean.

The eastern border of MCB Camp Lejeune is the Atlantic shoreline. The western and northwestern boundaries are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina, borders MCB Camp Lejeune to the north.

2.1.2 Land Use and Demographics

MCB Camp Lejeune presently covers an area of approximately 236 square miles. Military and civilian population is approximately 60,000. During World War II, MCB Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam conflicts, and the Gulf War (i.e., Desert Storm). Toward the end of World War II, the camp was designated as a home base for the Second Marine Division. Since that time, Fleet Marine Force (FMF) units also have been stationed here as tenant commands.

The following information was extracted from the document "Master Plan, Camp Lejeune Complex, North Carolina." The existing land use patterns in the various geographic areas within the Marine Corps Base are described in this section and listed, per geographic area, on Table 2-1. The areas described below are depicted on Figure 2-1. In addition, the number of acres comprising each land use category has been estimated and provided on the table.

Present military population of Camp Lejeune is approximately 40,928 active duty personnel. The military dependent community is in excess of 32,081. About 36,086 of these personnel and dependents reside in base housing units. The remaining personnel and dependents live off base. An additional 4,412 civilian employees perform facilities management and support functions. The population of Onslow County has grown from 17,739 in 1940, prior to the formation of the base, to its present population of 121,350.

The Greater Sandy Run Area (GSRA) is located in the southeast portion of Onslow County, North Carolina, near the Pender-Onslow County border. The GSRA is approximately 31 miles northeast of Wilmington, North Carolina; 15 miles south of Jacksonville, North Carolina; and 5 miles northwest of the Atlantic Ocean. The GSRA is located south and west of MCB, Camp Lejeune, sharing a common boundary along Route 17 between Dixon and Verona.

The following overview of the Complex was taken from the document "Master Plan, Camp Lejeune Complex, North Carolina" (DoN, 1988). The Complex consists of 12 identifiable developed areas. Of the developed areas, Hadnot Point comprises the most concentrated area of development. This area includes the organizational offices for the Host Activity and for the Headquarters, 26th Marine Amphibious Unit, as well as the Headquarters and regimental areas for the 2nd Marine Division, Marine Expeditionary Force, 6th Marine Expeditionary Brigade, 22nd Marine Expeditionary Unit, 24th Marine Amphibious Unit, the Central Exchange & Commissary and the Naval Dental Clinic Headquarters. Directly north of Hadnot Point are the family housing areas concentrated throughout the wooded areas of the central Complex and along the shores of the New River. Also located in this north central area are major personnel support land uses, including the newly-constructed Naval Hospital, school sites, recreational areas, as well as additional family housing areas (quarters developments, Midway Park and Tarawa Terrace I and II).

The Air Station and Camp Geiger are considered as a single urban area possessing two separate missions and supported by two unrelated groups of personnel. The Marine Corps Air Station (MCAS), New River encompasses 2,772 acres and is located in the northwestern section of the Complex and lies approximately five miles south of Jacksonville. The MCAS includes air support activities, troop housing and personnel support facilities, all of which immediately surround the aircraft operations and maintenance areas.

Camp Geiger, located directly north of MCAS, New River, contains a mixture of troop housing, personnel support and training uses. Currently, the area is utilized by a number of groups which have no direct relationship to one another. The majority of the land surrounding this area is comprised of buffer zones and unbuildable marshland.

The Camp Lejeune Complex contains five other areas of concentrated development, all of which are much smaller in size and population than either Hadnot Point, MCAS New River, or the Camp Geiger area. The oldest of these is the Montford Point area, which is bounded by the New River to the south and west and by Route 24 on the north. New development in Montford Point has been limited, with most of the facilities for troop housing, maintenance, supply and personnel support having been converted from their intended uses. A majority of the MCB training schools requiring classroom instruction are located here and use surrounding undeveloped areas for training operations when required. The French Creek area located directly south of Hadnot Point is occupied by the 2nd Force Service Support Group (2nd FSSG). Its activities are directed toward providing combat service and technical support as required by Headquarters, II Marine Expeditionary Force. Expansion of the French Creek Complex is constrained by the Ordnance Storage Depot explosives safety arc on the south and by the regimental area of Hadnot Point. Onslow Beach, located along the Onslow Bay, east of the New River Inlet, presents assets for amphibious training as well as recreational use. Courthouse Bay is located on one of a series of small bays which are formed by the New River. This area is used for maintenance, storage and training associated with amphibious vehicles and heavy engineering equipment. The Engineering School, also located here, conducts training activities in the large open area located to the southeast of the Courthouse Bay. Another concentrated area of development is the Rifle Range. This area is located on the southwest side of the New River, is singular in purpose and has only a small number of assigned personnel. It was constructed in the early stages of Base development and is used solely for rifle qualification training. The small group of barracks, located at the Rifle Range, are used for two-week periods by troops assigned to range training.

2.1.3 History and Mission of Camp Lejeune

Construction of MCB Camp Lejeune began in 1941 with the objective of developing the "World's Most Complete Amphibious Training Base." Construction of the base started at Hadnot Point, where the major functions of the base are centered. Development at the Camp Lejeune Complex is primarily in five geographical locations under the jurisdiction of the Base Command. These areas include Camp Geiger, Montford Point, Courthouse Bay, Mainside, and the Rifle Range Area. Site 90, 91, and 92 are located in the Courthouse Bay area. Appendix A contains photographs of all three sites.

The MCB organization functions as the host command to the two Fleet Marine Force Atlantic (FMFLANT) tenant activities -- Headquarters of the II Marine Expeditionary Division and the 2nd FSSG. The MCB host organization mission is to provide housing, training facilities, logistical support and certain administrative support for tenant units and for other units assigned to MCB Camp Lejeune and to conduct specialized schools and other training maneuvers, as directed.

The mission of the 6th Marine Expeditionary Brigade is to provide the Command element for a brigade-size Marine Air Ground Task Force (MAGTF) with the primary mission of preparing to join up with LantCom MPS equipment and to conduct subsequent combat operations.

The mission of the 2nd Marine Division is to execute amphibious assault operations, and other operations as may be directed, which are supported by Marine aviation and force service support units. With the aircraft wing, the Marine division provides combined arms for service with the Fleet in the seizure or defense of advanced naval bases and for the conduct of land operations essential to the prosecution of a naval campaign.

The mission of the 2nd FSSG is to command, administer and train assigned units in order to provide combat service and technical support as required by Headquarters FMFLANT and its subordinate command in accomplishment of the overall FMFLANT mission.

2.1.4 Previous Investigations

In response to the passage of CERCLA, the DoN initiated the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, investigate, and clean up past hazardous waste disposal sites at Navy installations. The NACIP investigations were conducted by the Navy Energy and Environmental Support Activity (NEESA) and consisted of Initial Assessment Studies (IAS) and Confirmation Studies. IAS are similar to the CERCLA Preliminary Assessments/Site Investigations (PAs/SIs). Confirmation Studies are similar to CERCLA RI/FS. When the SARA was passed in 1986, the DoN dissolved the NACIP in favor of the Installation Restoration Program (IRP), which adopted USEPA CERCLA terminology and procedures.

The IAS for MCB Camp Lejeune was conducted by Water and Air Research, Inc., in 1983. The IAS identified a number of sites at MCB Camp Lejeune as potential sources of contamination, Sites 90, 91, and 92 were not included under the IAS since it was only recently discovered. Sites 90, 91, and 92 were included in the Fiscal Year 96 Site Management Plan.

2.1.5 Topography and Surface Drainage

The generally flat topography of MCB Camp Lejeune is typical of the seaward portions of the North Carolina Coastal Plain. Elevations on the base vary from sea level to 72 feet above mean sea level (msl); however, the elevation of most of MCB Camp Lejeune is between 20 and 40 feet above msl.

Drainage at MCB Camp Lejeune is generally toward the New River, except in areas near the coast, which drain through the Intracoastal Waterway. In developed areas, natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of MCB Camp Lejeune is in broad, flat interstream areas. Drainage is poor in these areas (Water and Air Research, 1983).

The U.S. Army Corps of Engineers has mapped the limits of 100-year floodplain at MCB Camp Lejeune at 7 feet above msl in the upper reaches of the New River (Water and Air Research, 1983); this increases downstream to 11 feet above msl near the coastal area (Water and Air Research, 1983).

2.1.6 Regional Geology

MCB Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The sediments of the province consist predominantly of sand, silt, and clay. Other sediments may be present,

including peat, shell beds and gravel. Sediments may be of marine or continental origin (Back, 1966). These sediments lay in interfingering beds and lenses that gently dip and thicken to the southeast (ESE, 1991). These sediments range in age from early Cretaceous to Quaternary time and overlie igneous and metamorphic rocks of pre-Cretaceous age. Table 2-2 presents a generalized stratigraphic column for this area (ESE 1991).

United States Geological Survey (USGS) studies at MCB Camp Lejeune indicate that the Base is underlain by sand, silt, clay, calcareous clay and partially consolidated limestone. Aquifers that occur beneath the Base include the surficial, Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The combined thickness of these sediments beneath the base is approximately 1,500 feet. A generalized hydrogeologic cross-section illustrating the relationship between the aquifers in this area is presented in Figures 2-2 and 2-3.

2.1.7 Regional Hydrogeology

The aquifers of primary interest are the surficial aquifer and the aquifer immediately below it, the Castle Hayne. The following summary is a compilation of information, including Harned et al. (1989), and Cardinell et al. (1993).

The surficial aquifer consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells. These beds are thin and discontinuous, and have limited lateral continuity. This aquifer is not used for water supply MCB at Camp Lejeune.

The thickness of the surficial aquifer ranges from 0 to 73 feet and averages nearly 25 feet over the MCB Camp Lejeune area. It is generally thickest in the interstream divide areas and presumed absent where it is cut by the New River and its tributaries.

The general lithology of the surficial aquifer and the absence of any thick, continuous clay beds are indications of good vertical conductivity within the aquifer. Data compiled by Cardinell estimate the lateral hydraulic conductivity of the surficial aquifer in the MCB Camp Lejeune area 50 feet/day, and is based on a general composition of fine sand mixed with some silt and clay. However, data from slug tests on Baker wells indicate much lower lateral hydraulic conductivity values, ranging from 0.12 to 9.00 feet/day.

Between the surficial and the Castle Hayne aquifers lies the Castle Hayne confining unit. This unit consists of clay, silt, and sandy clay beds. In general, the Castle Hayne confining unit may be characterized as a group of less permeable beds at the top of the Castle Hayne aquifer that have been partly eroded or incised in places.

The Castle Hayne confining unit is discontinuous, and has a thickness ranging from 0 to 26 feet, averaging about 9 feet where present. There is no discernable trend in the thickness of the confining unit. There is no information in the USGS literature regarding any trend of the depth of the confining unit.

The data compiled by Cardinell, et. al., indicate that the vertical hydraulic conductivity of the confining unit ranged from 0.0014 to 0.41 feet/day. Based on the moderate conductivity values and the thin, discontinuous nature of the confining unit, this unit may only be partly effective in retarding the vertical movement of groundwater between the surficial aquifer.

The Castle Hayne aquifer lies below the surficial aquifer and consists primarily of unconsolidated sand, shell fragments, and fossiliferous limestone. Clay, silt, silty and sandy clay, and indurated limestone also occur within the aquifer. The upper part of the aquifer consists primarily of calcareous sand with some continuous and discontinuous thin clay and silt beds. The calcareous sand becomes more limy with depth. The lower part of the aquifer consists of consolidated or poorly consolidated limestone and sandy limestone interbedded with clay and sand.

The Castle Hayne aquifer is about 150 to 350 feet thick in the area, and thickens eastward across the base. The top of the aquifer lies approximately 20 to 65 feet below the ground surface. The top of the aquifer dips southward, and is deepest at the Atlantic coast, east of the New River. The top of the aquifer also forms a basin in the vicinity of Paradise Point. Estimates of hydraulic conductivity indicate a wide variation in range, from 14 to 91 feet/day.

Onslow County and MCB Camp Lejeune lie in an area where the Castle Hayne aquifer generally contains freshwater. However, the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Over-pumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer generally contains water having less than 250 milligrams per kilogram (mg/L) chloride throughout the base, except for one well (USGS-8) in the southern portion of the base that is screened in the lower portion of the aquifer. Chloride was measured at 960 mg/L in a single sample collected in 1989.

Rainfall in the MCB Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the surficial aquifer. Recharge areas at Camp Lejeune include the interstream areas. In the aquifer, groundwater flows in the direction of lower hydraulic head until it reaches discharge points or fronts. These discharge areas include the New River and its tributaries, and the ocean. Though most of the rainfall entering the surficial aquifer discharges to local streams, a relatively small amount infiltrates to the Castle Hayne. The surficial aquifer supplies the primary recharge to the Castle Hayne aquifer. Like the surficial aquifer, the Castle Hayne naturally discharges to the New River and major tributaries. However, pumping of the Castle Hayne may locally influence discharge directions.

The potentiometric surface of the surficial aquifer varies seasonally. The potentiometric surface is determined by the water levels in monitoring wells. The surficial aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. Therefore, the potentiometric surface is generally highest in the winter months and lowest in the summer or early fall.

Water levels in wells in deeper aquifers, such as the Castle Hayne were also used to establish potentiometric surfaces. Because the Castle Hayne is at least partially confined from the surficial aquifer and is not influenced by rainfall as strongly as the surficial aquifer, the seasonal variations tend to be slower and smaller than in surficial aquifer.

2.1.8 Surface Water Hydrology

The following summary of surface water hydrology was originally presented in the IAS report (Water and Air Research, 1983).

The dominant surface water feature at MCB Camp Lejeune is the New River. It receives drainage from most of the base. The New River is short, with a course of approximately 50 miles on the central Coastal Plain of North Carolina. Over most of its course, the New River is confined to a

relatively narrow channel entrenched in Eocene and Oligocene limestones. South of Jacksonville, the river widens dramatically as it flows across less resistant sands, clays, and marls. At MCB Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain the area of MCB Camp Lejeune not associated with the New River and its tributaries. These creeks flow into the Intracoastal Waterway, which is connected to the Atlantic Ocean by Bear Inlet, Brown's Inlet, and the New River Inlet (Water and Air, 1983). The New River, the Intracoastal Waterway, and the Atlantic Ocean meet at the New River Inlet.

Water quality criteria for surface waters in North Carolina have been published under Title 15 of the North Carolina Administrative Code. At MCB Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body-contact sports or commercial shellfishing) and SA (estuarine waters suited for commercial shellfishing). The SC classification applies to three areas of the New River at MCB Camp Lejeune, including the Rifle Range area; the rest of the New River at MCB Camp Lejeune falls into the SA classification (ESE, 1991).

2.1.9 Climatology

MCB Camp Lejeune experiences mild winters and hot and humid summers. The average yearly rainfall is greater than 50 inches, and the potential evapotranspiration in the region varies from 34 to 36 inches of rainfall equivalent per year. The winter and summer seasons usually receive the most precipitation. Temperature ranges are reported to be 33 to 53 degrees Fahrenheit (°F) in the winter (i.e., January) and 71 to 88°F in the summer (i.e., July). Winds are generally south-southwesterly in the summer, and north-northwesterly in the winter (Water and Air Research, 1983).

2.1.10 Natural Resources and Ecological Features

The following summary of natural resources and ecological features was obtained from the IAS Report (Water and Air Research, 1983).

The MCB Camp Lejeune is predominantly tree-covered with large amounts of softwood including shortleaf, longleaf, pond, and pines (primarily loblolly), and substantial stands of hardwood species. Approximately 60,000 of the 112,000 acres of MCB Camp Lejeune are under forestry management. Timber producing areas are under even-aged management with the exception of those areas along streams and swamps. These areas are managed to provide both wildlife habitat and erosion control. Forest management provides wood production, increased wildlife populations, enhancement of natural beauty, soil protection, prevention of stream pollution, and protection of endangered species.

Upland game species including black bear, whitetail deer, gray squirrel, fox squirrel, quail, turkey, and migratory waterfowl are abundant and are considered in the wildlife management programs.

Aquatic ecosystems on MCB Camp Lejeune consist of small lakes, the New River estuary, numerous tributaries, creeks, and part of the Intracoastal Waterway. A wide variety of freshwater and saltwater fish species exist here. Freshwater ponds are under management to produce optimum yields and ensure continued harvest of desirable fish species (Water and Air Research, 1983). Freshwater fish in the streams and ponds include largemouth bass, redbreast sunfish, bluegill, chain pickerel, yellow perch, and catfish. Reptiles include alligators, turtles, and snakes, including venomous species. Both recreational and commercial fishing are practiced in the waterways of the New River and its tributaries.

Wetland ecosystems at MCB Camp Lejeune can be categorized into five habitat types: (1) pond pine or pocosin; (2) sweet gum, water oak, cypress, and tupelo; (3) sweet bay, swamp black gum, and red maple; (4) tidal marshes; and, (5) coastal beaches. Pocosins provide excellent habitat for bear and deer because these areas are seldom disturbed by humans. The presence of pocosin-type habitat at MCB Camp Lejeune is primarily responsible for the continued existence of black bear in the area. Many of the pocosins are overgrown with brush and pine species that would not be profitable to harvest. Sweet gum, water oak, cypress, and tupelo habitat is found in the rich, moist bottomlands along streams and rivers. This habitat extends to the marine shorelines. Deer, bear, turkey, and waterfowl are commonly found in this type of habitat. Sweet bay, swamp black gum, and red maple habitat exist in the floodplain areas of MCB Camp Lejeune. Fauna including waterfowl, mink, otter, raccoon, deer, bear, and gray squirrel frequent this habitat. The tidal marsh at the mouth of the New River is one of the few remaining North Carolina coastal areas relatively free from filling or other manmade changes. This habitat, which consists of marsh and aquatic plants such as algae, cattails, saltgrass, cordgrass, bulrush, and spikerush, provides wildlife with food and cover. Migratory waterfowl, alligators, raccoons, and river otter exist in this habitat. Coastal beaches along the Intracoastal Waterway and along the outer banks of MCB Camp Lejeune are used for recreation and to house a small military command unit. Basic assault training maneuvers are also conducted along these beaches. Training regulations presently restrict activities that would impact ecologically sensitive coastal barrier dunes. The coastal beaches provides habitat for many shorebirds (Water and Air Research, 1983).

The Natural Resources and Environmental Affairs (NREA) Division of MCB Camp Lejeune, the U.S. Fish and Wildlife Service, and the North Carolina Wildlife Resource Commission have entered into an agreement for the protection of endangered and threatened species that might inhabit MCB Camp Lejeune. Habitats are maintained at MCB Camp Lejeune for the preservation and protection of rare and endangered species through the Base's forest and wildlife management programs. Full protection is provided to such species, and critical habitat is designated in management plans to prevent or mitigate adverse effects of Base activities. Special emphasis is placed on habitat and sightings of alligators, osprey, bald eagles, cougars, dusky seaside sparrows, and red-cockaded woodpeckers (Water and Air Research, 1983).

Neither of the sites included in this investigation are within or in close proximity (i.e., one-half mile) to either a natural area or a protected area. Protected areas have only been established for the red-cockaded woodpecker.

Within 15 miles of MCB Camp Lejeune are three publicly owned forests: Croatan National Forest; Hofmann Forest; and Camp Davis Forest. The remaining land surrounding MCB Camp Lejeune is primarily used for agriculture. Typical crops include soybeans, small grains, and tobacco (Water and Air Research, 1983).

2.1.11 Water Supply

MCB Camp Lejeune water is supplied entirely from groundwater. Groundwater is obtained from approximately 90 water supply wells and treated. There are eight water treatment plants with a total capacity of approximately 15.8 million gallons per day (mgd). Groundwater usage is estimated at over 7 mgd (Harned, et al., 1989).

The water supply wells are all located within the boundaries of the Base. The average water supply well at the base has a depth of 162 feet, a casing diameter of eight inches, and yields 174 gpm (Harned, et al., 1989).

All of the water supply wells utilize the Castle Hayne aquifer. The Castle Hayne aquifer is a highly permeable, semiconfined aquifer that is capable of yielding several hundred to 1,000 gpm in municipal and industrial wells in the MCB Camp Lejeune Area. The water retrieved is typically a hard, calcium bicarbonate type. However, some water supply wells on Base have been closed due to contamination, etc.

The Preliminary Draft Report Wellhead Monitoring Study for MCB, Camp Lejeune, North Carolina (Greenhorne, 1992) was reviewed to locate water supply wells within a 3-mile radius of Sites 90, 91, and 92. Based on a review of this sources, there are five supply wells (BB-220, BB-221, BB-218, BB-44, and BB-47) located within a one-mile radius of the sites. The supply well locations are shown on Figure 2-4. Presently, all wells are in service.

2.2 Site 90 (BB-9)

2.2.1 Site Location and Setting

Site 90, the former underground storage tanks (USTs) for Building BB-9, is located near the intersection of Middle Road and Peach Street between Buildings BB-9 and BB-16 in the Courthouse Bay area of MCB Camp Lejeune (Figure 2-5). Building BB-9 currently operates as a steam generation and heating plant. Three steel 1,000-gallon USTs, used to store heating oil, were located adjacent to Building BB-9. A dry cleaning facility (Building BB-16) is located northeast of the site (no dry cleaning on the premises, drop-off and pick-up point only). Located to the north and northwest of Building BB-9 are several buildings and paved parking areas. The New River is the nearest surface water body, located approximately 800 feet south of the former UST basin. The nearest known water supply well (BB-44) is located approximately 1,275 feet west of the site.

2.2.2 Site History

Building BB-9 is currently operating as a steam generation and heat plant. Adjacent to the building were three 1,000-gallon steel USTs used to store heating oil for the steam plant. All three tanks were excavated and permanently closed in March 1993. Soil contamination was noted during the tank removal activities; however, there was no information documenting the collection of soil or groundwater to confirm or estimate the extent of the impact. The former tank basin currently remains unpaved. There are three active above ground storage tanks (ASTs) of unknown capacity reported to store diesel fuel #2 east of Building BB-9. There is an active concrete oil/water separator for storm water runoff from the active AST pad southeast of the former UST basin. There also were two active 250-gallon ASTs which were used for solvent storage located west of the former UST basin. The dry cleaning process is no longer conducted in Building BB-16, but previously there was a 250-gallon AST in the building which contained dry cleaning fluid.

2.2.3 Site Topography

The area is dominated by relatively flat topography. The nearest body of surface water is in the New River, which is located approximately 800 feet down gradient of the site. The area upgradient of the site is comprised of buildings and paved parking areas.

2.2.4 Site Geology and Hydrogeology

The site is underlain with poorly graded sands or gravelly sands with little or no fines, such as silt, to a depth of approximately 25 feet. Noncontinuous lenses of clay were encountered. Underlying

the surficial sediments from approximately 25 feet to at least 50 feet deep are comprised of shelly limestone, with sand and silt. No continuous confining layer is known. The shelly limestone encountered at \pm 25 feet deep appears to be part of the Castle Hayne Aquifer.

Groundwater was encountered at approximately six to ten feet below ground surface (bgs). Groundwater table elevations indicate groundwater flow to be predominantly to the south-southwest with minor flow components to the north, east, and west in the vicinity of the UST. There appears to be a dewatering feature on the east side of Peach Street in the vicinity of BB-906. Due to the approximate distance (800 feet) of the site from the nearest tidally-influenced body of water, it is unlikely the daily tidal fluctuations would affect groundwater movement (Catlin, 1994).

2.2.5 Previous Investigations

As a follow-up to the tank removals, a three well site check was conducted in April 1993 by Groundwater Technology Government Services, Inc., to identify and/or verify the suspected hydrocarbon impact in the subsurface soil and groundwater. The activities included:

- Installing three monitoring wells (BB9-1 through BB9-3) around the former UST basin in April 1993. The wells were installed approximately 20 feet below ground surface (bgs). Groundwater was encountered approximately 5 feet bgs. Figure 2-6 presents the monitoring well locations.
- TPH analysis of three soil samples (one from each soil boring) revealed concentrations ranging from: 142,000 to 690,000 micrograms per kilogram ($\mu\text{g}/\text{kg}$) total petroleum hydrocarbon (TPH)-diesel; 120,000 to 1,700,000 $\mu\text{g}/\text{kg}$ TPH-lubrication oil; and 870,000 to 3,800,000 total oil and grease.
- Analyzing groundwater samples for benzene, toluene, ethylbenzene, and total xylenes (BTEX). The results revealed maximum concentrations of 2.7 micrograms per liter ($\mu\text{g}/\text{L}$) benzene, 5.1 $\mu\text{g}/\text{L}$ toluene, 11.0 $\mu\text{g}/\text{L}$ ethylbenzene, and 48.0 $\mu\text{g}/\text{L}$ total xylenes. No free phase product was noted in any of the wells.

A leaking underground storage tank comprehensive site assessment for Site 90 was conducted in December 1994 by Richard Catlin & Associates, Inc. to determine site subsurface characteristics and the extent of impact to subsurface soil and groundwater. The work performed included:

- Utilizing 12 HydroPunch™ penetrometers (HP-1 through HP-12) to provide preliminary data to assist with the location of the permanent monitoring wells. The HydroPunch™ samples were analyzed for polynuclear aromatic hydrocarbons (PAHs). Figure 2-7 presents the HydroPunch™ locations.
- Advancing fifteen soil borings to install 12 Type II (BB9-4 through BB9-15) and three Type III (BB9-16 through BB9-18) monitoring wells to determine the horizontal and vertical extent of petrochemical contamination in the former UST area. Figure 2-6 presents the monitoring well locations. Designated soil boring samples were analyzed for TPH, Toxicity Characteristic Leaching Procedure (TCLP) organics and metals, flashpoint, purgeable aromatics, and soil pH.

- Collecting 15 groundwater samples from the newly installed monitoring wells. Select samples were analyzed for PAHs, purgeable organics, TCLP metals, and drinking water volatiles.

The results of the analyses requested above are provided below:

- **HydroPunch™ Groundwater:** The highest total PAH concentrations detected were in HydroPunch™ samples HP-8 (21.4 µg/L) and HP-7 (17.3 µg/L), located upgradient of the former UST basin. Trace levels were detected in samples HP-1 (4.1 µg/L), HP-2 (2.1 µg/L), HP-4 (1.5 µg/L), HP-5 (2.7 µg/L), HP-9 (0.6 µg/L), and HP-10 (0.9 µg/L). HydroPunch™ results are presented in Table 2-3 and on Figure 2-7.
- **Soil Borings:** TPH, identified as gasoline, was detected in BB9-18 at two depths (7.5 to 10.0 feet and 22.5 to 25.0 feet) at concentrations of 16,000 and 26,000 µg/kg, respectively. No TPH-gasoline or TPH-diesel was identified in any other soil samples.
- **Soil Borings:** Total contaminant levels of purgeable aromatics were detected in soil borings BB9-7 (36.5 µg/kg) and BB9-11 (8.6 µg/kg), located north and upgradient of the former UST basin. Lower levels also were detected in BB9-4 and BB9-15 (4.5 µg/kg), BB9-12 (4.0 µg/kg), and BB9-14 (5.8 µg/kg). Soil boring locations BB9-4, BB9-12, and BB9-15 were all within the immediate vicinity of the former UST basin. Soil boring BB9-14 is located topographically downgradient from the AST pad. Soil boring results for purgeable aromatics are presented in Table 2-4 and on Figure 2-8.
- **Monitoring Wells:** Trace levels of PAH compounds were detected in monitoring wells BB9-4, BB9-5, BB9-7, and BB9-13 through BB9-18. The highest detections were interpreted to be immediately south and downgradient of the former UST basin and the active oil/water separator and in the northern portion of the area adjacent to Building BB-210. Groundwater results for PAHs are presented in Table 2-5. The shallow monitoring well sample results are presented on Figure 2-9. The intermediate well results are presented on Figure 2-10.
- **Monitoring Wells:** Trace levels of PAH compounds were detected in the Type III wells BB9-16, BB9-17, and BB9-18, which monitor the upper zone of the Castle Hayne. Groundwater results for PAHs are presented in Table 2-5.
- **Monitoring Wells:** Purgeable organics were detected below regulatory limits in monitoring well BB9-4 and BB9-5. Drinking water volatiles (purgeable organics and chlorinated organic compounds) were detected in excess of State standards in monitoring wells BB9-4, BB9-5, BB9-7, BB9-9, and BB9-12. The highest detections were immediately adjacent to and downgradient of the former UST basin and west of Building BB-210, located north and upgradient of the former UST basin. Groundwater results for purgeable organics are presented in Table 2-6. Groundwater results for drinking water volatiles are presented in Table 2-7.
- **Monitoring Wells:** TCLP metals which exceeded established state standards were cadmium, lead, and silver in monitoring wells BB9-4, BB9-5, BB9-6, BB9-15, and

BB9-16. In addition, monitoring wells BB9-5 and BB9-6 reported elevated chromium levels. Groundwater results for TCLP metals are presented in Table 2-8.

- No evidence or measurable thickness of free product was identified during the course of this investigation.

2.3 Site 91 (BB-51)

2.3.1 Site Location and Setting

Site 91, the two former USTs associated with Building BB-51, is located at the north end of Clinton Street northeast of Building BB-51 in the Courthouse Bay area of MCB Camp Lejeune (Figure 2-11). Building BB-51 is an instruction building for the Marine Corps Engineering School. Two USTs, both constructed of steel with a 300-gallon capacity, were reportedly used to store waste oil at the facility. The tanks were located in an unpaved area on the edge of the treeline, approximately 200 feet northeast of Building BB-51. Much of the area around Building BB-51 is unpaved and wooded. The New River is the nearest surface water body, located approximately 2,975 feet south-southwest of Building BB-51. The nearest known water supply well (BB-44) is located approximately 1,275 feet northwest of the site.

2.3.2 Site History

Building BB-51 was constructed, and is currently used, as an instruction building for the Marine Corps Engineering School. Northeast of the building were two 300-gallon steel USTs, used to store waste oil at the facility. The tanks were excavated and removed in August 1992. No information was available about the age or condition of the tanks at removal. Soil samples collected during the UST closure were analyzed and revealed concentrations of TPH-oil and grease. The former tank basin is now grass covered. There is a vehicle storage area west of the former UST basin and directly north of Building BB-51. A bermed petroleum, oil, and lubricants area is located 300 feet north of Building BB-51 and northwest of the former UST basin. An active lube-oil drum storage pad is located approximately 250 feet north of Building BB-51 and west of the former UST basin. An active vehicle/equipment wash pad is located approximately 170 feet north-northwest of Building BB-51 and west of the former UST basin. An active temporary storage area of hazardous/potentially hazardous materials is located west of the former UST basin and north-east of Building BB-51.

2.3.3 Site Topography

The site is relatively flat with a gradual grade to the south. The nearest surface water is the New River located to the south of the site.

2.3.4 Site Geology and Hydrogeology

The site is underlain with poorly graded to well graded sands with little or no fines, to a depth of approximately 20 feet. Noncontinuous lenses of silty sand were encountered throughout the area. A continuous layer of silty sands and sand-silt mixtures are present at 25 feet, underlain by an apparent continuous layer of well-graded sand at approximately 30 feet. Sediments below 30 feet are represented by integrated poorly to well graded sands and silty sands. No confining unit was identified (Catlin, 1994).

Groundwater was encountered between approximately 9 to 11 feet bgs. Groundwater flow is predominantly to the south-southeast.

2.3.5 Previous Investigations

As a follow-up to the tank removals, a three well site check was conducted in April 1993 by Groundwater Technology Government Services, Inc., to identify and/or verify the suspected hydrocarbon impact in the subsurface soil and groundwater. The activities included:

- Installing three shallow monitoring wells (BB51-1 through BB51-3) around the former UST basin in April 1993. The wells were constructed approximately 20 feet bgs. Groundwater was encountered approximately 9 to 11 feet bgs. Figure 2-12 presents the monitoring well locations.
- TPH analysis of the three soil samples (one from each soil boring). The results revealed concentrations ranging from 45,000 to 2,500,000 $\mu\text{g}/\text{kg}$ TPH-total oil and grease. There were no detectable concentrations of TPH-gasoline, diesel, lubricating oil, mineral spirits, kerosene, or fuel oil #6 reported.
- Analyzing groundwater samples for BTEX. The results revealed only a maximum concentration of 0.5 $\mu\text{g}/\text{L}$ toluene. No free phase product was noted in any of the wells.

A leaking underground storage tank comprehensive site assessment for Site 91 was conducted in September 1994 by Richard Catlin & Associates, Inc. to determine site subsurface characteristics and the extent of impact to subsurface soil and groundwater. The work performed included:

- Utilizing 10 HydroPunch™ penetrometers (HP-1 through HP-10) to provide preliminary data to assist with the location of the permanent monitoring wells. The HydroPunch™ samples were analyzed for PAHs. Figure 2-12 presents the HydroPunch™ locations.
- Advancing fifteen soil borings to install 12 Type II (BB51-4 through BB51-15) and three Type III (BB51-16 through BB51-18) monitoring wells to determine the horizontal and vertical extent of petrochemical contamination in the former UST area. Figure 2-12 presents the monitoring well locations. Designated soil boring samples were analyzed for oil and grease, TCLP organics and metals, flashpoint, purgeable aromatics, and soil pH.
- Collecting 15 groundwater samples from the newly installed monitoring wells. Select samples were analyzed for PAHs, purgeable organics, TCLP metals, and drinking water volatiles.

The results of the analyses requested above are provided below:

- HydroPunch™ Groundwater: The only PAH concentration detected was chrysene in HydroPunch™ sample HP-5 (1.2 $\mu\text{g}/\text{L}$). Sample HP-5 is located approximately 50 feet southwest of the UST basin.
- Soil Borings: Oil and grease was identified in all but three of the soil boring samples analyzed (BB51-12, BB51-14, and BB51-15); however, only two of the concentrations reported were above state regulatory levels. Sample BB51-12 (10 to 12 feet bgs) and BB51-16 (2.5 to 5 feet bgs) had detections of 460,000 $\mu\text{g}/\text{kg}$ and 430,000 $\mu\text{g}/\text{kg}$, respectively. Two areas of oil and grease contaminated soil were

identified in the subsurface within the area of investigation. The first area appears to be the vadose zone in and immediately surrounding the former UST basin. The second area was identified south of the former UST basin. Soil boring results for oil and grease are presented in Table 2-9.

- Soil Borings: Total purgeable aromatics were detected in all the soil borings. The majority of the compounds were detected in the 2 to 4 feet bgs and 10 to 12 foot bgs intervals, indicating a surface release. Soil boring results for purgeable aromatic results are presented in Table 2-10.
- Monitoring Wells: Trace levels of drinking water volatiles, cadmium, silver, and arsenic were detected in concentrations above State standards. However, no definite petrochemical plume within the vicinity of the former UST basin was identified. PAHs did not exceed established State standards. Groundwater results for: drinking water volatiles are presented in Table 2-11; PAHs are presented in Table 2-12; and TCLP metals are presented in Table 2-13. The shallow monitoring well sample results are presented on Figure 2-13. The intermediate monitoring well results are presented on Figure 2-14.
- No evidence or measurable thickness of free product was identified during the course of this investigation.

2.4 Site 92 (BB-46)

2.4.1 Site Location and Setting

Site 92, the UST for Building BB-46, is located at the end of Front Street in the Courthouse Bay area of MCB Camp Lejeune (Figure 2-15). Building BB-46 has been dismantled. Building BB-246 has been constructed nearby to replace Building BB-46. One steel 1,000-gallon UST, used to store regular gasoline for retail use, was located northwest of Building BB-46. A playground is located 100 feet west to southwest from the former UST basin. A metal storage shed, used to store 5-gallon gas cans, is located 10 feet northwest from the former UST basin. The site is directly adjacent to Courthouse Bay. The nearest known supply well (BB-45) is located approximately 2,350 feet southeast of the site.

2.4.2 Site History

Building BB-46, which was used as a boat house, has been replaced by Building BB-246. A concrete pad, in the vicinity of where Building BB-46 was located, is now used as a covered picnic area. Northwest of Building BB-46 and north of Building BB-246, one 1,000-gallon steel UST was used to store regular gasoline for retail use. The UST was installed in 1980, deactivated in 1989, and removed in January 1994. A groundwater sample taken during UST closure activities indicated elevated levels of BTEX.

2.4.3 Site Geology and Hydrogeology

The site is primarily underlain by shallow fine-grained sand, with a layer of underlying clay. Groundwater was encountered between 5.0 and 5.5 feet bgs. Groundwater flow is apparent to the northeast.

2.4.4 Previous Investigations

As a follow-up to the tank removals, a three well site check was conducted in August 1994 by R. E. Wright Associates, Inc., to identify and/or verify the suspected petroleum hydrocarbon impact in the subsurface and groundwater. The activities included:

- Installing three shallow monitoring wells (MW-01, MW-02, and MW-03) around the former UST basin. The wells were constructed approximately 13 to 14 feet bgs. Groundwater was encountered between 5.0 and 5.5 feet bgs. Monitoring well data is presented in Table 2-14. Figure 2-16 presents the monitoring well locations.
- Analyzing three soil samples (one from each soil boring) for TPH-gasoline range organics (GRO). The results were all below detection limits.

Analytical findings for three groundwater samples, analyzed for BTEX, indicated nondetectable concentrations for gasoline constituents. Tetrachloroethene (PCE) was detected in groundwater samples in each well ranging from 16.0 $\mu\text{g/L}$ at MW-02 to 30.0 $\mu\text{g/L}$ at MW-01. PCE is not a constituent of gasoline and its source therefore is believed not to be associated with the former UST basin. No free phase product was noted in any of the wells. The analytical findings are presented in Table 2-15 and on Figure 2-17.

A site survey including monitoring well, soil boring, and building locations also was completed.

3.0 DATA QUALITY AND SAMPLING OBJECTIVES

The purpose of this section is to define the site evaluation data quality and sampling objectives in order to fulfill the overall goals of characterizing the problems at all three sites assessing potential impacts to the public health and environment, and identifying feasible remedial alternatives for remediating the sites, if necessary. The specific site evaluation objectives presented in this section have been identified based on review and evaluation of existing background information.

3.1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that ensure data of known and appropriate quality are obtained during the site evaluation. The DQOs associated with each field sampling and analysis program are discussed and presented in this section. The DQOs were developed using the following three stages:

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses/needs
- Stage 3 - Design data collection program

Stage 1 of the DQO process takes place during project scoping. This stage involves the evaluation of existing information and the development of objectives for field data collection efforts.

Stage 2 of the DQO process involves definition of the quality and quantity of data that will be required to meet the objectives established in Stage 1.

Stage 3 involves the design of a data collection program to meet the requirements identified in Stage 2.

3.1.1 Stage 1 - Identification of Decision Types

As part of the Stage 1 DQO process, available information from previous site investigations and other sources (e.g., UST reports) were reviewed in order to describe current site conditions, evaluate existing data, and assess the adequacy of the data. This was documented in Section 2.0 of this Work Plan. From this review and evaluation, site evaluation objectives have been developed to (1) assess the nature of the threat posed by the release or potential release of hazardous substances; (2) characterize the site with respect to the environmental setting; and (3) evaluate potential remedial alternatives. These objectives are presented in Section 3.2.

3.1.2 Stage 2 - Identification of Data Uses/Needs

The data quality and quantity required to support the site evaluation objectives developed during Stage 1 are identified in Stage 2 of the DQO process. With respect to the site evaluation objectives, data will be required to address specific environmental media at each site. Data uses for each environmental media are presented in Section 3.1.2.1. Site-specific data needs are discussed in Section 3.1.2.2.

3.1.2.1 Data Uses for Environmental Media

The site evaluation data uses can be described in general purpose categories. These categories include the following:

- Site Characterization - Data are used to determine the nature and extent of contamination at a site. Site characterization data are generated through the sampling and analysis of waste sources and environmental media.
- Health and Safety - Data are typically used to establish the level of protection needed for investigators or workers at a site, and if there should be an immediate concern for the population living within the site vicinity.
- Risk Assessment - Data are used to evaluate the threat posed by a site to public health and the environment. Risk assessment data are generated through the sampling and analysis of environmental media, particularly where the potential for human exposure is great (e.g., surface soil, potable groundwater supplies).
- Evaluation of Alternatives - Data are used to evaluate various remedial technologies. Engineering data are collected in support of remedial alternative evaluation and to develop cost estimates for remediating the site. This may involve conducting bench or pilot-scale studies to determine the effectiveness or implementability of the technology.
- Engineering Design of Alternatives - Data collected during the RI can be used for engineering purposes to develop a preliminary data base in reference to the performance of various remedial technologies. Data types collected during the Site Evaluation which are applicable to the RD process include waste characterization and preliminary volume estimates (these estimates can be further defined during the remedial design/remedial action via additional field verification sampling).

The above discussion of data uses was extracted from the document entitled Data Quality Objectives for Remedial Response Activities: Development Process (OSWER Directive 9355.0-7B). It has been presented in this Work Plan to provide the user with an understanding of the rationale for determining the site-specific site evaluation objectives as well as the rationale for the proposed sampling and analytical program for each site evaluation.

With respect to the above data uses, an understanding of the site background, site history, and contaminant migration and exposure pathways are required in order to define the data needs (or data limitations). This "background" information was presented in Section 2.0 for each site. The site-specific data needs are presented in Section 3.1.2.2. RI/FS objectives, which have been formed to meet the data needs, are presented in Section 3.2.

3.1.2.2 Site-Specific Data Needs

Operable Unit No. 17 (Sites 90, 91, and 92)

- Determine the nature of soil and shallow groundwater contamination in the investigation area.

- Verify the presence or absence of subsurface soil contamination within the vicinity of all three sites.
- If present, determine the horizontal and vertical extent of soil contamination within the investigation area.
- Verify the presence of shallow and intermediate groundwater contamination and determine the extent of this contamination.
- Provide hydrogeologic parameters of the upper portion of the shallow aquifer.

The type and quality of data required to meet the criteria listed above are presented in Section 4.0. The data quality levels differ with respect to the end use of the data. Level IV data quality are generally required in risk assessments, characterizing the nature and extent of contamination, and to support subsequent investigations. Level III data quality is appropriate for risk assessments, site characterization, and evaluating treatment alternatives. Level II data quality is appropriate for field screening (e.g., ENSYS Screening). Level I data is appropriate for field measurements such as static water level, specific conductance, and pH. The analytical methods also differ with respect to the end use of the data. For this RI, USEPA methods and Contract Laboratory Program (CLP) methods will be used when applicable.

This field investigation will employ the use of Levels III and IV data. Level III data includes field screening activities using USEPA approved methods, whereas Level IV data includes fixed-based CLP. All samples collected for engineering parameters will be analyzed in accordance with Level II. Field screening data will be confirmed by Level IV data conducted in accordance with CLP.

3.1.3 Stage 3 - Design Data Collection Program

The data collection program for all three sites has been designed to meet the objectives outlined in the following sections. Section 4.0 of the RI/FS Work Plan provides a general description of the various sampling programs for each site. Sections 3.0 through 5.0 of the FSAP provide the specific details of these sampling programs.

The RI field activities will be conducted in two phases. Phase I includes the installation of temporary shallow and intermediate monitoring wells to better define the horizontal and vertical extent of contamination. The Phase I field work will begin following the submission of the draft Project Plans. Phase II activities will begin after the Phase I report has been submitted and the Project Plans have been finalized. The Phase II activities will be based on the recommendations presented in the Phase I report and will include the installation of permanent shallow and intermediate monitoring wells.

3.2 Study Objectives

For each site-specific study objectives, the criteria necessary to meet each objective along with a general description of the study or investigation required to obtain the information are presented in Table 3-1.

4.0 REMEDIAL INVESTIGATION TASKS

This section identifies the tasks and field investigations required to complete remedial investigation activities at OU No. 17.

4.1 Task 1 - Project Management

Project Management activities involve such activities as daily technical support and guidance, budget and schedule review and tracking, preparation and review of invoices, personnel resources planning and allocation, preparation of monthly progress reports, and communication with LANTDIV and the Activity.

4.2 Task 2 - Subcontract Procurement

Task 2 involves the procurement of services such as drilling, surveying, laboratory analysis, and data validation. Procurement of these services will be performed in accordance with the Navy Clean Contract Procurement Manual.

4.3 Task 3 - Field Investigations

The field investigations will be conducted under Task 3. An overview of the field investigation to be conducted at the site is presented in the following subsections. Specific details with respect to the sampling procedures, locations and number of samples, and analytical methods are provided in the Field Sampling and Analysis Plan (FSAP) and the Quality Assurance Project Plan (QAPP). The field investigations described below will provide data to meet the overall site evaluation objectives presented in Section 3.0 of this RI/FS Work Plan. Table 4-1 summarizes the sampling and analytical requirements.

The field investigation will be separated into two phases, Phase I and Phase II. The Phase II investigation will be based on the results of the Phase I investigation. The following outlines the activities that will be conducted during Phase I only.

4.3.1 Surveying

A site survey will be conducted and include the existing site features such as fence lines, sidewalks, utilities, nearby buildings foundations, tree lines, access roads and established roadways, existing monitoring wells, soil borings, new temporary wells, surface water and sediment sampling stations, and the banks along the New River. Specific details with respect to the survey are provided in the FSAP.

4.3.2 Soil Investigation

A soil investigation is planned to be conducted in the vicinity of Sites 90, 91, and 92 to determine the horizontal and vertical extent of subsurface soil contamination. This investigation is necessary to determine if contamination has impacted the subsurface soil which could act as a potential source of contamination to shallow groundwater. The following provides a description of the proposed soil investigation.

One subsurface soil sample will be collected from each of the initial soil boring/temporary monitoring well locations at each of the sites. This sample will be collected from just above the

water table and submitted for chemical analysis. If the depth to groundwater is greater than 10 feet below ground surface (bgs) or there is evidence of contamination, one additional subsurface soil sample will be collected from a mid-depth level.

The Phase I investigation will include augering 23 soil boring locations. These 23 soil borings will be completed at each of the sites as described below:

- Site 90 - 7 soil borings
- Site 91 - 12 soil borings
- Site 92 - 4 soil borings

The locations of the proposed soil borings are shown in Figures 4-1 through 4-3 of the FSAP. However, additional soil borings will be installed and subsurface soil samples obtained if deemed necessary to further delineate the extent of the contamination.

The subsurface soil samples collected will be analyzed for Target Compound List (TCL) volatile organic compounds (VOCs) by an on-site mobile laboratory. The samples will be analyzed in accordance with EPA Method 8240 (DQO Level III). Additionally, in order to determine if other contamination has impacted the soil three subsurface soil samples from each site will be submitted for fixed base laboratory analysis. The samples submitted for fixed base analysis will be selected based on the findings of the on-site laboratory. To confirm the lower bound and upper bound analytical limits of the mobile laboratory, one sample with a low detected concentration, one sample with a medium detected concentration, and one sample with a high detected concentration will be submitted to a fixed based analytical laboratory. These samples will be analyzed for TCL VOCs, semivolatile organic compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), and Target Analyte List (TAL) metals. All fixed based analysis will be conducted in accordance with Contract Laboratory Program (CLP) Statement of Work (SOW) DQO Level IV. All soil samples will be analyzed and reported on a 28-day turnaround time.

4.3.3 Groundwater Investigation

The objective of the groundwater investigation is to determine if contamination has migrated in a horizontal direction in the shallow zone and vertically from the shallow to the Castle Hayne aquifer. Detailed information regarding well depths and locations is provided in Section 4 of the FSAP. The following provides the scope of the groundwater investigation.

4.3.3.1 Site 90

- Seven temporary shallow monitoring wells will be installed and one round of groundwater samples will be collected for on-site mobile laboratory analysis (volatile organics).
- All existing monitoring wells that are to be sampled will be redeveloped prior to sampling.
- One round of groundwater samples will be collected from 15 existing shallow monitoring wells for on-site mobile laboratory analysis (volatile organics).
- One round of groundwater samples will be collected from 3 existing intermediate monitoring wells for on-site mobile laboratory analysis (volatile organics).

- In addition to being sampled for on-site analysis, one round of groundwater samples will be collected from five existing shallow (BB-4, 5, 6, 12, 15) and two existing intermediate (BB-16, 18) monitoring wells for fixed based analysis (TCL organics [VOC, SVOC, Pesticides/PCBs], TAL total metals, TDS, and TSS).
- In addition to being sampled for on-site analysis, one temporary shallow monitoring well sample will be collected for TCL VOC analyses at a fixed based analytical laboratory.
- Static water level measurements will be collected from all existing and temporary wells.

4.3.3.2 Site 91

- Ten temporary shallow monitoring wells and two temporary monitoring wells will be installed and one round of groundwater samples will be collected for on-site mobile laboratory analyses (volatile organics).
- All existing monitoring wells that are to be sampled will be redeveloped prior to sampling.
- One round of groundwater samples will be collected from 15 existing shallow monitoring wells for on-site mobile laboratory analysis (volatile organics).
- One round of groundwater samples will be collected from three existing intermediate monitoring wells for on-site mobile laboratory analysis (volatile organics).
- In addition to being sampled for on-site laboratory analysis, groundwater samples will be collected from five existing shallow (BB-4, 6, 8, 9, 12) and two existing intermediate (BB-16, 17) monitoring wells and submitted for fixed base analyses (TCL organics, TAL total metals, TDS, and TSS).
- In addition to being sampled for on-site analysis, one temporary shallow and one temporary intermediate monitoring well sample will be collected for TCL VOC analysis at a fixed based analytical laboratory.
- Static water level measurements will be collected from all existing and temporary wells.

4.3.3.3 Site 92

- Three temporary shallow monitoring wells and one temporary intermediate monitoring well will be installed and one round of groundwater samples will be collected for on-site mobile laboratory analysis (volatile organics).
- All existing monitoring wells that are to be sampled will be redeveloped prior to sampling.

- One round of groundwater samples will be collected from three existing shallow monitoring wells for on-site mobile laboratory analysis (volatile organic compounds).
- In addition to being sampled for on-site laboratory analysis, one groundwater sample will be collected from an existing shallow monitoring well (MW-1) and submitted for fixed base analyses (TCL organics, TAL total metals, TDS, and TSS).

If contamination is detected the installation of temporary wells will be expanded until the vertical and horizontal extent of the plume has been defined. The North Carolina Water Quality Standard (NC WQS) or the Federal Maximum Contaminant Level (MCL) will be used as endpoints to determine if the limits of the contamination have been defined.

Groundwater samples from the temporary and existing wells will be analyzed for VOCs by an on-site laboratory in accordance with EPA Method 8240 (DQO Level III). Groundwater samples collected for fixed base analysis will be analyzed for full TCL organics, TAL total metals, Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). TCL organics and TAL metals will be analyzed in accordance with the CLP SOW (DQO Level IV). TSS and TDS analysis will be performed in accordance with EPA Methods 160.1 and 160.2, respectively.

4.3.4 Surface Water and Sediment Investigation

A surface water and sediment investigation will be conducted at Site 92 to assess the possible impact of the site, other source areas, and possible groundwater contamination to the adjacent water body (New River). The locations of the proposed locations are shown in Figure 4-3 of the FSAP. The following provides a description of the proposed investigation.

One surface water sample will be collected from six stations in Courthouse Bay. Two sediment samples will be collected from each sample station. The initial sediment sample will be collected from 0- to 6-inch depth; the second sample will be collected from the 6- to 12-inch depth. Final sample locations will be determined in the field based on accessibility.

Three staff gauges, one on each side of the point and one at the point into the New River will be installed. These staff gauges will be established for long term monitoring with pressure transducers to determine the amount of tidal influence and whether groundwater is discharging to the surface water, surface water is discharging to groundwater, or depending on the tidal influence determine if both are occurring.

All surface water and sediment samples will be submitted for fixed base analysis of TCL organics, TAL metals, grain size and Total Organic Carbon (TOC). TCL organic and TAL total metals analysis will be conducted in accordance with the CLP SOW. Grain size and TOC analysis will be completed using ASTM D 1140, and EPA 415.1, respectively.

4.3.5 Investigation Derived Waste Handling

Drill cuttings or excavated soils will be collected and contained in a rolloff box. One rigid storage tank with a capacity of 1,000 gallons will be available for containing groundwater development and purge water. A composite soil sample from the rolloff box will be collected and analyzed for full toxicity characteristics leaching procedure (TCLP) (organics and inorganics), RCRA hazardous waste characterization (corrosivity, reactivity, and ignitability), and PCBs. One sample will be collected

from the tank and analyzed for full TCL organics, TAL total metals, TSS and TDS. Additional details regarding IDW handling and disposal are provided in Section 6.9 of the FSAP.

4.4 Task 4 - Sample Analysis and Validation

This task involves efforts relating to the following post-field sampling activities:

- Sample Management
- Laboratory Analysis
- Data Validation

Sample management activities involve: coordination with laboratories; tracking of samples submitted for analysis; tracking of analyses received; and tracking of information related to samples submitted and received from a third party validator. Sample management also involves resolving technical or administrative problems (e.g., reanalysis, resubmission of information).

Laboratory analysis begins when the samples are shipped from the field and received by the laboratory. Validation begins when the "raw" laboratory data is received by the validator from Baker. Baker will first receive the data from the laboratory, log it into a database for tracking purposes, and then forward it to the validator. A validation report will be expected within three weeks following receipt of laboratory data packages by the validator. CLP data will be validated per the CLP criteria as outlined in the following document:

- USEPA, Hazardous Site Control Division, Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, 1994.
- USEPA, Hazardous Site Evaluation Division, Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, 1988.

All other data will be validated in accordance with the method of analysis using the National Functional Guidelines as a reference.

4.5 Task 5 - Data Evaluation

This task involves efforts related to the data once it is received from the laboratory and is validated. It also involves the evaluation of any field-generated data including: water level measurements, test boring logs, and other field notes. Efforts under this task will include the tabulation of validated data and field data, generation of test boring logs and monitoring well construction logs, generation of geologic cross-section diagrams, and the generation of other diagrams associated with field notes or data received from the laboratory (e.g., sampling location maps).

4.6 Task 6 - Qualitative Human Health Risk Assessment

A qualitative human health risk assessment will be conducted to evaluate potential impacts from site-related contaminants to human receptors. A preliminary list of chemicals of potential concern (COPCs) will be determined based on the Phase I RI findings. Also, potential exposure scenarios will be developed based on current and expected land uses of the sites. A quantitative risk assessment will be performed following the Phase II field investigation. Details of the quantitative RA will be provided in the final RI/FS Plans.

4.6.1 Site Location and Characterization

A background section will be presented at the beginning of the risk assessment to provide an overview of the characteristics of each site. This section will provide a site location, a general site description, and the site-specific chemicals as discussed in past reports. The physical characteristics of the site and the geographical areas of concern will be discussed. This site description will help to characterize the exposure setting.

4.6.2 Data Summary

Because decisions regarding data use may influence the results of this qualitative risk assessment, careful consideration must be given to the treatment of those data. For purposes of this qualitative risk evaluation, the site at MCB Camp Lejeune may be partitioned into operable units, sites, and areas of concern for which chemical concentrations will be characterized and risks will be evaluated. Sites will be grouped into operable units if they are close to one another, have similar contamination, and/or may impact the same potential receptors. In selecting data to include in the risk assessment, the objective is to characterize, as accurately as possible, the distribution and concentration of chemicals at each site. Finally, data summary tables will be developed for each medium sampled (e.g., surface water, sediment, groundwater, soil). Each data summary table will indicate the frequency of detection, observed range of concentrations, and average background concentrations (inorganics).

4.6.3 Identifying Preliminary COPCs

All data determined to be of usable quality will be used to qualitatively identify preliminary COPCs based on comparisons with applicable criteria. The criteria used in the identification of a chemical as a preliminary COPC include comparing the maximum detected soil concentrations to corresponding risk-based USEPA Region III residential chemicals of concern (COC) screening values, as presented in the Region III COC Screening Table (USEPA, 1994) and updated using information from the Region III Risk-Based Concentration (RBC) Table (USEPA, 1996) and USEPA Region III Soil Screening Levels (transfers from soil to groundwater), as presented in the Region III RBC Table (USEPA, 1996). In addition, detected groundwater concentrations will be compared with corresponding North Carolina Water Quality Standards for Groundwater (NCWQS); surface water concentrations will be compared to NCWQS for surface water and sediment concentrations will be compared to Region III residential COC screening values for soil. In order to assess qualitative risks, all contaminants must be retained unless contaminants levels can be attributed to sources other than the site (i.e., blank contamination).

All of the available sample data will undergo review upon initiation of the qualitative risk assessment. Common laboratory contaminants such as acetone, methylene chloride, phthalate esters, toluene, and methyl ethyl ketone (2-butanone) will be addressed only if concentrations are 10 times greater than the corresponding blanks. In addition, chemicals that are not common laboratory contaminants will be evaluated if they are greater than five times the laboratory blank. The number of chemicals analyzed in the risk assessment will be a subset of the total number of chemicals detected at a site based on the elimination criteria discussed previously.

Tables will be prepared that list chemical concentrations for all media by site. Data will be further grouped according to organic and inorganic species within each table.

4.6.4 Exposure Assessment

The objectives of the exposure assessment for the qualitative risk assessment at MCB Camp Lejeune will be to characterize the potential exposure setting and identify potential migration and exposure pathways. When characterizing the exposure setting, the potentially exposed populations will be described. The migration pathway, comprised of the source, the mechanism of release in a medium for the COPC (e.g., groundwater), and the point of potential human contact with the contaminated medium will be described. Finally, the COPC exposure route(s) (e.g., ingestion) will be identified for each potential receptor.

The identification of potential exposure pathways at the site will include the activities described in the subsections that follow. Additionally, the potential exposure pathways will be re-evaluated after the Phase II investigation for the RI evaluation.

Analysis of the Probable Fate and Transport of Site-Specific Chemicals

To determine the environmental fate and transport of the chemicals of concern at the site, the physical/chemical and environmental fate properties of the chemicals will be reviewed. Some of these properties include volatility, photolysis, hydrolysis, oxidation, reduction, biodegradation, accumulation, persistence, and migration potential. This information will assist in predicting potential current and future exposures. It will help in determining those media that are currently receiving site-related chemicals or may receive site-related chemicals in the future. Sources that may be consulted in obtaining this information include computer databases (e.g., AQUIRE, ENVIROFATE), as well as the open literature.

The evaluation of fate and transport may be necessary where the potential for changes in future chemical characteristics is likely and for those media where site-specific data on the chemical distribution is lacking.

Identification of Migration Pathways

Migration of COPCs from each medium sampled (e.g., surface water, sediment, groundwater, and soil) can occur in the following ways:

- Leaching of contaminants from subsurface soil to water-bearing zones.
- Vertical migration from shallow water-bearing zones to deeper flow systems.
- Horizontal migration in groundwater in the direction of groundwater flow.
- Groundwater discharge into local streams.
- Wind erosion and subsequent deposition of windblown dust.

Identification of Potentially Exposed Human Populations

Human populations that may be potentially exposed to chemicals at the MCB Camp Lejeune include base personnel and their families, base visitors, on-site workers and recreational fishermen. The Base Master Plan will be consulted to confirm or modify these potential exposures. Current military personnel and future residents could be exposed to chemicals as they carry out activities at the site located at MCB Camp Lejeune.

Identification of Potential Exposure Scenarios Under Current and Future Land Uses

The exposure scenarios will be finalized after consulting with the Base Master Plan, USEPA and after the physical and geographical characterization of the soils are performed. Preliminarily, current and future exposure pathways are as follows:

- Soil Pathway
 - ▶ Direct ingestion (construction worker)
 - ▶ Dermal contact (construction worker)
- Groundwater
 - ▶ Direct ingestion (future residents)
 - ▶ Inhalation (future residents)
 - ▶ Dermal contact (future residents)
- Surface Water/Sediment (Site 92 only)
 - ▶ Direct ingestion (recreational user)
 - ▶ Dermal contact (recreational user)

4.6.5 Uncertainty Analysis

There is uncertainty associated with a qualitative risk assessment. The uncertainties analysis is performed to fully specify the uncertainty associated with the assumptions with risk assessment. Also, the uncertainty analysis can be used to identify areas where a moderate amount of additional information can result in significant improvement to the risk assessment. Uncertainty in a qualitative risk assessment may arise from many sources including:

- Environmental chemistry sampling and analysis.
- Misidentification or failure to be all-inclusive in chemical identification.
- Assumptions concerning exposure scenarios and population distributions.

The uncertainty analysis will qualitatively discuss non-site and site-specific factors that may produce uncertainty in the risk assessment.

4.6.6 Preliminary Remediation Goals

This section discusses the Preliminary Remediation Goals (PRGs) (ARAR-based and/or risk-based) which are determined using information on media and chemicals of potential concern, the most appropriate future land use, potential exposure pathways, toxicity information, and potential ARARs. The development of PRGs will assist in the initiation of remedial alternatives and in the selection of analytical limits of detection. Risk-based PRGs established at this time are initial, and do not establish that clean up to meet these goals is warranted. Therefore, a risk-based PRG will be considered a final remediation level only after appropriate analysis in the RI/FS and Record of Decision (ROD).

The initial step in developing PRGs is to identify media of potential concern. Important media at these sites include groundwater, soil, surface water, and sediment. COPCs include any chemical

reasonably expected to be at the sites. These chemicals may have been previously detected at the site, may be presented based on site history, or may be present as degradation products. Identifying future land use for the site is used to determine risk-based PRGs. In general, residential land use should be used as a conservative estimation for the PRGs. Chemical-specific ARARs are evaluated as PRGs because they are often readily available and provide preliminary indication about the goals that a remedial action may have to attain. For groundwater, Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs), and state drinking water standards are ARARs.

In general, chemical-specific ARARs are not available for soil; however, some states have promulgated soil standards (e.g., PCB clean-up levels) that may be criteria appropriate to use as PRGs. Risk-based PRGs will be obtained from USEPA, Region III, Risk-Based Concentration Table (USEPA, 1996). The risk-based PRGs will be reviewed and modified after the completion of the baseline risk assessment after the Phase II investigation. This modification will involve adding or subtracting chemicals of concern, media, pathways or revising individual chemical-specific goals. Table 4-2 provides PRGs for OU No. 17, respectively.

4.7 Task 7 - Phase I RI Evaluation Report

This task is intended to cover all work efforts related to the preparation of the document providing the findings once the data have been evaluated under Task 5. The task covers the preparation of a Phase I RI Report. This report will be used for Phase II planning purpose.

4.8 Task 8 - Meetings

This task involves providing technical support to LANTDIV during the RI/FS. It is anticipated that the following meetings will be required:

- A remedial project management (RPM) meeting with LANTDIV/EMD, USEPA Region IV, and the NC DEHNR prior to submission of the Final Project Plans. This meeting will be used to confirm the second phase of the RI, if necessary.
- A Restoration Advisory Board (RAB) meeting to present the findings of the RI after the investigation findings have been completed.

The meetings will be attended by the Baker Project Manager.

5.0 PROJECT MANAGEMENT AND STAFFING

The Baker Project Team will be managed by Mr. Matthew D. Bartman. The primary responsibilities of the Project Manager will be to monitor the technical performance, cost, and schedule, and to maintain close communication with the Navy Technical Representative, Ms. Katherine Landman. The Project Manager will report to Mr. John W. Mentz and Mr. Raymond P. Watras who will be responsible to provide program level support and overall QA/QC, respectively.

The Project Team will consist of a Project Engineer, Project Geologist, Health and Safety Specialist, and technical support staff as shown in Figure 5-1.

6.0 SCHEDULE

The proposed project schedule for Operable Unit No. 17 is presented as Figure 6-1. The field investigation portion of the RI is subject to the availability of government funding. Therefore, the dates shown for the Phase I investigation and the Final RI/FS Project Plans are subject to change.

- Begin in April
- to eliminate duplication
- Perform OU 15, 16 + 17
- @ same time
- use MICROSTEPS on site
- lab to delete mob etc.
- Phase I Report
30 Aug. 97
- Final Project Plans
30 Nov 97
- streamline during neg

7.0 REFERENCES

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TABLE 2-1

LAND UTILIZATION: DEVELOPED AREAS LAND USE⁽¹⁾
 SITE EVALUATION PROJECT PLANS - CTO-0344
 MCB, CAMP LEJEUNE, NORTH CAROLINA

Geographic Area	Oper.	Training (Instruc.)	Maint.	Supply/ Storage	Medical	Admin.	Family Housing	Troop Housing	CM	CO	Recreat.	Utility	Total
Hadnot Point	31 (2.9)	15 (1.4)	154 (14.3)	157 (14.4)	10 (0.9)	122 (11.3)	22 (2.0)	196 (18.1)	115 (10.7)	36 (3.3)	182 (16.9)	40 (3.7)	1,080 (100)
Paradise Point	1 (0)		3 (0.4)	1 (0)			343 (34)	19 (1.9)	31 (3.1)		610 (60.4)	2 (0.2)	1,010 (100)
Berkeley Manor/ Watkins Village							406 (80)		41 (8.1)	1 (0.2)	57 (11.2)	2 (0.5)	507 (100)
Midway Park		1 (0.4)		2 (0.7)		2 (0.7)	248 (92.2)		8 (3.0)	3 (1.1)	4 (1.5)	1 (0.4)	269 (100)
Tarawa Terrace I and II			3 (0.5)			1 (0.3)	428 (77.4)		55 (9.9)	11 (2.0)	47 (8.5)	8 (1.4)	553 (100)
Knox Trailer							57 (100)						57 (100)
French Creek	8 (1.4)	1 (0.2)	74 (12.7)	266 (45.6)	3 (0.5)	7 (1.2)		122 (20.9)	22 (3.8)	6 (1.0)	74 (12.7)		583 (100)
Courthouse Bay		73 (28.6)	28 (10.9)	14 (5.5)		12 (4.7)	12 (4.7)	43 (16.9)	15 (5.9)	4 (1.6)	43 (16.9)	11 (4.3)	255 (100)
Onslow Beach	6 (9.8)	1 (1.6)	3 (4.8)	2 (3.2)	1 (1.6)	2 (3.2)		2 (3.2)	12 (19.3)		25 (40.3)	8 (13.0)	62 (100)
Rifle Range		1 (1.3)	1 (1.3)	7 (8.8)	1 (1.3)	5 (6.3)	7 (8.8)	30 (37.5)	5 (6.3)	1 (1.3)	9 (11.3)	13 (16.3)	80 (100)
Camp Geiger	4 (1.9)	15 (6.9)	19 (8.8)	50 (23.1)		23 (10.6)		54 (25.0)	27 (12.5)	2 (1.0)	16 (7.4)	6 (2.8)	216 (100)
Montford Point	6 (2.6)	48 (20.5)	2 (0.9)	4 (1.7)	2 (0.9)	9 (3.9)		82 (35.2)	20 (8.6)	1 (0.4)	49 (21.0)	10 (4.3)	233 (100)
Base-Wide Misc.	1 (0.8)			87 (68.0)		3 (2.3)			19 (14.8)			18 (14.1)	128 (100)
TOTAL	57 (1.1)	155 (3.1)	287 (5.7)	590 (11.7)	17 (0.38)	186 (3.7)	1,523 (30.2)	548 (10.8)	370 (7.4)	65 (1.3)	1,116 (22.2)	119 (2.4)	5,033 (100)

Note:

⁽¹⁾Upper number is acres, lower number is percent.

TABLE 2-2

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE
 COASTAL PLAIN OF NORTH CAROLINA
 SITE EVALUATION PROJECT PLANS - CTO-0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

GEOLOGIC UNITS			HYDROGEOLOGIC UNITS	
System	Series	Formation	Aquifer and Confining Unit	
Quaternary	Holocene/Pleistocene	Undifferentiated	Surficial Aquifer	
Tertiary	Pliocene	Yorktown Formation ⁽¹⁾	Yorktown Confining Unit	
			Yorktown Aquifer	
	Miocene	Eastover Formation ⁽¹⁾		
		Pungo River Formation ⁽¹⁾	Pungo River Confining Unit	
			Pungo River Aquifer	
		Belgrade Formation ⁽²⁾	Castle Hayne Confining Unit	
	Oligocene	River Bend Formation	Castle Hayne Aquifer	
	Eocene	Castle Hayne Formation	Beaufort Confining Unit ⁽³⁾	
Palocene	Beaufort Formation	Beaufort Aquifer		
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee Confining Unit	
			Peedee Aquifer	
		Black Creek and Middendorf Formations		Black Creek Confining Unit
				Black Creek Aquifer
		Cape Fear Formation		Upper Cape Fear Confining Unit
				Upper Cape Fear Aquifer
			Lower Cape Fear Confining Unit	
			Lower Cape Fear Aquifer	
Lower Cretaceous ⁽¹⁾	Unnamed Deposits ⁽¹⁾	Lower Cretaceous Confining Unit		
		Lower Cretaceous Aquifer ⁽¹⁾		
Pre-Cretaceous Basement Rocks		--	--	

Notes:

- (1) Geologic and hydrologic units probably not present beneath Camp Lejeune.
- (2) Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.
- (3) Estimated to be confined to deposits of Paleocene age in the study area.

Source: USGS, 1989.

TABLE 2-3

**COMPREHENSIVE SITE ASSESSMENT (1994) - HYDROPUNCH GROUNDWATER SAMPLE ANALYTICAL RESULTS
FOR POLYNUCLEAR AROMATIC HYDROCARBONS
OPERABLE UNIT NO. 17 (SITE 90)
CTO 0344
MCB CAMP LEJEUNE, NORTH CAROLINA**

Analyte	HP-1	HP-2	HP-2 DUP	HP-3	HP-4	HP-5	HP-6	HP-7	HP-8	HP-9	HP-10	HP-11	HP-12
Napthalene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	10.0	BQL	BDL	BDL	BDL	BDL
Acenaphthylene	BDL	1.0	BDL	BDL	BDL	BDL	BDL	BQL	BDL	BDL	BDL	BDL	BDL
Acenaphthene	3.0	BDL	BDL	BDL	1.5	2.7	BDL	4.2	3.2	0.6	0.9	BDL	BDL
Phenanthrene	1.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Anthracene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BQL	0.5	BDL	BDL	BDL	BDL
Fluoranthene	BDL	1.1	2.0	BDL	BDL	BDL	BDL	0.6	1.3	BDL	BDL	BDL	BDL
Pyrene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BQL	2.3	BDL	BDL	BDL	BDL
Benzo(a)anthracene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	2.5	10.0	BDL	BDL	BDL	BDL
Benzo(g,h,i)perylene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	4.1	BDL	BDL	BDL	BDL
All Others	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Totals	4.1	2.1	2.0	BDL	1.5	2.7	BDL	17.3	21.4	0.6	0.9	BDL	BDL

Notes:

BDL - Below Detection Limit

BQL - Below Quantitation Limit

Concentrations expressed in $\mu\text{g/L}$ (ppb)

Shaded areas indicate non compliant concentrations

TABLE 2-4

COMPREHENSIVE SITE ASSESSMENT (1994) - SOIL SAMPLE ANALYTICAL RESULTS
 FOR PURGEABLE AROMATICS
 OPERABLE UNIT NO. 17 (SITE 90)
 CTO 0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	BB9-4	BB9-5	BB9-7	BB9-8	BB9-9	BB9-10	BB9-11	BB9-12	BB9-13	BB9-14	BB9-15
1,1,1-Trichloroethane	BQL	BQL	BQL	BQL	BQL	BQL	4.5	4.0	BQL	5.8	4.5
Toluene	BQL	BQL	3.5	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Tetrachloroethene	BQL	BQL	BQL	BQL	BQL	BQL	4.1	BQL	BQL	BQL	BQL
Ethylbenzene	BQL	BQL	4.2	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
m,p-Xylene	BQL	BQL	9.8	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
o-Xylene/Styrene	BQL	BQL	7.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
n-Propylbenzene	BQL	BQL	1.9	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
1,3,5-Trimethylbenzene	BQL	BQL	3.0	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
1,2,4-Trimethylbenzene	BQL	BQL	7.1	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Napthalene	4.5	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
All Others	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL
Total	4.5	BQL	36.5	BQL	BQL	BQL	8.6	4.0	BQL	5.8	4.5

Notes:

BQL - Below Quantitation Limit
 Concentrations expressed in $\mu\text{g}/\text{kg}$ (ppb)

TABLE 2-5

COMPREHENSIVE SITE ASSESSMENT (1994) - MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
 FOR POLYNUCLEAR AROMATIC HYDROCARBONS
 OPERABLE UNIT NO. 17 (SITE 90)
 CTO 0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Federal MCL	North Carolina	BB9-4	BB9-5	BB9-6	BB9-7	BB9-8	BB9-9	BB9-10	BB9-11	BB9-12	BB9-13	BB9-14	BB9-15	BB9-16	BB9-17	BB9-18
Naphthalene	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	2.3	1.1	0.8
Acenaphthene	--	80	1.9	2.1	BDL	7.9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Phenanthrene	--	--	0.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Anthracene	--	2,100	BQL	1.7	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Fluorathene	--	--	2.2	BQL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pyrene	--	--	0.9	BQL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	3.0	3.3	4.0	BDL	BDL	15.0
Benzo(a)anthracene	--	0.05	2.6	1.6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chrysene	--	5	1.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
All Others	--	--	BDL/BQL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total			9.5	5.4	BDL	7.9	BDL	BDL	BDL	BDL	BDL	3.0	3.3	4.0	2.3	1.1	15.8

Notes:

-- - No Published Standard

BDL - Below Detection Limit

BQL - Below Quantitation Limit

Concentrations expressed in µg/L (ppb)

Shaded areas indicate non compliant concentrations

TABLE 2-6

**COMPREHENSIVE SITE ASSESSMENT (1994) -
MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
FOR PURGEABLE ORGANICS
OPERABLE UNIT NO. 17 (SITE 90)
CTO 0344
MCB CAMP LEJEUNE, NORTH CAROLINA**

Analyte	Federal MCL	North Carolina	BB9-4	BB9-5	BB9-7	BB9-9	BB9-13	BB9-14
Benzene	5	1	0.6	0.6	BDL	BDL	BDL	BDL
Toluene	1,000	1,000	0.6	BQL	BDL	BDL	BDL	BDL
All others	--	--	BDL	BDL	BDL	BDL	BDL	BDL
Total			1.2	0.6	BDL	BDL	BDL	BDL

Notes:

-- - No Published Standard

BDL - Below Detection Limit

BQL - Below Quantitation Limit

Wells BB9-6, BB9-8, BB9-10, BB9-11, BB9-12, BB9-15, BB9-16, BB9-17, and BB9-18 not sampled.

Concentrations are expressed in $\mu\text{g/L}$ (ppb)

TABLE 2-7

COMPREHENSIVE SITE ASSESSMENT (1994) - MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
 FOR DRINKING WATER VOLATILES
 OPERABLE UNIT NO. 17 (SITE 90)
 CTO 0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Federal MCL	North Carolina	BB9-4	BB9-5	BB9-6	BB9-7	BB9-8	BB9-9	BB9-10	BB9-11	BB9-12	BB9-13	BB9-14	BB9-15
Chloromethane	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	16.0
Bromomethane	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.6
Chloroform	80	0.19	5.9	7.0	BDL	BDL	BDL	1.9	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	200	200	2.2	BDL	1.5	BDL	BDL	BDL	2.0	BDL	BDL	BDL	BDL	BDL
Bromodichloromethane	80	--	2.8	4.4	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dibromochloromethane	80	--	BDL	2.3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Benzene	5	1	2.2	2.2	BDL	1.7	BDL	2.5	BDL	BDL	2.1	BDL	BDL	BDL
m,p-Xylenes	10,000	530	BDL	BDL	BDL	BDL	BDL	BDL	1.8	BDL	BDL	BDL	BDL	BDL
1,2,3-Trichloropropane	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	3.6	BDL
n-Propylbenzene	--	--	3.0	4.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
sec-Butylbenzene	--	--	2.8	2.6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Naphthalene	--	21	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	13.0
All others	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total			18.9	23.0	1.5	1.7	BDL	4.4	3.8	BDL	2.1	BDL	3.6	30.6

Notes:

- - No Published Standard
- BDL - Below Detection Limits
- BQL - Below Quantitation Limits
- Concentrations are expressed in µg/L (ppb)
- Shaded areas indicate non compliant concentrations

TABLE 2-8
COMPREHENSIVE SITE ASSESSMENT (1994) -
MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
FOR TCLP METALS
OPERABLE UNIT NO. 17 (SITE 90)
CTO 0344
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Federal MCL	North Carolina	BB9-4	BB9-5	BB9-6	BB9-15	BB9-16
Arsenic	50	50	BQL	BQL	BQL	BQL	BQL
Barium	2,000	2,000	98	281	147	BQL	95
Cadmium	5	5	45	69	59	36	104
Chromium	100	50	BQL	97	55	BQL	42
Lead	15*	15	133	169	121	69	221
Mercury	2	1.1	1	BQL	BQL	1	BQL
Selenium	50	50	BQL	BDL	BDL	BQL	BDL
Silver	--	18	132	237	143	191	204

Notes:

BDL - Below Detection Limit

BQL - Below Quantitation Limit

Concentrations are expressed in µg/L (ppb)

Shaded areas indicate non compliant concentrations

* Action level

TABLE 2-9

COMPREHENSIVE SITE ASSESSMENT (1994) -
 SOIL SAMPLE ANALYTICAL RESULTS
 FOR OIL AND GREASE, FLASHPOINT, AND pH
 OPERABLE UNIT NO. 17 (SITE 91)

CTO 0344

MCB CAMP LEJEUNE, NORTH CAROLINA

Sample ID	Sample Depth (ft)	Laboratory Results		
		Oil and Grease 9071 (µg/kg)	Flashpoint (Degree C)	pH
BB51-4	2-4	120,000	NA	NA
	2-4 DUP	7,000	NA	NA
	10-12	110,000	NA	NA
BB51-5	2-4	130,000	NA	NA
	10-12	240,000	NA	NA
BB51-6	2-4	7,000	NA	NA
	10-12	29,000	NA	NA
BB51-7	2-4	54,000	NA	NA
	10-12	29,000	NA	NA
BB51-8	2-4	32,000	NA	NA
	10-12	54,000	>97	8.68
BB51-9	2-4	94,000	NA	NA
	10-12	7,000	>97	8.40
BB51-10	2-4	46,000	NA	NA
	10-12	46,000	>97	8.48
BB51-11	2-4	33,000	NA	NA
	10-12	7,000	>97	8.11
BB51-12	2-4	BDL	NA	NA
	2-4 DUP	110,000	NA	NA
	10-12	460,000	>97	7.03
BB51-13	2-4	47,000	NA	NA
	10-12	110,000	>97	6.76

TABLE 2-9 (Continued)

COMPREHENSIVE SITE ASSESSMENT (1994) -
 SOIL SAMPLE ANALYTICAL RESULTS
 FOR OIL AND GREASE, FLASHPOINT, AND pH
 OPERABLE UNIT NO. 17 (SITE 91)
 CTO 0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

Sample ID	Sample Depth (ft)	Laboratory Results		
		Oil and Grease 9071 (µg/kg)	Flashpoint (Degree C)	pH
BB51-14	2-4	BDL	NA	NA
	10-12	140,000	>97	8.30
BB51-15	2-4	8,000	NA	NA
	10-12	BDL	>97	8.66
BB51-16	2.5-5.0	430,000	NA	NA
	10-12.5	NA	>97	7.04
	37.5-40	10,000	NA	NA
BB51-17	2.5-5.0	86,000	NA	NA
	10-12.5	NA	>97	7.06
	37.5-40	44,000	NA	NA
BB51-18	2.5-5.0	57,000	NA	NA
	37.5-40	95,000	NA	NA

Notes:

NA - Not Analyzed

BDL - Below Detection Limits

BQL - Below Quantitation Limits

Concentrations are expressed in µg/kg (ppb), except as noted

Shaded areas indicate non compliant concentrations

TABLE 2-10 (Continued)

COMPREHENSIVE SITE ASSESSMENT (1994) - SOIL SAMPLE ANALYTICAL RESULTS
 FOR PURGEABLE AROMATICS
 OPERABLE UNIT NO. 17 (SITE 91)
 MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	BB51-11 (2-4)	BB51-11 (10-12)	BB51-12 (2-4)	BB51-12 (2-4 DUP)	BB51-12 (10-12)	BB51-13 (2-4)	BB51-13 (10-12)	BB51-14 (2-4)	BB51-14 (10-12)	BB51-15 (2-4)	BB51-15 (10-12)	BB51-17 (2.5-5.0)
Naphthalene	1.3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	1.0	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
p-Isopropyltoluene	BDL	BDL	18	1.6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hexachlorobutadiene	BDL	BDL	BDL	BDL	0.6	BDL	BDL	BDL	BDL	BDL	BDL	BDL
All others	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total	41.1	6.7	25	10.9	6.3	4.2	3.1	16.3	24.9	10.0	4.4	6.2

Notes:

BDL - Below Detection Limits

Concentrations are expressed in $\mu\text{g}/\text{kg}$ (ppb)

TABLE 2-11

**COMPREHENSIVE SITE ASSESSMENT (1994) -
MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
FOR DRINKING WATER VOLATILES
OPERABLE UNIT NO. 17 (SITE 91)
CTO 0344
MCB CAMP LEJEUNE, NORTH CAROLINA**

Analyte	Federal MCL	North Carolina	BB51-3	BB51-4	BB51-5	BB51-6	BB51-7	BB51-8	BB51-9	BB51-10	BB51-11	BB51-12	BB51-13	BB51-14	BB51-15
Chloroform	80	0.19	0.7	2.9	0.8	1.2	1.5	4.6	3.0	BDL	0.9	7.5	BDL	0.5	0.9
1,1,1-Trichloroethane	200	200	BDL	BDL	BDL	1.2	BDL	1.6	2.0	BDL	1.2	2.1	BDL	1.2	1.6
1,1-Dichloroethane	--	--	BDL	BDL	BDL	BDL	1.1	BDL	1.9	BDL	4.6	1.9	BDL	BDL	BDL
Bromochloromethane	--	--	BDL	BDL	BDL	BDL	BDL	1.5	0.8	BDL	BDL	BDL	BDL	BDL	BDL
Benzene	5	1	BDL	BDL	BDL	BDL	BDL	1.1	0.6	BDL	BDL	BDL	BDL	BDL	BDL
Dibromomethane	--	--	BDL	BDL	BDL	BDL	2.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Toluene	1,000	1,000	BDL	BDL	BDL	0.8	0.5	5.7	2.7	1.3	3.6	3.9	BDL	2.3	2.9
Ethylbenzene	700	29	BDL	BDL	BDL	BDL	BDL	1.4	1.1	BDL	BDL	BDL	BDL	BDL	BDL
m,p-Xylene	10,000	530	BDL	BDL	BDL	BDL	BDL	7.8	7.9	BDL	3.2	4.7	BDL	3.1	12
o-Xylene	10,000	--	BDL	BDL	BDL	BDL	BDL	3.6	3.4	BDL	1.2	2.7	BDL	1.0	4.5
Isopropylbenzene	--	--	BDL	BDL	BDL	1.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,3,5-Trimethylbenzene	--	--	BDL	BDL	BDL	BDL	BDL	1.6	1.3	BDL	BDL	BDL	BDL	BDL	0.8
1,2,4-Trimethylbenzene	--	--	0.8	BDL	BDL	3.0	1.8	21	20	1.8	5.8	2.8	0.9	11	19
1,2,4-Trichlorobenzene	70	--	BDL	0.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Naphthalene	--	--	BDL	BDL	BDL	1.3	BDL	3.4	6.3	1.3	BDL	BDL	BDL	17	36
tert-Butylbenzene	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.8	BDL	BDL	BDL	BDL	BDL
p-Isopropyltoluene	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.6	BDL	BDL	BDL
All others	--	--	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total			1.5	3.4	0.8	9.0	7.0	53.3	50.8	5.2	20.5	26.2	0.9	20.8	45.3

Notes:

-- - No Published Standard

BDL - Below Detection Limits

BQL - Below Quantitation Limits

Concentrations are expressed in µg/L (ppb)

Shaded Areas indicate non compliant concentrations

TABLE 2-12

COMPREHENSIVE SITE ASSESSMENT (1994) -
 MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
 FOR POLYNUCLEAR AROMATIC HYDROCARBONS
 OPERABLE UNIT NO. 17 (SITE 91)
 CTO 0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	BB51-3	BB51-4	BB51-5	BB51-5DUP	BB51-6	BB51-7	BB51-8	BB51-9	BB51-10	BB51-11	BB51-12	BB51-13	BB51-14	BB51-15	BB51-16	BB51-17	BB51-18
Fluorene	BQL	BQL	BDL	BDL	BDL	1.0	1.2	0.9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pyrene	BQL	BQL	3.6	1.7	BDL	BQL	BQL	BQL	4.8	2.4	3.8	22	5.4	3.4	BDL	BDL	BQL
Phenanthrene	BQL	BQL	BDL	BDL	BDL	BQL	BQL	BQL	BQL	BQL	BDL	BDL	BDL	BDL	1.8	2.4	BQL
Indeno(1,2,3-cd)pyrene	BQL	BQL	BDL	BDL	BDL	BQL	BQL	BQL	BQL	BQL	5.6	BDL	BDL	BDL	1.6	BDL	BQL
All others	BQL	BQL	BDL	BDL	BDL	BQL	BQL	BQL	BQL	BQL	BDL	BDL	BDL	BDL	BDL	5.4	BQL
Total	BQL	BQL	3.6	1.7	BDL	1.0	1.2	0.9	4.8	2.4	9.4	22.0	5.4	3.4	3.4	7.8	BQL

Notes:

BDL - Below Detection Limits

BQL - Below Quantitation Limits

Concentrations are expressed in $\mu\text{g/L}$ (ppb)

TABLE 2-13

COMPREHENSIVE SITE ASSESSMENT (1994) -
 MONITORING WELL GROUNDWATER SAMPLE ANALYTICAL RESULTS
 FOR TCLP METALS
 OPERABLE UNIT NO. 17 (SITE 91)
 CTO 0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Federal MCL	North Carolina	BB51-4	BB51-6	BB51-7	BB51-8	BB51-9
Arsenic	50	50	BQL	BQL	BQL	62	BQL
Barium	2,000	2,000	BQL	BQL	BQL	BQL	BQL
Cadmium	5	5	44	37	34	34	23
Chromium	100	50	BQL	BQL	BQL	BQL	BQL
Lead	15*	15	BQL	BQL	BQL	BQL	BDL
Mercury	2	1.1	BQL	BQL	BQL	BQL	BQL
Selenium	50	50	BQL	BQL	BQL	BQL	BDL
Silver	--	18	66	89	62	61	64
Totals			110	126	96	157	87

Notes:

- - No Published Standard
 - BTEX - Benzene, Toluene, Ethylbenzene, and Xylene
 - BDL - Below Detection Limits
- Concentrations reported in $\mu\text{g/L}$ (ppb)
 Shaded areas indicate non compliant concentrations
 * Action Level

TABLE 2-14

**MONITORING WELL DATA
OPERABLE UNIT NO. 17 (SITE 92)
CTO 0344
MCB CAMP LEJEUNE, NORTH CAROLINA**

Sample Location	Surface Elevation (msl)	Top of Casing Elevation (msl)	Depth to Groundwater (BTOC)	Calculated Groundwater Elevation (msl)
MW-1	5.49	5.19	4.60	0.59
MW-2	5.33	4.93	4.50	0.43
MW-3	4.83	4.47	3.80	0.67

Notes:

msl - Mean Sea Level (in feet)

BTOC - Below Top of Casing (in feet)

TABLE 2-15

SITE CHECK (1994) - GROUNDWATER SAMPLE ANALYTICAL RESULTS
 OPERABLE UNIT NO. 17 (SITE 92)
 CTO 0344
 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Federal MCL	North Carolina	MW-1	MW-2	MW-2 DUP	MW-3
Tetrachloroethene	5	0.7	30.0	16.0	25.0	27.0
BTEX	--	--	BDL	BDL	BDL	BDL
Lead	15*	15	BDL	BDL	BDL	BDL

Notes:

- - No Published Standard
- BTEX - Benzene, Toluene, Ethylbenzene, and Xylene
- BDL - Below Detection Limits
- Concentrations reported in $\mu\text{g/L}$ (ppb)
- Shaded areas indicate non compliant concentrations
- * Action Level

TABLE 3-1

SITE EVALUATION OBJECTIVES FOR OPERABLE UNIT NO. 17
CTO-0344
MARINE CORPS BASE CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	Site Evaluation Objective	Criteria for Meeting Objective	Proposed Investigation/Study
1. Site 90 - Soil	Assess the extent of soil contamination in the vicinity of Building BB-9.	Characterize contaminant levels in subsurface soils in the vicinity of Building BB-9.	Soil Investigation
	Assess health risks to construction workers posed by potential contact with subsurface soil.	Evaluate subsurface soil quality and compare to health-based remediation levels.	Soil Investigation Qualitative Risk Assessment
	Determine whether VOC contamination from soil is migrating to groundwater.	Characterize groundwater and subsurface soil quality in the vicinity of Building BB-9.	Soil and Groundwater Investigation
	Evaluate Remedial Alternatives	Characterize and evaluate soil contaminant levels in the vicinity of Building BB-9.	Soil Investigation Feasibility Study
2. Site 90 - Groundwater	Assess the extent of groundwater contamination.	Determine the horizontal and vertical extent of groundwater contamination.	Groundwater Investigation
	Assess health risks posed by potential future usage of the groundwater.	Evaluate groundwater quality and compare to state and federal standards and criteria and health-based remediation levels.	Groundwater Investigation Qualitative Risk Assessment
	Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the aquifer (flow direction, transmissivity, permeability, etc.).	Groundwater Investigation
	Evaluate Remedial Alternatives	Characterize and evaluate groundwater contaminant levels in the vicinity of Building BB-9.	Groundwater Investigation Feasibility Study

TABLE 3-1 (Continued)

**SITE EVALUATION OBJECTIVES FOR OPERABLE UNIT NO. 17
CTO-0344
MARINE CORPS BASE CAMP LEJEUNE, NORTH CAROLINA**

Medium or Area of Concern	Site Evaluation Objective	Criteria for Meeting Objective	Proposed Investigation/Study
1. Site 91 - Soil	Assess the extent of soil contamination in the vicinity of Building BB-51.	Characterize contaminant levels in subsurface soils in the vicinity of Building BB-51.	Soil Investigation
	Assess health risks to construction workers posed by potential contact with subsurface soil.	Evaluate subsurface soil quality and compare to health-based remediation levels.	Soil Investigation Qualitative Risk Assessment
	Determine whether VOC contamination from soil is migrating to groundwater.	Characterize groundwater and subsurface soil quality in the vicinity of Building BB-51.	Soil and Groundwater Investigation
	Evaluate Remedial Alternatives	Characterize and evaluate soil contaminant levels in the vicinity of Building BB-51.	Soil Investigation
2. Site 91 - Groundwater	Assess the extent of groundwater contamination.	Determine the horizontal and vertical extent of groundwater contamination.	Groundwater Investigation
	Assess health risks posed by potential future usage of the groundwater.	Evaluate groundwater quality and compare to state and federal standards and criteria and health-based remediation levels.	Groundwater Investigation Qualitative Risk Assessment
	Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the aquifer (flow direction, transmissivity, permeability, etc.).	Groundwater Investigation
	Evaluate Remedial Alternatives	Characterize and evaluate groundwater contaminant levels in the vicinity of Building BB-51.	Groundwater Investigation

TABLE 3-1 (Continued)

SITE EVALUATION OBJECTIVES FOR OPERABLE UNIT NO. 17
 CTO-0344
 MARINE CORPS BASE CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	Site Evaluation Objective	Criteria for Meeting Objective	Proposed Investigation/Study
1. Site 92 - Soil	Assess the extent of soil contamination in the vicinity of Building BB-46.	Characterize contaminant levels in subsurface soils in the vicinity of Building BB-46.	Soil Investigation
	Assess health risks to construction workers posed by potential contact with subsurface soil.	Evaluate subsurface soil quality and compare to health-based remediation levels.	Soil Investigation Qualitative Risk Assessment
	Determine whether VOC contamination from soil is migrating to groundwater.	Characterize groundwater and subsurface soil quality in the vicinity of Building BB-46.	Soil and Groundwater Investigation
	Evaluate Remedial Alternatives	Characterize and evaluate soil contaminant levels in the vicinity of Building BB-46.	Soil Investigation
2. Site 92 - Groundwater	Assess the extent of groundwater contamination.	Determine the horizontal and vertical extent of groundwater contamination.	Groundwater Investigation
	Assess health risks posed by potential future usage of the groundwater.	Evaluate groundwater quality and compare to state and federal standards and criteria and health-based remediation levels.	Groundwater Investigation Qualitative Risk Assessment
	Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the aquifer (flow direction, transmissivity, permeability, etc.).	Groundwater Investigation
	Evaluate Remedial Alternatives	Characterize and evaluate groundwater contaminant levels in the vicinity of Building BB-46.	Groundwater Investigation
3. Site 92 - Surface Water	Assess the presence or absence of surface water contamination in the New River.	Determine surface water quality in the New River adjacent to the site.	Surface Water Investigation
	Assess human health and ecological risks posed by potential contact with surface water.	Evaluate surface water quality and compare to surface water screening values.	Surface Water Investigation Qualitative Risk Assessment

TABLE 3-1 (Continued)

**SITE EVALUATION OBJECTIVES FOR OPERABLE UNIT NO. 17
CTO-0344
MARINE CORPS BASE CAMP LEJEUNE, NORTH CAROLINA**

Medium or Area of Concern	Site Evaluation Objective	Criteria for Meeting Objective	Proposed Investigation/Study
4. Site 92 - Sediment	Assess the presence or absence of sediment contamination in the New River.	Identify extent of sediment contamination where levels exceed state or regulation levels.	Sediment Investigation
	Assess human health and ecological risks posed by potential contact with sediment.	Evaluate sediment quality and compare to surface water screening values.	Sediment Investigation Qualitative Risk Assessment

TABLE 4-1

SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS
 OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)
 REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344
 MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Study Area	Investigation	Baseline Number Of Samples ⁽¹⁾	Analysis	Analytical Method
Site 90 - Phase I 13 VOAs 3 SVOAs 3 Metals	Soil	7 subsurface soil borings (7 soil samples)	TCL VOAs - Mobile laboratory	EPA 8240
		3 subsurface soil samples (1 high/1 med/1 low detection)	TCL Organics ⁽²⁾ ← VOAs TAL Metals ⁽³⁾ ← SVOAs	CLP/SOW CLP/SOW
		Expanded soil borings/temporary shallow monitoring wells	TCL VOAs - Mobile laboratory	EPA 8240
VOAs	Groundwater	22 shallow monitoring wells (15 existing, 7 new initial temporary) 3 existing intermediate temporary monitoring wells	TCL VOAs - Mobile Laboratory	EPA 8240
		1 temporary shallow monitoring well	TCL VOAs	CLP/SOW
		5 existing shallow monitoring wells (BB-4, 5, 6, 12, 15) 2 existing intermediate monitoring wells (BB-16, 18)	TCL Organics TAL Total Metals TDS/TSS	CLP/SOW CLP/SOW EPA 160.1/160.2
		Expanded temporary shallow monitoring wells	TCL VOAs - Mobile Laboratory	EPA 8240
		Site 91 - Phase I	Soil	12 subsurface soil borings (12 soil samples - 10 shallow and 2 intermediate soil borings) 3 subsurface soil samples (1 high/1 med/1 low detection) Expanded soil borings/temporary shallow monitoring wells
	Groundwater	25 shallow monitoring wells (15 existing, 10 new initial temporary) 5 intermediate monitoring wells (3 existing, 2 new initial temporary) 1 temporary shallow monitoring well 1 temporary intermediate monitoring well	TCL VOAs - Mobile Laboratory TCL VOAs	EPA 8240 CLP/SOW

TABLE 4-1 (Continued)

**SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS
OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA**

Study Area	Investigation	Baseline Number Of Samples ⁽¹⁾	Analysis	Analytical Method
Site 91 - Phase I (continued)	Groundwater (continued)	5 existing shallow monitoring wells (BB-4, 6, 8, 9, 12) 2 existing intermediate monitoring wells (BB-16, 17)	TCL Organics TAL Total Metals TDS/TSS	CLP/SOW CLP/SOW EPA 160.1/160.2
		Expanded temporary shallow monitoring wells	TCL VOAs - Mobile Laboratory	EPA 8240
Site 92 - Phase I	Soil	4 subsurface soil borings (4 soil samples - 3 shallow and 1 intermediate soil boring)	TCL VOAs - Mobile Laboratory	EPA 8240
		3 subsurface soil samples (1 high/1 med/1 low detection)	TCL Organics TAL Metals	CLP/SOW CLP/SOW
		Expanded soil borings/temporary shallow monitoring wells	TCL VOAs - Mobile Laboratory	EPA 8240
	Groundwater	6 shallow monitoring wells (3 existing, 3 new initial temporary) 1 new initial temporary intermediate monitoring well	TCL VOAs - Mobile Laboratory	EPA 8240
		1 existing shallow monitoring well (MW-1)	TCL Organics TAL Total Metals TDS/TSS	CLP/SOW CLP/SOW EPA 160.1/160.2
		Expanded temporary shallow monitoring wells	TCL VOAs - Mobile Laboratory	EPA 8240
		Surface Water - Courthouse Bay	6 stations/1 sample per station	TCL Organics TAL Total Metals
	Sediment - Courthouse Bay	6 stations/2 samples per station	TCL Organics TAL Metals TOC Grain Size	CLP/SOW CLP/SOW EPA 415.1 ASTM D 1140

TABLE 4-1 (Continued)

**SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS
OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA**

Study Area	Investigation	Baseline Number Of Samples ⁽¹⁾	Analysis	Analytical Method
Investigation Derived Waste	Development/ Purge Water	1 sample per site	TCL Organics TAL Total Metals TSS/TDS	CLP/SOW CLP/SOW EPA 160.1/160.2
	Soil	1 sample per site	TCLP RCRA TCL PCBs	SW 846 SW846 CLP/SOW

Notes:

(1) Baseline Number of samples does not include QA/QC.

(2) Target Compound List (TCL) Organics:
VOAs - volatile organic analysis
SVOAs - semivolatile organic analysis
Pesticides/PCBs - Pesticides and polychlorinated biphenyls

(3) Target Analyte List (TAL) Metals:

Aluminum	EPA 3010/EPA 200.7	Cobalt	EPA 3010/EPA 200.7	Potassium	EPA 3010/EPA 200.7
Antimony	EPA 3010/EPA 200.7	Copper	EPA 3010/EPA 200.7	Selenium	EPA 3020/EPA 270.2
Arsenic	EPA 3020/EPA 206	Iron	EPA 3010/EPA 200.7	Silver	EPA 3010/EPA 200.7
Barium	EPA 3010/EPA 200.7	Lead	EPA 3020/EPA 239	Sodium	EPA 3010/EPA 200.7
Beryllium	EPA 3010/EPA 200.7	Magnesium	EPA 3010/EPA 200.7	Thallium	EPA 3020/EPA 279
Cadmium	EPA 3010/EPA 200.7	Manganese	EPA 3010/EPA 200.7	Vanadium	EPA 3010/EPA 200.7
Calcium	EPA 3010/EPA 200.7	Mercury	EPA 3010/EPA 245.1	Zinc	EPA 3010/EPA 200.7
Chromium	EPA 3010/EPA 200.7	Nickel	EPA 3010/EPA 200.7		

ASTM - American Society for Texting and Materials

CLP - Contract Laboratory Program

EPA - United States Environmental Protection Agency

RCRA - Resource Conservation and Recovery Act (Corrosivity, Reactivity [reactive sulfide and cyanide], and Ignitability)

SOW - Statement of Work

TDS - Total Dissolved Solids

TCLP - Toxicity Characteristic Leaching Procedure (analysis of volatile organics, semivolatile organics, pesticides, herbicides, and metals on a leachate)

TOC - Total Organic Carbon

TSS - Total Suspended Solids

TABLE 4-2

**PRELIMINARY REMEDIATION GOALS
OPERABLE UNIT NO. 17
SITE EVALUATION, CTO 0344
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA**

Medium	Contaminant of Concern	Preliminary Remediation Goal	Unit	Basis of Goal
Soil	Benzene	200	µg/kg ⁽¹⁾	Groundwater Protection
	Toluene	5,000	µg/kg	Risk ⁽³⁾
	Xylenes	74,000	µg/kg	Risk
	1,1,1-Trichloroethane	900	µg/kg	Risk
	Ethylbenzene	5,000	µg/kg	Risk
	1,1-Dichloroethane	11,000	µg/kg	Risk
	Tetrachloroethane	40	µg/kg	Risk
Groundwater	Benzene	1	µg/L ⁽²⁾	NCWQS ⁽⁴⁾
	Toluene	1,000	µg/L	NCWQS
	Xylenes	530	µg/L	NCWQS
	1,1,1-Trichloroethane	200	µg/L	NCWQS
	Ethylbenzene	29	µg/L	NCWQS
	1,1-Dichloroethane	700	µg/L	NCWQS
	Tetrachloroethane	0.7	µg/L	NCWQS

Notes:

- (1) µg/kg - microgram per kilogram
- (2) µg/L - microgram per liter
- (3) Risk - EPA Region III Soil Screening Levels - Transfers from Soil to Groundwater
- (4) NCWQS - North Carolina Water Quality Standard

Tab. 1
Remedial Investigation/Feasibility Study Site Management Schedule
Operable Unit 17 (Sites 90, 91, and 92), MCB Camp Lejeune, North Carolina

Task Name	Duration	Start	Finish	1997											
				Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
Prepare Final Strategy Plan	32ed	8/5/96	9/6/96												
Prepare Draft RI/FS Project Plans	90ed	9/6/96	12/5/96												
Submit Draft RI/FS Project Plans	1ed	12/5/96	12/6/96					◆							
Agency Review	60ed	12/5/96	2/3/97												
Phase I Field Investigation	45ed	2/3/97	3/20/97												
Analysis and Validation	50ed	2/24/97	4/15/97												
Phase I RI Evaluation Report	21ed	4/15/97	5/6/97												
Final RI/FS Project Plans	30ed	5/6/97	6/5/97												
Submit Final RI/FS Project Plans	1ed	6/5/97	6/6/97												◆

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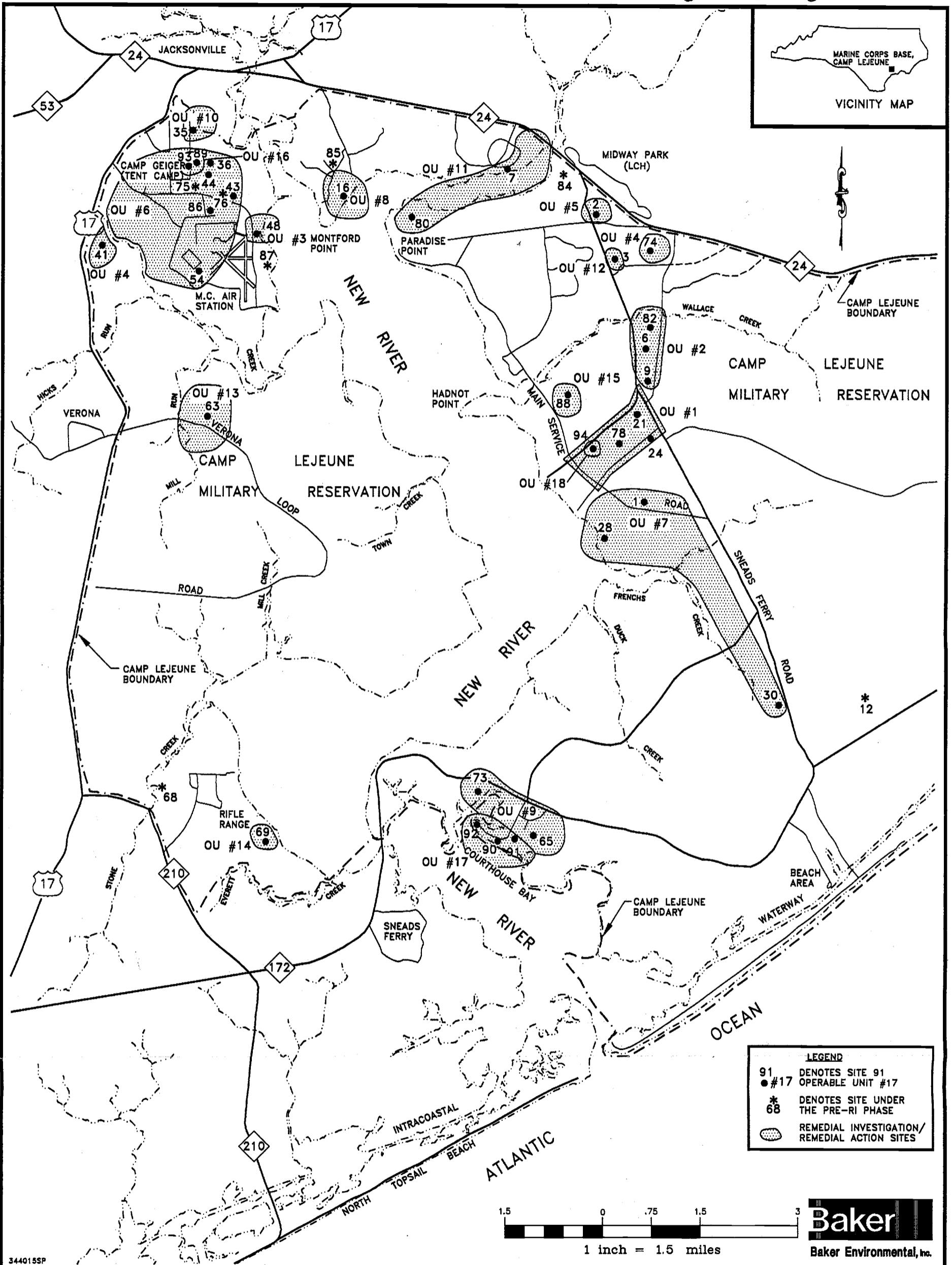
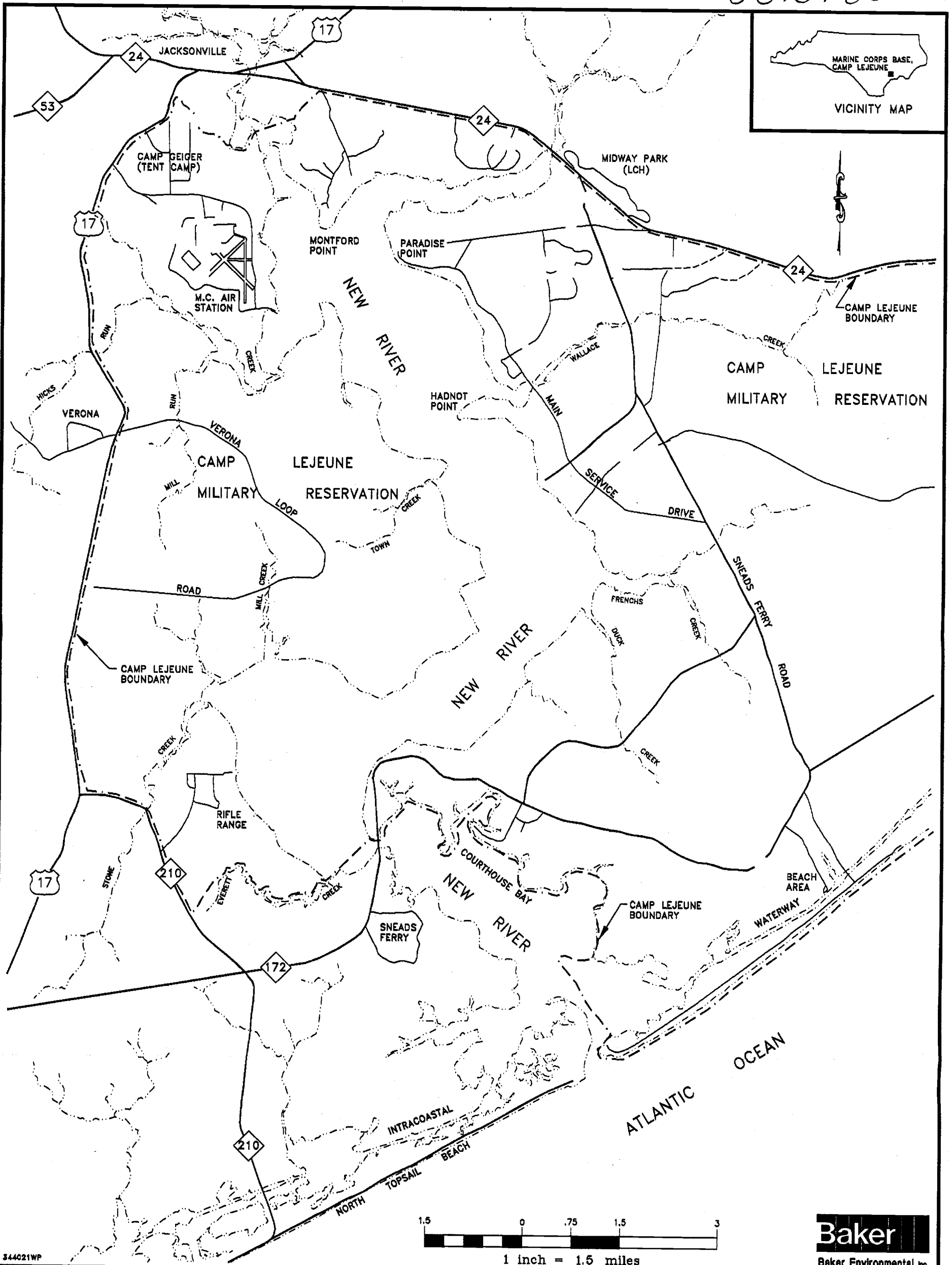


FIGURE 1-1
 OPERABLE UNITS AND SITE LOCATIONS AT
 MARINE CORPS BASE CAMP LEJEUNE
 CTO-0344

MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

00151002Z



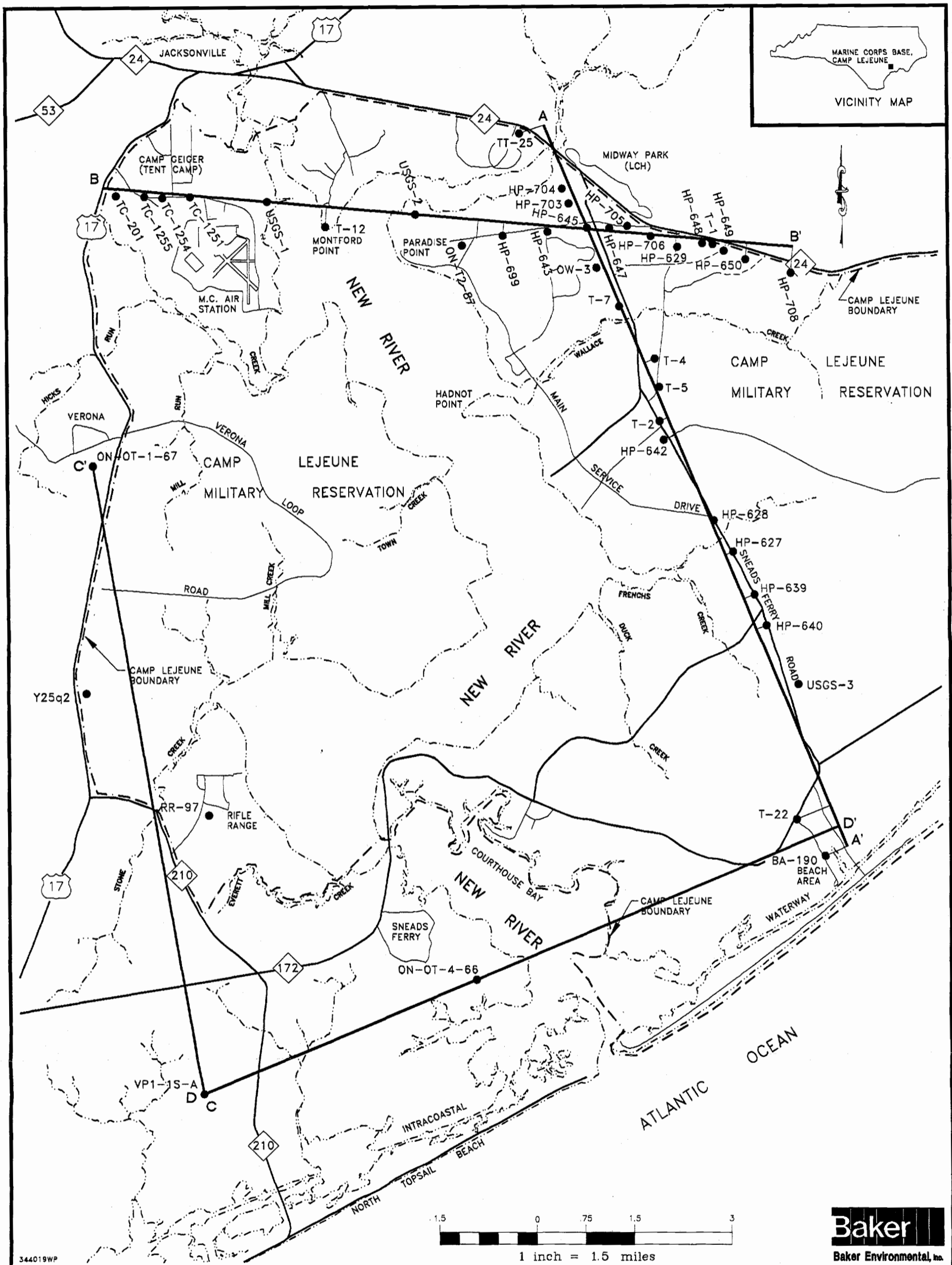
344021WP

SOURCE: U.S. GEOLOGICAL SURVEY, WATER-RESOURCES INVESTIGATIONS REPORT, 93-4049, FIGURE 9

FIGURE 2-1
LOCATION MAP OF MARINE CORPS
BASE, CAMP LEJEUNE
CTO-0344

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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 SOURCE: U.S. GEOLOGICAL SURVEY,
 WATER-RESOURCES INVESTIGATIONS
 REPORT, 93-4049, FIGURE 9

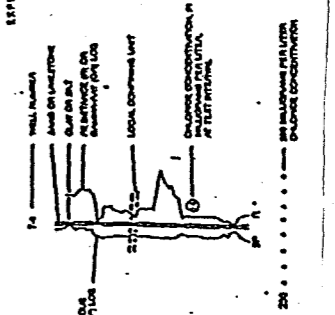
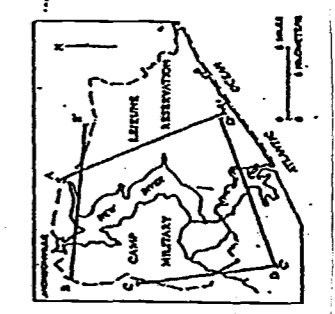
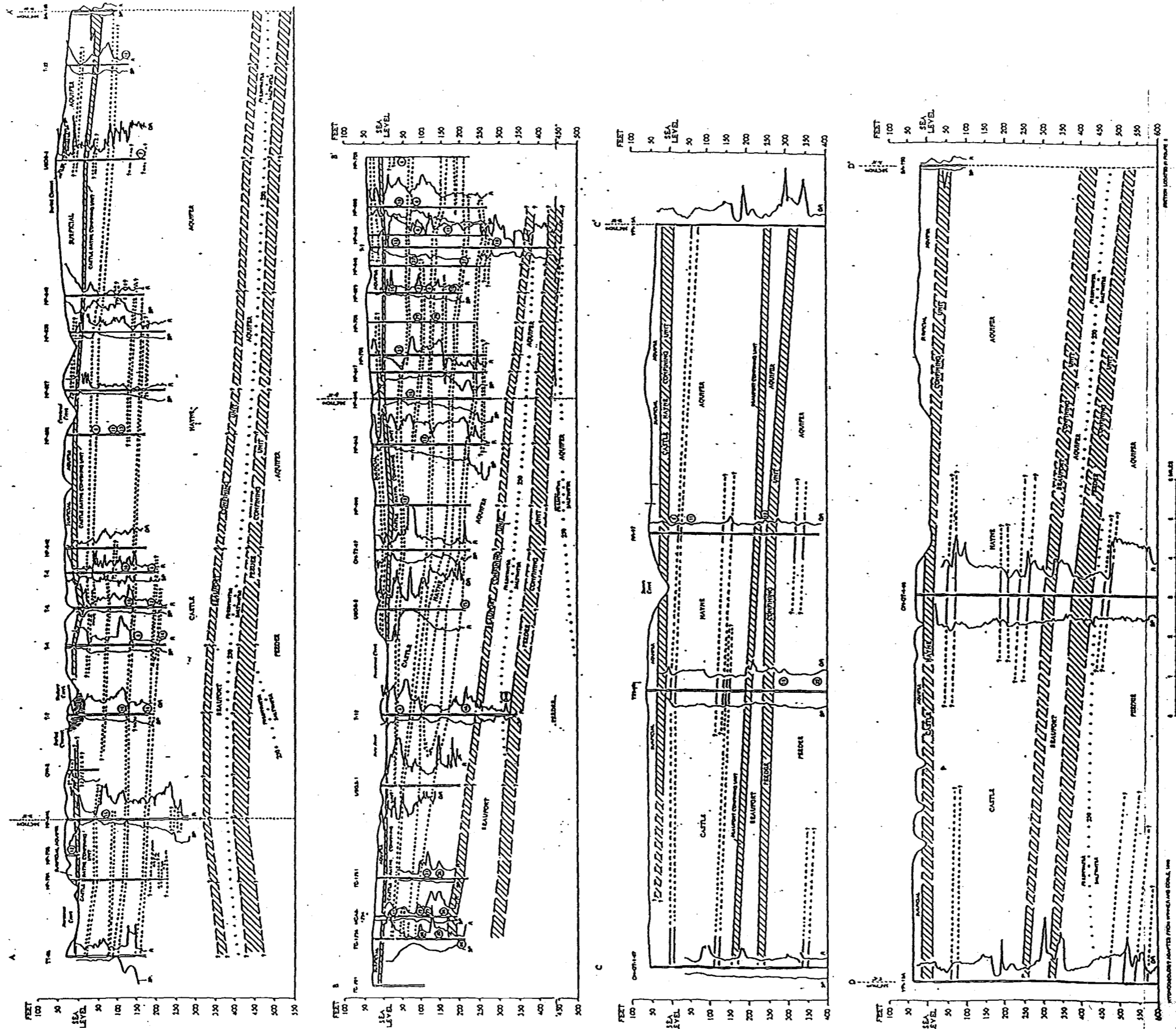
FIGURE 2-2
 LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
 CTO-0344

MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

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00151003Z

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SOURCE: U.S. GEOLOGICAL SURVEY,
WATER RESOURCES INVESTIGATIONS
REPORT, 93-4049, FIGURE 9

FIGURE 2-3
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB CAMP LEJUNE AREA
CTO-0344

MARINE CORPS BASE, CAMP LEJUNE
NORTH CAROLINA

00151005Z

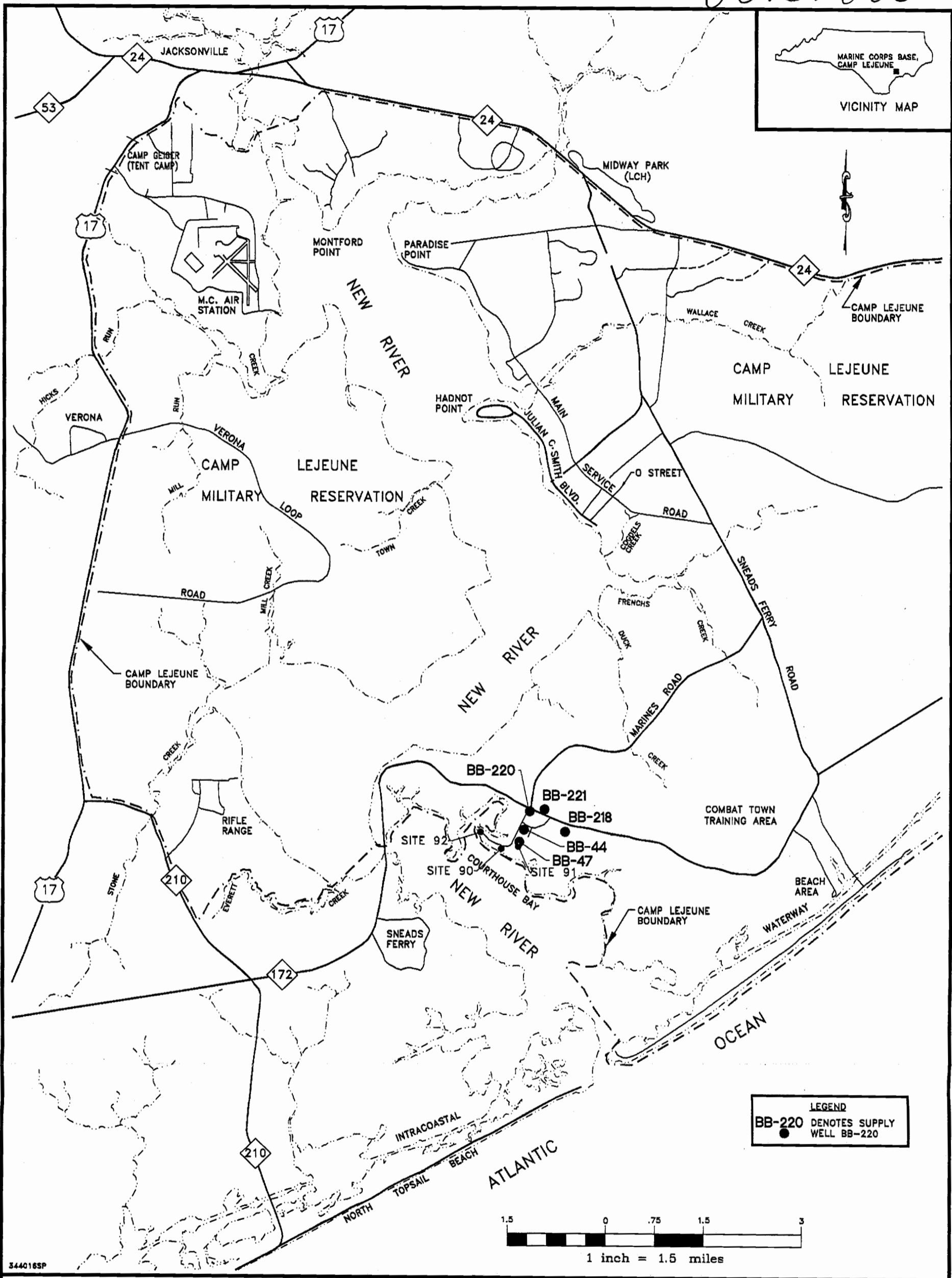


FIGURE 2-4
 ACTIVE WATER SUPPLY WELL LOCATIONS
 NEAR SITES 90, 91 AND 92
 CTO-0344
 MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

3440165P

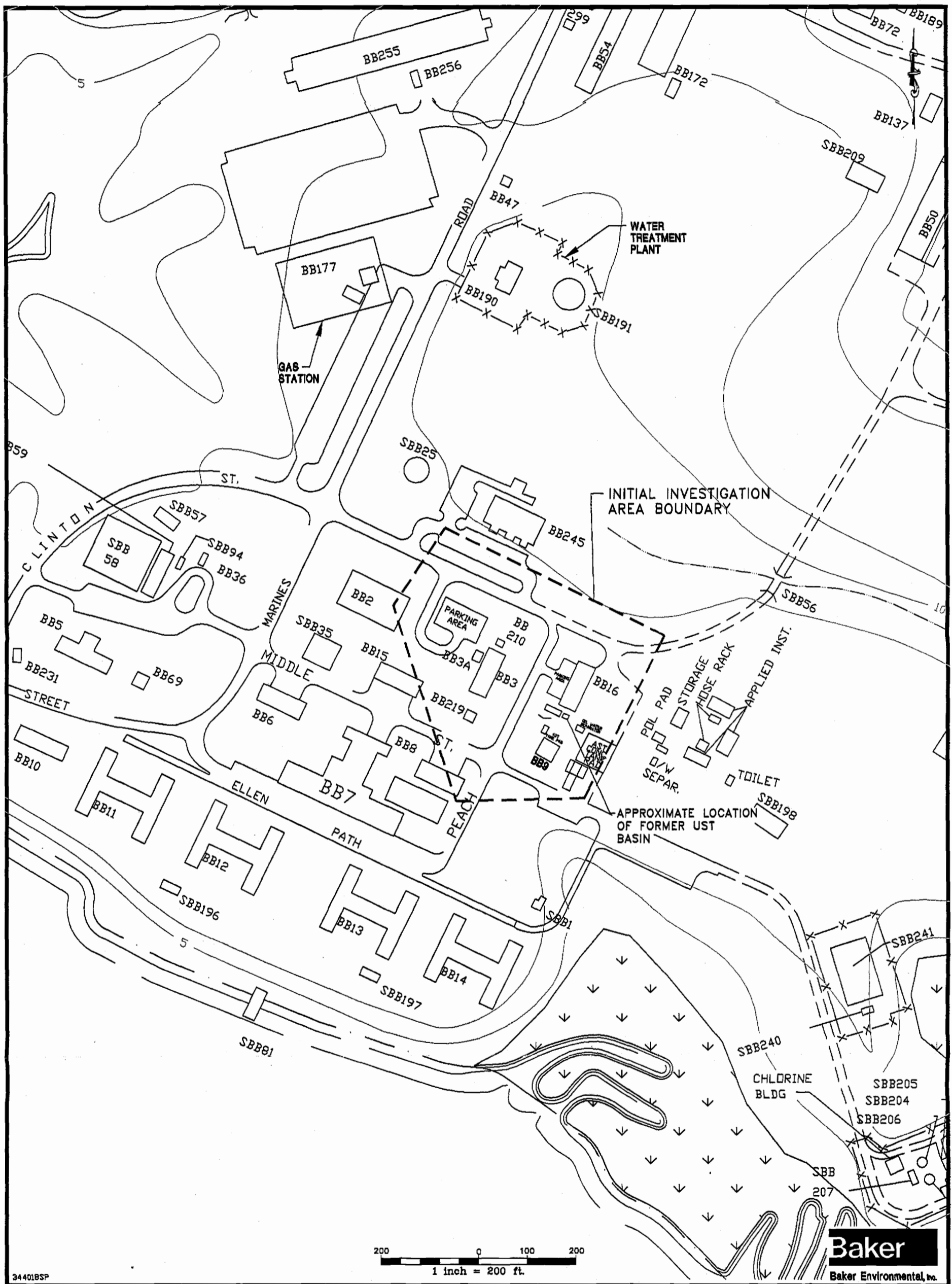
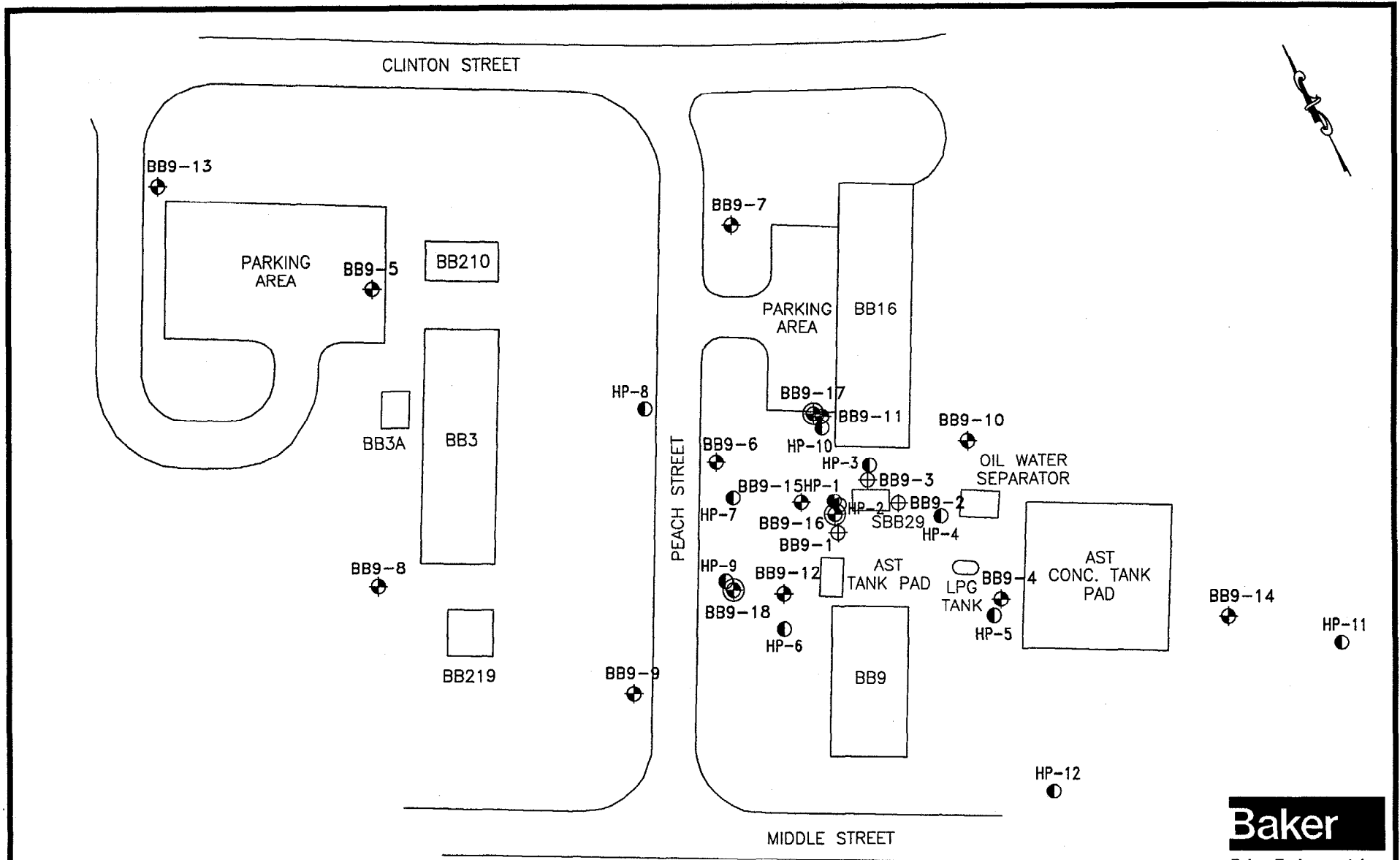


FIGURE 2-5
 SITE 90 (BB9)
 LOCATION MAP
 CTO-0344

MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

001510062



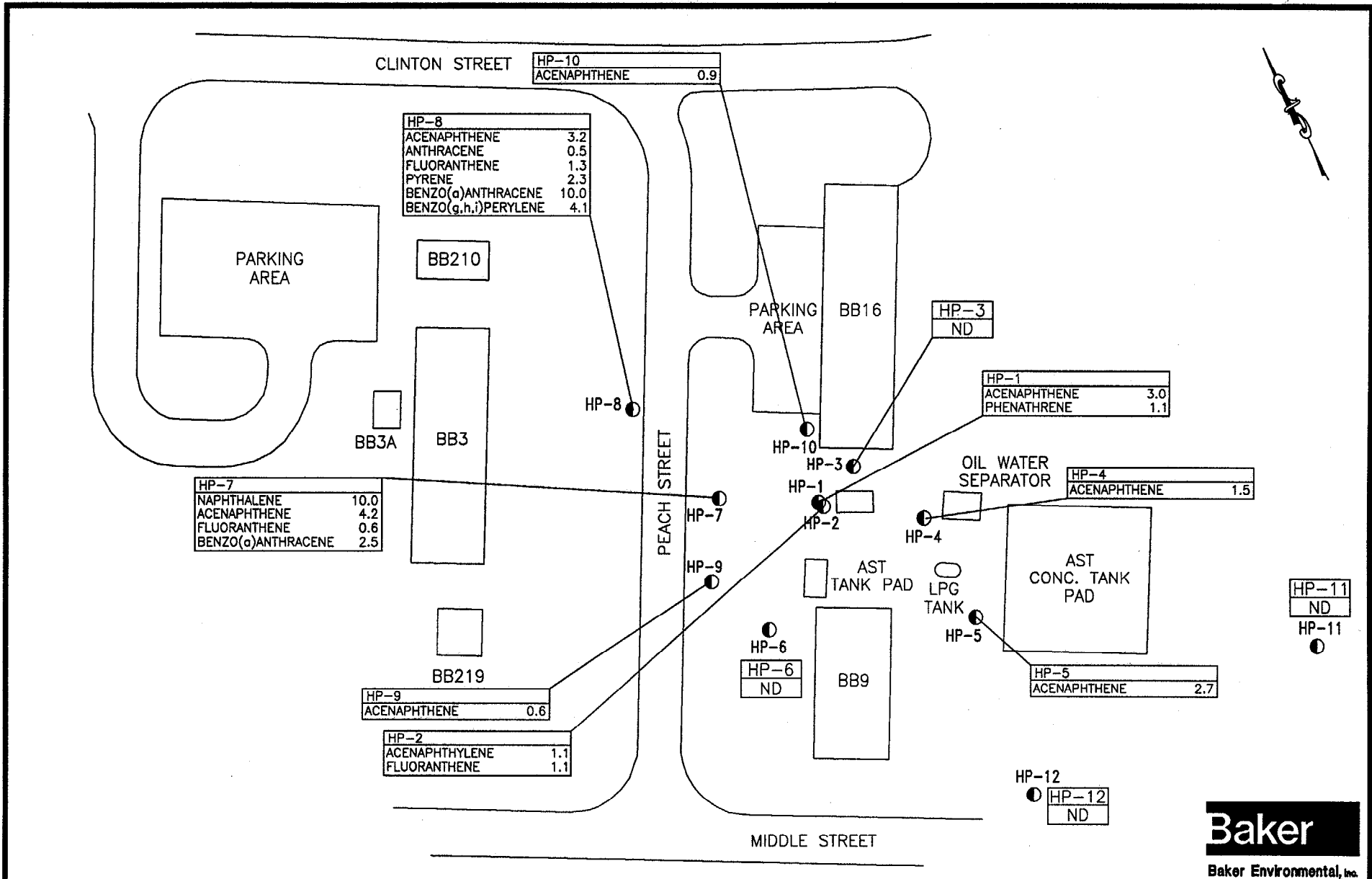
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LEGEND

◆	- EXISTING TYPE II WELL	□ - BUILDING
⊕	- PRE-EXISTING TYPE II WELL	
⊗	- EXISTING TYPE III WELL	
●	- EXISTING HYDROPUNCH	

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 2-6
SITE 90 (BB9)
PREVIOUS SITE INVESTIGATION
SAMPLING LOCATIONS (1993, 1994)
CTO-344
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



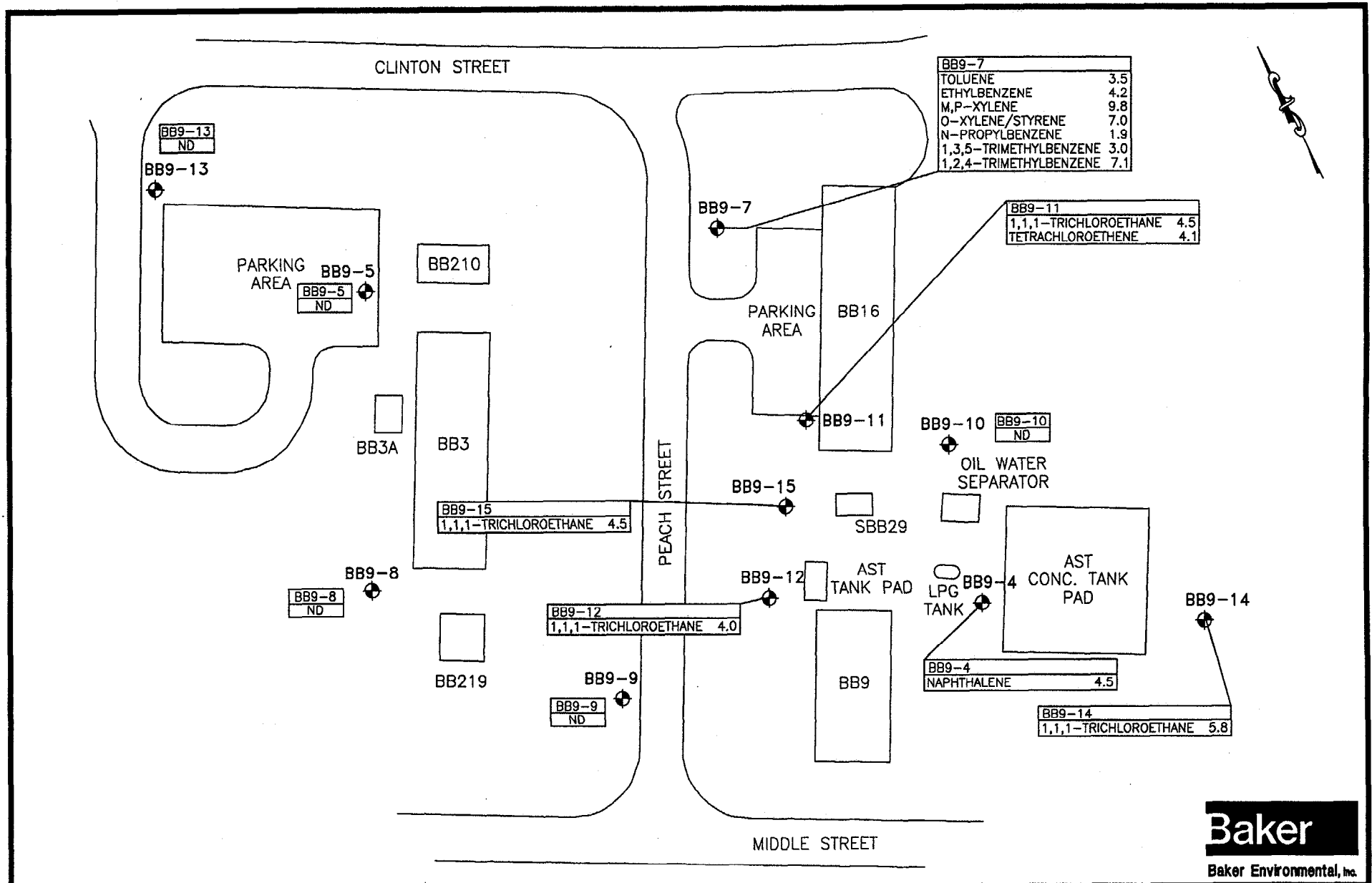
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LEGEND

● - EXISTING HYDROPUNCH □ - BUILDING

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 2-7
SITE 90 (BB9)
PREVIOUS SITE INVESTIGATION
HYDROPUNCH GROUNDWATER
SAMPLE RESULTS (1993, 1994)
CTO-344
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



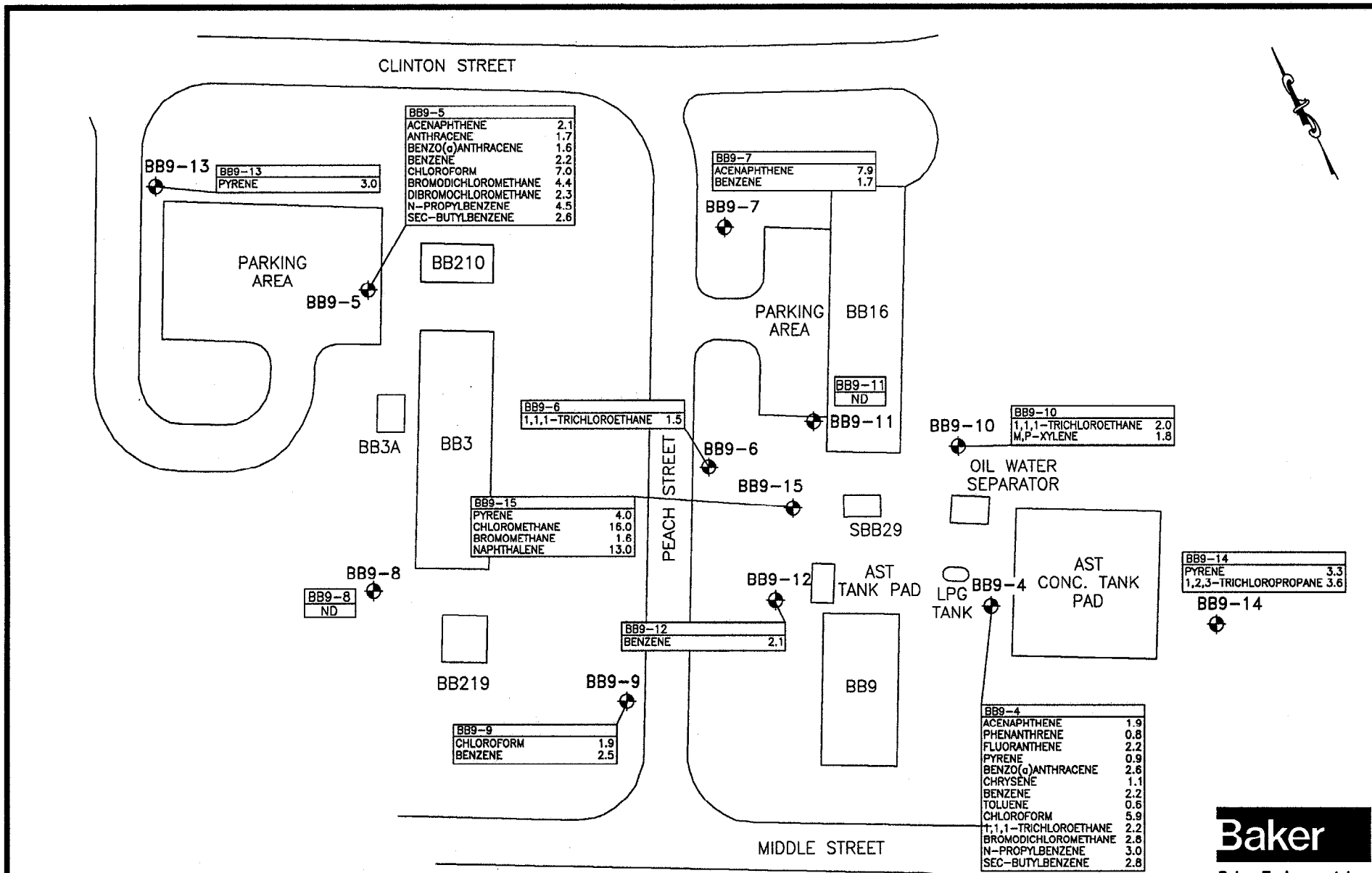
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LEGEND

⊕ - EXISTING TYPE II WELL □ - BUILDING

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 2-8
SITE 90 (BB9)
PREVIOUS SITE INVESTIGATION
SOIL SAMPLE RESULTS (1994)
CTO-344
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

◆ - EXISTING TYPE II WELL

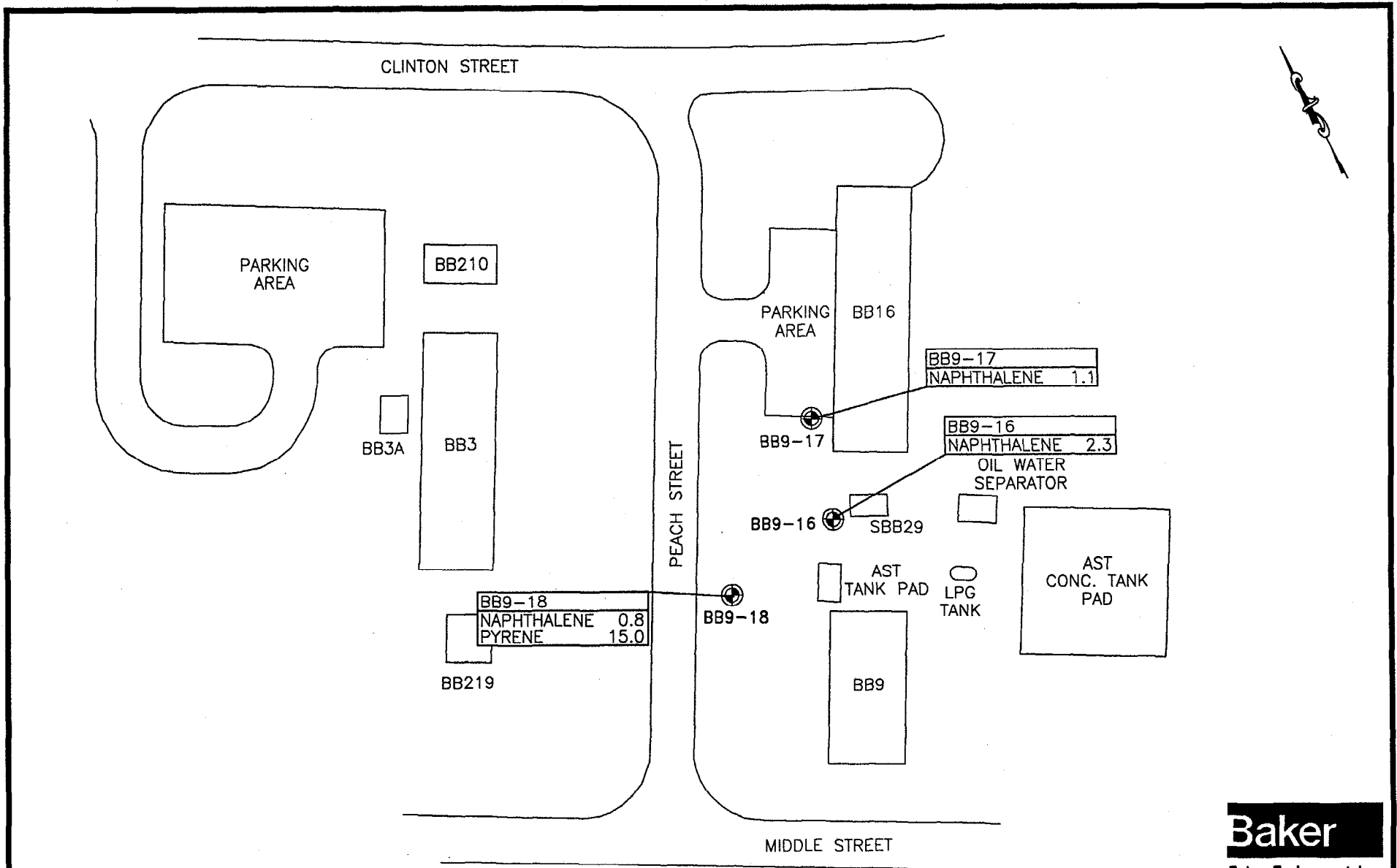
⊕ - EXISTING TYPE III WELL

□ - BUILDING

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 2-9
SITE 90 (BB9)
 PREVIOUS SITE INVESTIGATION
 SHALLOW MONITORING WELL
 GROUNDWATER SAMPLE RESULTS (1994)
 CTO-344
 MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA





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LEGEND

⊙ - EXISTING TYPE III WELL
 - BUILDING

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 2-10
SITE 90 (BB9)
 PREVIOUS SITE INVESTIGATION
 INTERMEDIATE MONITORING WELL
 GROUNDWATER SAMPLE RESULTS (1994)
 CTO-344
 MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

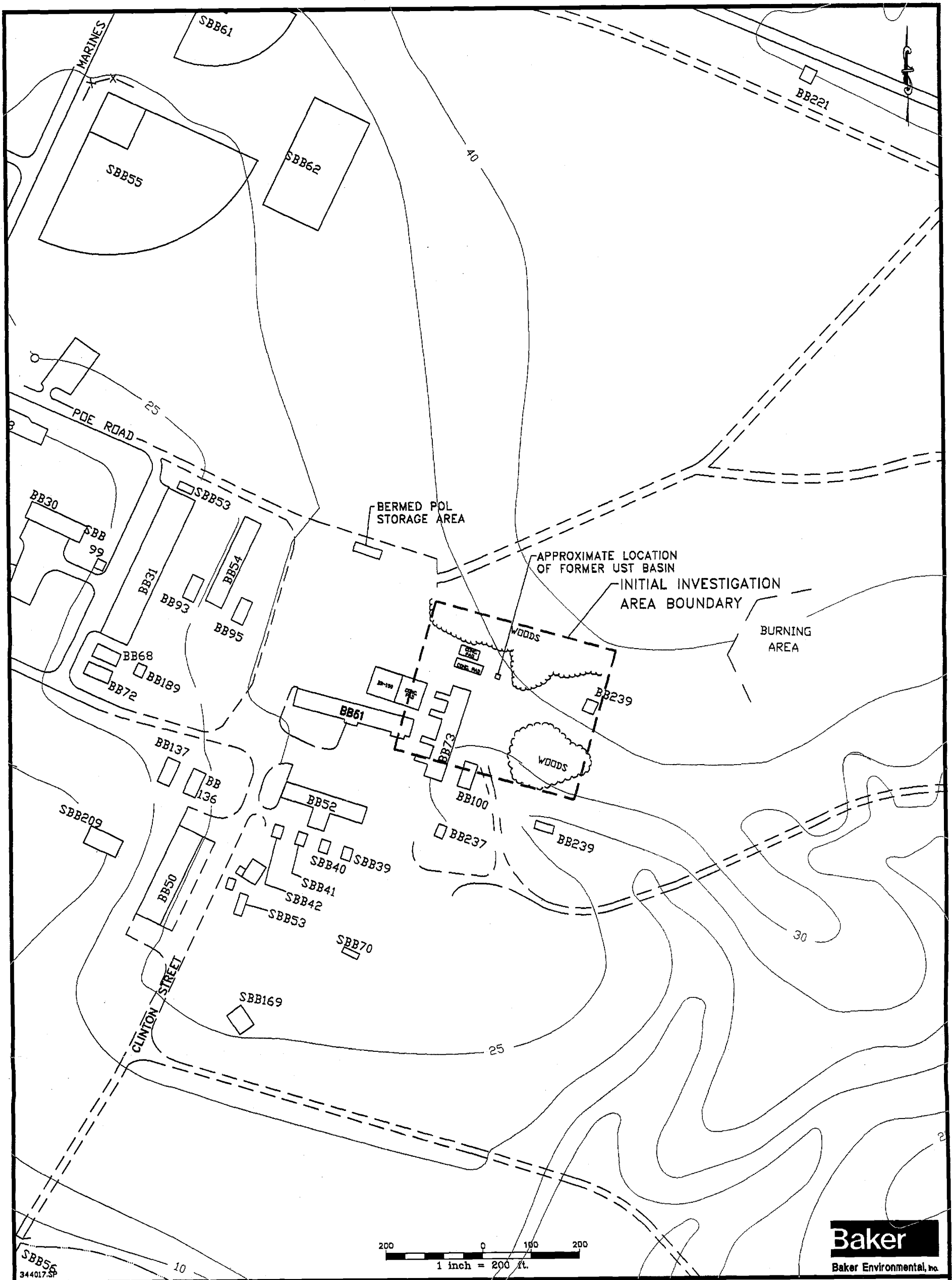
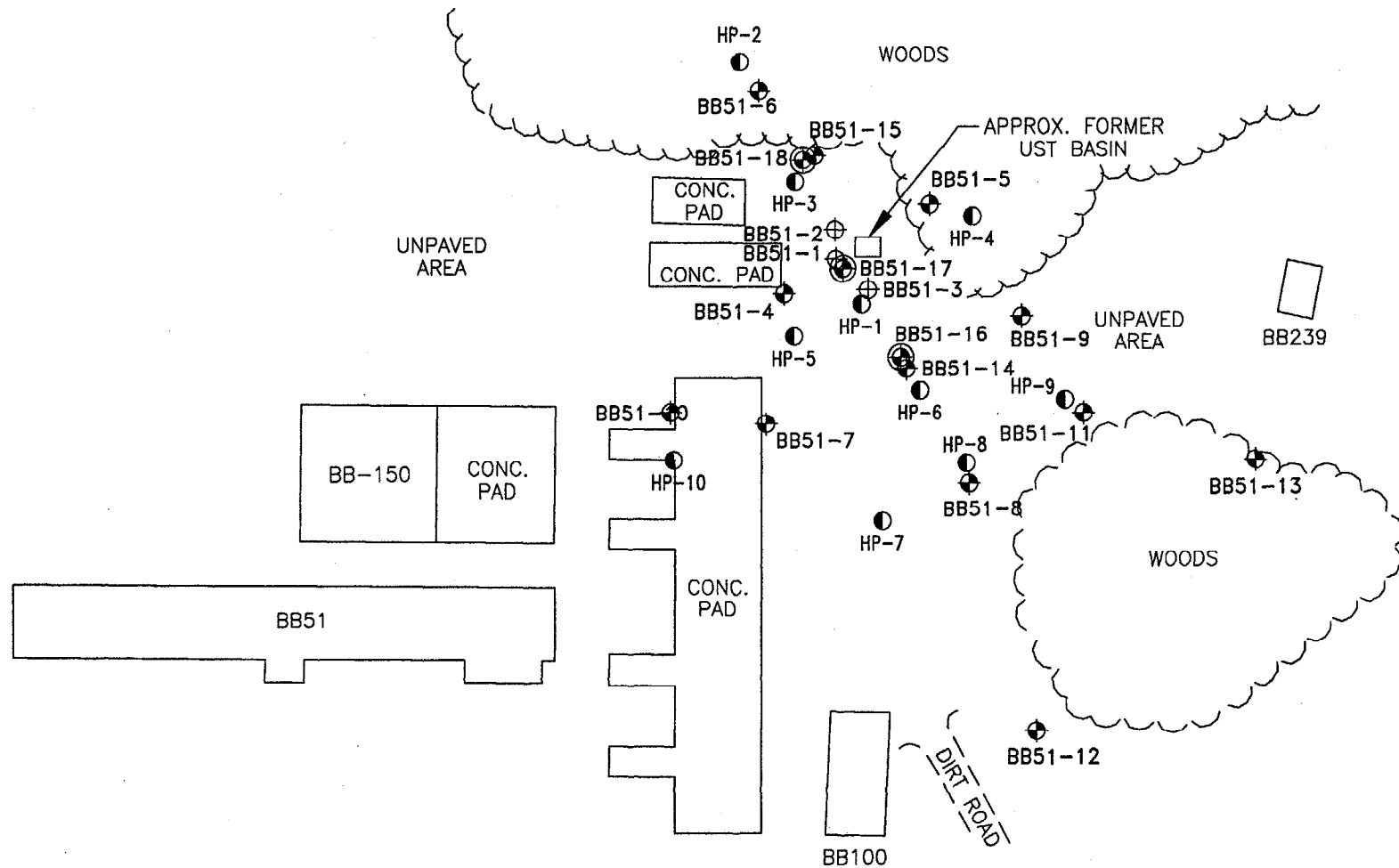


FIGURE 2-11
 SITE 91 (BB-51)
 LOCATION MAP
 CTO-0344

MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

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001510072



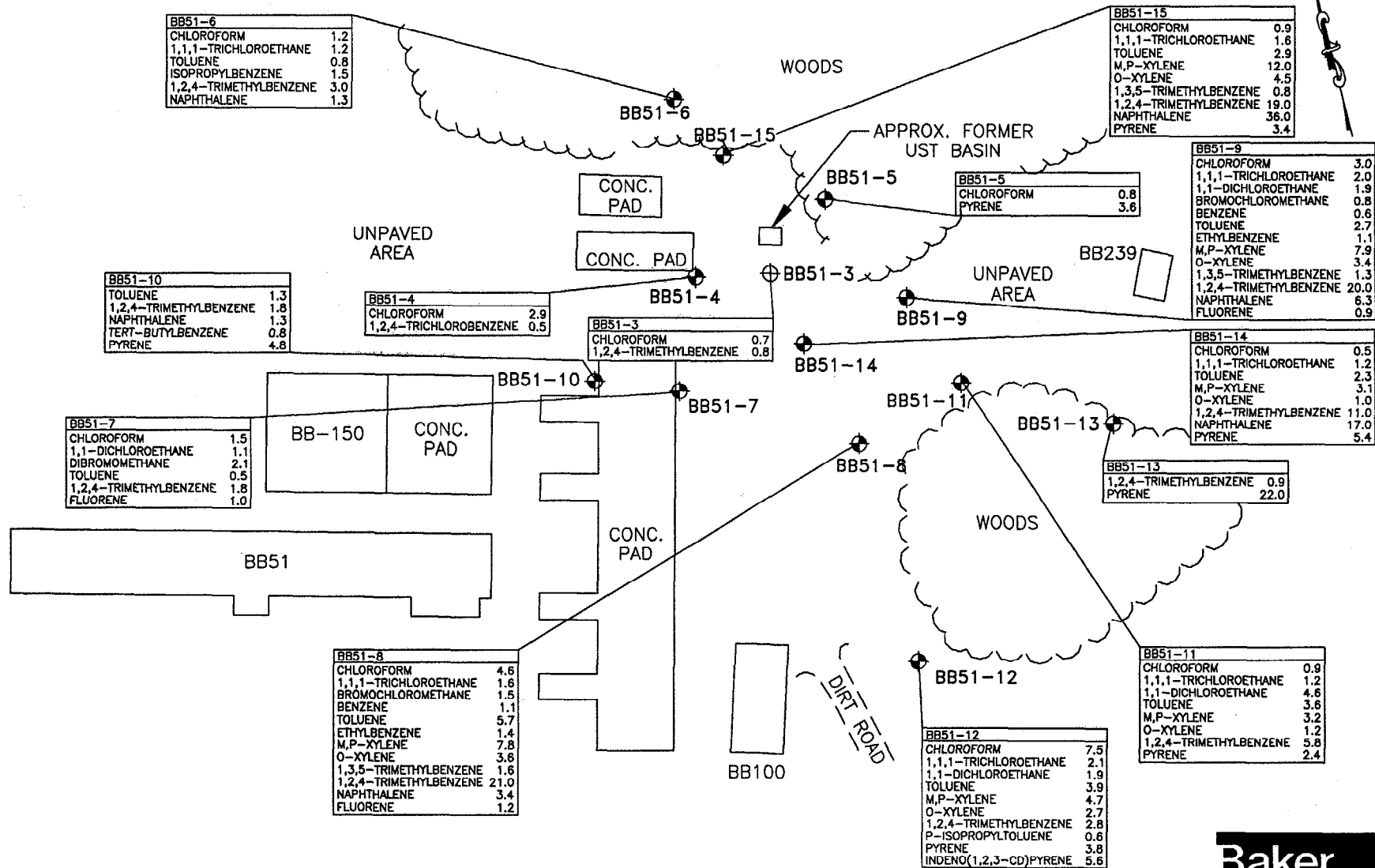
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LEGEND

- ⊕ - EXISTING TYPE II WELL
- ⊕ - PRE-EXISTING TYPE II WELL
- ⊕ - EXISTING TYPE III WELL
- - EXISTING HYDROPUNCH
- ~~~~~ - TREELINE
- ▭ - BUILDING

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 2-12
SITE 91 (BB-51)
PREVIOUS SITE INVESTIGATION
SAMPLING LOCATIONS (1993, 1994)
CTO-344
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

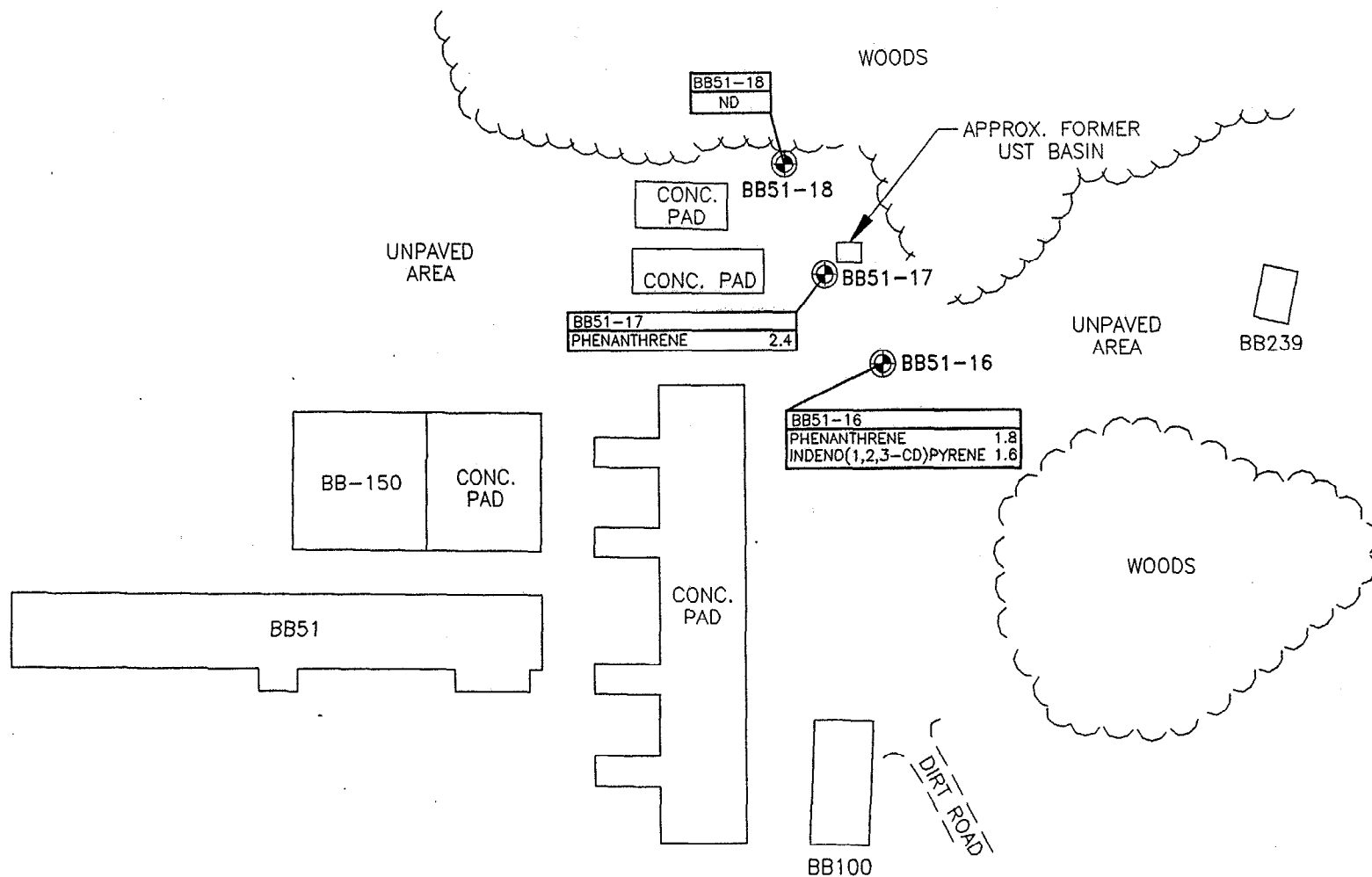


LEGEND

- ◆ - EXISTING TYPE II WELL
- ~ - TREELINE
- ▭ - BUILDING

FIGURE 2-13
SITE 91 (BB-51)
 PREVIOUS SITE INVESTIGATION
 SHALLOW MONITORING WELL
 GROUNDWATER SAMPLE RESULTS (1994)
 CTO-344
 MARINE CORPS BASE, CAMP LEJEUNE
 NORTH CAROLINA

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LEGEND

⊕ - EXISTING TYPE III WELL

~~~~~ - TREELINE

▭ - BUILDING

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 2-14  
SITE 91 (BB-51)  
PREVIOUS SITE INVESTIGATION  
INTERMEDIATE MONITORING WELL  
GROUNDWATER SAMPLE RESULTS (1994)  
CTO-344  
MARINE CORPS BASE, CAMP LEJEUNE  
NORTH CAROLINA

COURTHOUSE  
BAY

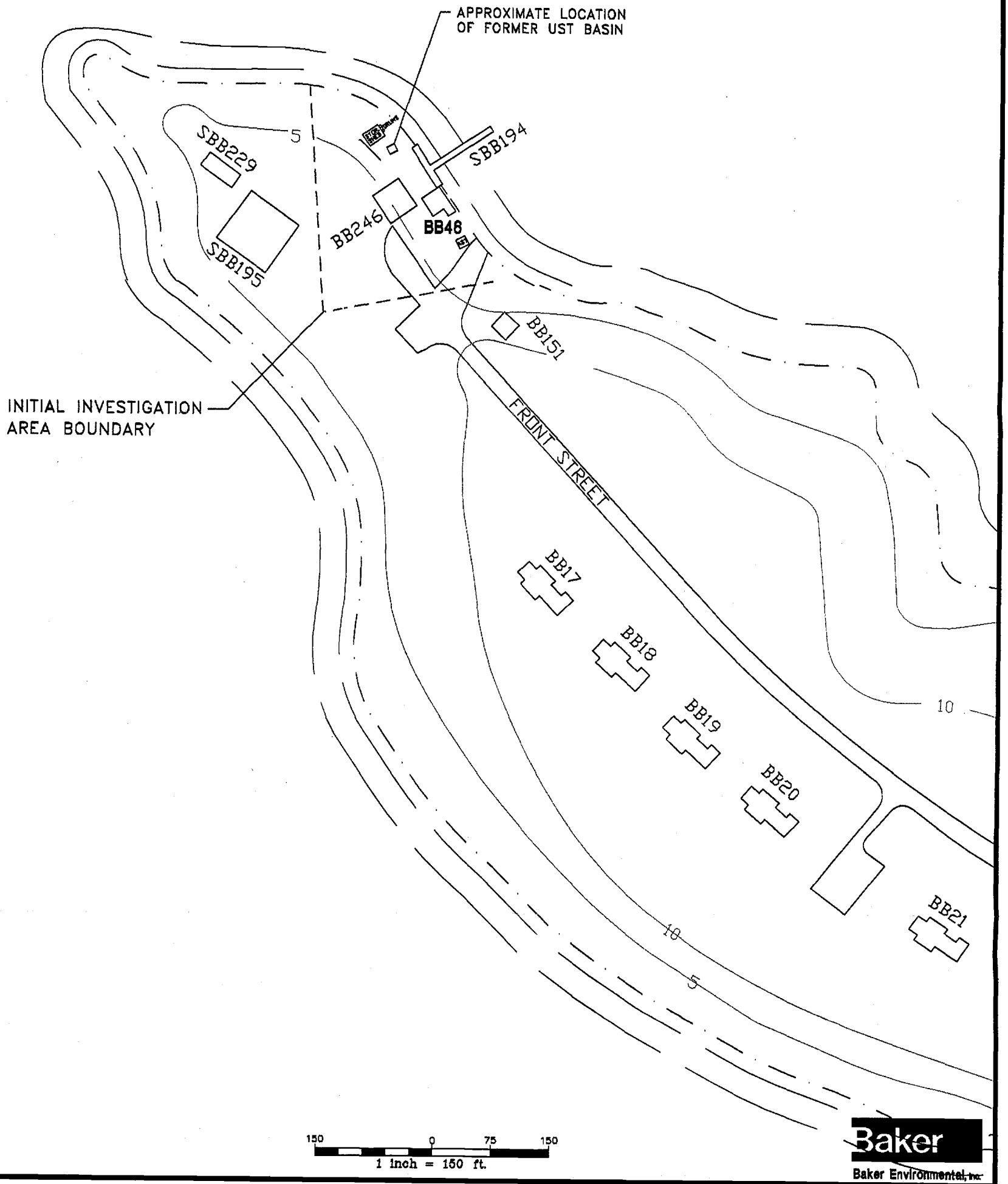


FIGURE 2-15  
SITE 92 (BB46)  
LOCATION MAP  
CTO-0344

MARINE CORPS BASE, CAMP LEJEUNE  
NORTH CAROLINA

00151008Z

APPROXIMATELY  
60 FEET



STOR. SHED  
8 DRUMS

MW-2

MW-1

MW-3

COURTHOUSE BAY

SBB194

APPROXIMATELY  
60 FEET

BB246

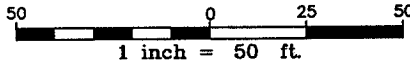
BB46

AST

BB151

FRONT STREET

NOTE : STORAGE SHED/EXISTING WELLS APPROXIMATE.



**Baker**  
Baker Environmental, Inc.

LEGEND

- ⊕ - EXISTING MONITORING WELL
- - BUILDING

FIGURE 2-16

SITE 92 (BB-46)

PREVIOUS SITE INVESTIGATION  
SAMPLING LOCATIONS (1994)

CTO-344

MARINE CORPS BASE, CAMP LEJEUNE  
NORTH CAROLINA

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

APPROXIMATELY  
60 FEET



STOR. DRUMS  
SHED

MW-2  
◆ (16)  
MW-1  
◆ (30)  
MW-3  
◆ (27)

COURTHOUSE BAY

SBB194

APPROXIMATELY  
60 FEET

BB246

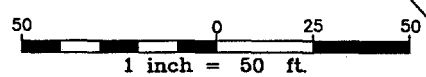
BB46

AST

BB151

FRONT STREET

NOTE : STORAGE SHED/EXISTING WELLS APPROXIMATE.



**Baker**  
Baker Environmental, Inc.

LEGEND

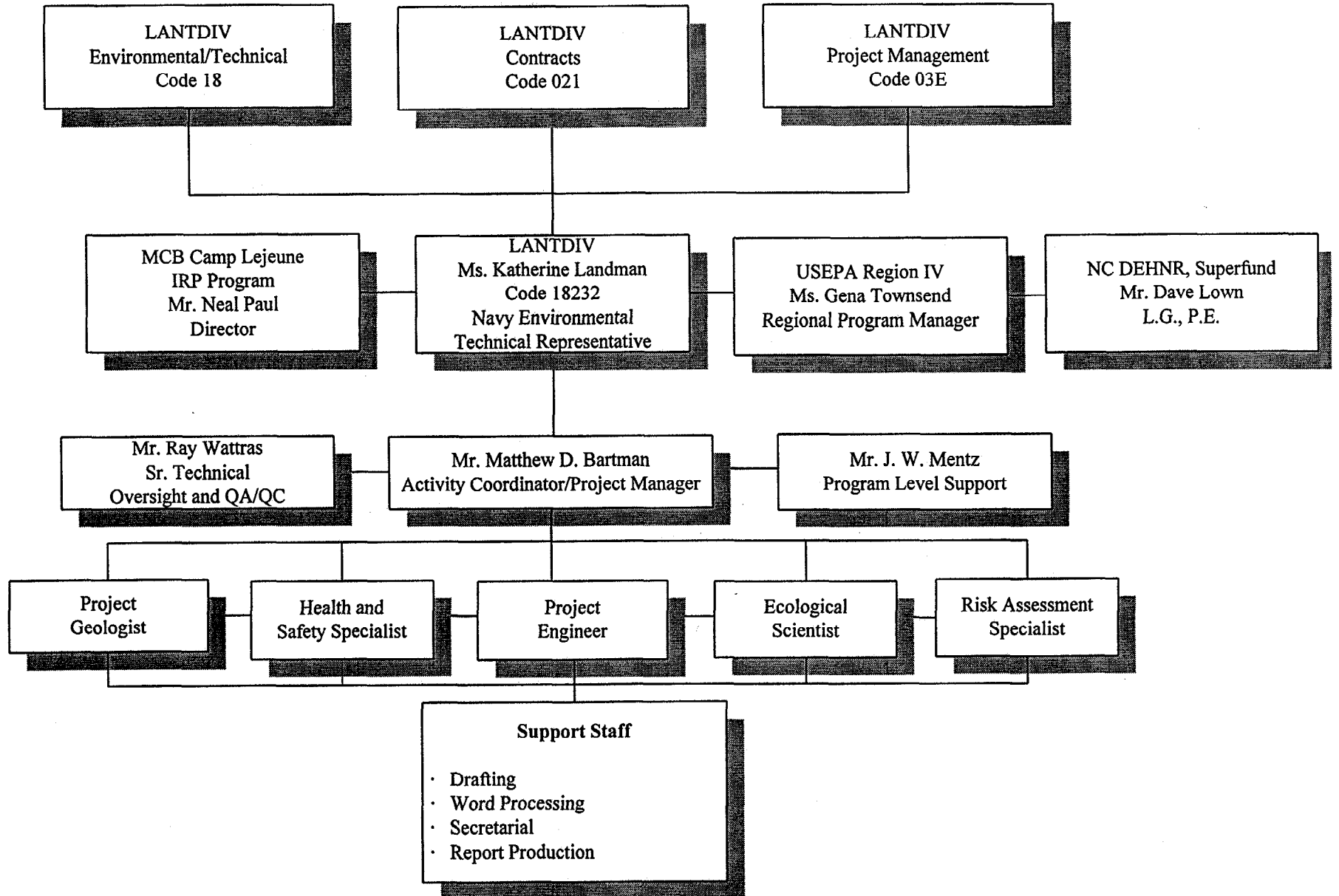
- ◆ - EXISTING MONITORING WELL
- (30) - TETRACHLOROETHENE CONCENTRATION IN ug/L (ppb)
- - BUILDING

FIGURE 2-17  
 SITE 92 (BB-46)  
 PREVIOUS SITE INVESTIGATION  
 SHALLOW MONITORING WELL  
 GROUNDWATER SAMPLE RESULTS (1994)  
 CTO-344  
 MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

SOURCE: MCB CAMP LEJEUNE REVISED BASE MAP 1/10/89.

FIGURE 5-1

PROJECT ORGANIZATION



**APPENDIX A**  
**Photographs**

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SITES 90, 91 AND 92 LOCATION MAP  
SAMPLE STRATEGY PLAN CTO-344  
MCB CAMP LEJEUNE  
NORTH CAROLINA

SOURCE: U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE:  
AERIAL PHOTOGRAPH FIELD OFFICE

344014

00151009Y



Site 90, Building BB-16 (foreground), UST excavation area, and Building BB-9 (background), looking south.



Site 90, Oil/water separator (foreground), UST excavation area, and Building BB-9 (background), looking southwest.

00151010Y



Site 91, Buildings BB-150 and BB-51, looking west.

001510114



Site 91, UST excavation area, looking north.



Site 91, UST excavation area and drainage from site, looking north.

00151012Y



Site 92, UST excavation area and metal storage shed, looking northwest.



Site 92, UST excavation area (foreground) and marina (background), looking northeast.

001510134

**DRAFT**

**REMEDIAL INVESTIGATION/  
FEASIBILITY STUDY  
FIELD SAMPLING AND ANALYSIS PLAN**

**OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)  
MCB CAMP LEJEUNE, NORTH CAROLINA**

**CONTRACT TASK ORDER 0344**

**DECEMBER 5, 1996**

*Prepared For:*

**DEPARTMENT OF THE NAVY  
ATLANTIC DIVISION  
NAVAL FACILITIES  
ENGINEERING COMMAND  
*Norfolk, Virginia***

*Under the:*

**LANTDIV CLEAN Program  
Contract N62470-89-D-4814**

*Prepared By:*

**BAKER ENVIRONMENTAL, INC.  
*Coraopolis, Pennsylvania***

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| O | Field Logbook                                                             |



## ACRONYMS AND ABBREVIATIONS

|                     |                                                                                            |
|---------------------|--------------------------------------------------------------------------------------------|
| AQTESOLV            | Aquifer Test Solver                                                                        |
| ASTM                | American Society for Testing and Materials                                                 |
| Baker               | Baker Environmental, Inc.                                                                  |
| bgs                 | Below Ground Surface                                                                       |
| BOD                 | Biological Oxygen Demand                                                                   |
| CLP                 | Contract Laboratory Program                                                                |
| COD                 | Chemical Oxygen Demand                                                                     |
| CTO                 | Contract Task Order                                                                        |
| DEHNR               | Department of Environment, Health, and Natural Resources                                   |
| DOT                 | Department of Transportation                                                               |
| DQO                 | Data Quality Objective                                                                     |
| ECBSOPQAM           | Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual |
| Eh                  | Oxidation-Reduction Potential                                                              |
| EMD                 | Environmental Management Division                                                          |
| ESD                 | Environmental Services Division                                                            |
| FID                 | Flame Ionization Detector                                                                  |
| FSAP                | Field Sampling and Analysis Plan                                                           |
| HASP                | Health and Safety Plan                                                                     |
| ID                  | Inside Diameter                                                                            |
| IDW                 | Investigation Derived Waste                                                                |
| L/min               | Liter per Minute                                                                           |
| LANTDIV             | Atlantic Division, Naval Facilities Engineering Command                                    |
| MCB                 | Marine Corps Base                                                                          |
| MCL                 | Maximum Contaminant Level                                                                  |
| MS/MSD              | Matrix Spike/Matrix Spike Duplicate                                                        |
| NCWQS               | North Carolina Water Quality Standard                                                      |
| NFESC               | Naval Facilities Engineering Service Center                                                |
| NTU                 | Nephelometric Turbidity Unit                                                               |
| O <sub>2</sub> /LEL | Oxygen/Combustible Gas Meter                                                               |
| OD                  | Outside Diameter                                                                           |
| OU                  | Operable Unit                                                                              |
| PCB                 | Polychlorinated Biphenyl                                                                   |
| PID                 | Photoionization Detector                                                                   |
| POL                 | Petroleum/Oil/Lubricant                                                                    |
| PVC                 | Polyvinyl Chloride                                                                         |

**ACRONYMS AND ABBREVIATIONS**  
**(Continued)**

|         |                                               |
|---------|-----------------------------------------------|
| QA/QC   | Quality Assurance/Quality Control             |
| QAPP    | Quality Assurance Project Plan                |
| RCRA    | Resource Conservation and Recovery Act        |
| RI      | Remedial Investigation                        |
| RI/FS   | Remedial Investigation/Feasibility Study      |
| SOP     | Standard Operating Procedure                  |
| SVOC    | Semivolatile Organic Compound                 |
| TAL     | Target Analyte List                           |
| TCL     | Target Compound List                          |
| TCLP    | Toxicity Characteristic Leaching Procedure    |
| TDS/TSS | Total Dissolved Solids/Total Suspended Solids |
| TOC     | Total Organic Carbon                          |
| TSDf    | Treatment Storage and Disposal Facility       |
| USCS    | Unified Soil Classification System            |
| USEPA   | United States Environmental Protection Agency |
| VOC     | Volatile Organic Compound                     |
| WQP     | Water Quality Indicator Parameter             |

## 1.0 INTRODUCTION

This Field Sampling and Analysis Plan (FSAP) presents the proposed Remedial Investigation (RI) field activities that are to be conducted at Operable Unit (OU) No. 17 (Site 90 - BB-9, Site 91 - BB-51, and Site 92 - BB-46) at Marine Corps Base (MCB), Camp Lejeune, North Carolina. The RI field activities will be conducted in two phases. Phase I includes the installation of temporary monitoring wells to better define the horizontal extent of contamination and surface water/sediment sampling, while Phase II may include the installation of permanent shallow, intermediate, and possibly deep monitoring wells. The FSAP is part of the Project Plans, which also contain the Work Plan, Quality Assurance Project Plan (QAPP), and Health and Safety Plan (HASP).

The primary purpose of the FSAP is to provide guidance for all project field activities by describing in detail the sampling and data collection methods to be used in implementing the various field tasks identified in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan for Sites 90, 91, and 92. This document also helps to ensure that project activities are carried out in accordance with the United States Environmental Protection Agency (USEPA) Region IV and Naval Facilities Engineering Service Center (NFESC) standard operating procedures (SOPs) so that data obtained during the field investigation are of sufficient quantity and quality to evaluate the nature and extent of contamination in various media, estimate human health and environmental risks, and to evaluate potential technologies for remediation of contaminated media.

This FSAP will provide the guidance for all the project field activities planned for Phase I of the work to be performed. The Phase I field work will begin after all comments have been received for the draft FSAP. A Phase I Report, which will summarize the Phase I findings, will be submitted prior to the submission of the final RI/FS Project Plans. The final FSAP will address the recommendations of the Phase I Report and outline the Phase II scope of work, as necessary.

## **2.0 SITE BACKGROUND**

A description of the history and setting of MCB, Camp Lejeune and Sites 90, 91, and 92 is contained in Section 2.0 of the RI/FS Work Plan.

### **3.0 SAMPLING OBJECTIVES**

The sampling and data quality objectives (DQOs) for field investigations at Sites 90, 91, and 92 are summarized in Section 3.0 of the RI/FS Work Plan.

#### 4.0 SAMPLING LOCATIONS AND FREQUENCY

The following Phase I investigations and support activities will be conducted at Sites 90, 91, and 92:

- Surveying
- Subsurface Soil Investigation
- Groundwater Investigation
- Surface Water and Sediment Investigation

Quality Assurance/Quality Control (QA/QC) requirements and investigation derived waste handling activities also are discussed in this section. Each activity is described in the following subsections.

##### 4.1 Surveying

The site survey will be conducted of the current site features, including fence lines, sidewalks, utilities, nearby building foundations, tree lines, access roads and established roadways, existing monitoring wells, newly installed soil borings for temporary shallow and intermediate monitoring wells, surface water/sediment sampling stations, staff gauge locations, and the banks along the New River.

The location and elevation of a reference point on top of the polyvinyl chloride (PVC) riser and the elevation of the ground surface will be surveyed for each existing monitoring well. The location of each soil boring and staff gauge and the corresponding elevation will be surveyed. Survey points will include a latitude coordinate, a longitude coordinate, and an elevation expressed in feet above mean sea level. The vertical accuracy of the survey will be within 0.01 feet and the horizontal accuracy will be within 0.1 feet. All survey points will be correlated to the North Carolina State Plane Coordinate System.

##### 4.2 Phase I Soil Investigation

A soil investigation will be conducted in the vicinity of Sites 90, 91, and 92 during the Phase I field investigation to determine horizontal and vertical extent of contamination. The potential soil contaminant migration route is contaminant transport to shallow groundwater via soil leaching. The following subsections provide a description of the proposed soil investigation.

All soil borings/temporary monitoring wells installed during the Phase I investigation will be installed using a drill rig according to the procedures described in Section 6.1 and 6.2.

##### 4.2.1 Sampling Locations

During the Phase I field activities, one subsurface soil sample will be collected from each of the initial soil boring/temporary monitoring well locations at each site from just above the water table and submitted for chemical analysis. If the depth to groundwater is greater than 10 feet below ground surface (bgs) or there is evidence of contamination, one additional subsurface soil sample (for a total of two subsurface soil samples) will be collected from a mid-depth.

The initial Phase I investigation will include augering 23 soil boring locations. These 23 soil borings will be completed at each of the sites as described below:

- Site 90 - 7 soil borings @ 2 samples
- Site 91 - 12 soil borings
- Site 92 - 4 soil borings

The locations of the proposed soil borings/temporary monitoring wells are shown in Figures 4-1 through 4-3 within the Initial Investigation Area Boundary. Additional soil borings will be installed if deemed necessary to further delineate the extent of contamination. Possible expanded investigation locations are shown on Figures 4-1 through 4-3 within the Expanded Investigation Area Boundary.

A utility clearance will be conducted prior to soil boring/temporary monitoring well installation. The shallow soil borings will be augered to a depth approximately 15 to 25 feet bgs. The intermediate soil borings will be augered to a depth approximately 40 to 50 feet bgs. Section 6.1 presents specific details on procedures for soil sampling procedures.

#### 4.2.2 Sampling and Analytical Requirements

The subsurface soil samples collected during Phase I of the investigation will be analyzed for Target Compound List (TCL) volatile organic compounds (VOCs) by an on-site laboratory. The samples will be analyzed in accordance with USEPA Method 8240 (DQO Level III). Three subsurface soil samples from each site will be submitted for fixed base laboratory analysis. The samples submitted for fixed base analysis will be selected based in the findings of the on-site laboratory. To confirm the lower bound and upper bound analytical limits of the mobile laboratory, one sample with a low detected concentration, one sample with a medium detected concentration, and one sample with a high detected concentration will be submitted to a fixed base analytical laboratory. These samples will be analyzed for TCL organics (VOCs, semivolatile organic compounds [SVOC], pesticides/polychlorinated biphenyls [PCBs]) and Target Analyte List (TAL) metals in accordance with Contract Laboratory Program (CLP) methods, DQO Level IV. All soil samples will be analyzed and reported on a 28-day turnaround time.

#### 4.3 Phase I Groundwater Investigation

A groundwater investigation will be conducted in the vicinity of Sites 90, 91, and 92 during the Phase I field investigation to delineate the nature and extent of contamination in the surficial aquifer resulting from activities at the sites or surrounding activities. The potential groundwater migration routes at a minimum include: horizontal migration of contaminant confined within the shallow groundwater zone and vertical contaminant migration from the shallow groundwater to deeper groundwater zones. The following subsections provide a description of the proposed groundwater investigation.

All temporary monitoring wells installed during the Phase I investigation will be installed using a drill rig according to the procedures described in Section 6.2.

##### 4.3.1 Well Construction and Locations

The initial Phase I investigation will include the installation of 23 soil boring/temporary monitoring wells as described below:

- Seven temporary shallow monitoring wells (90-TW01 through 90-TW07) will be installed at Site 90;

Ten temporary shallow monitoring wells (91-TW01 through 91-TW10) and two temporary intermediate monitoring wells (91-TW11IW and 91-TW12IW) nested with designated existing shallow monitoring wells (BB51-11 and BB51-12) will be installed at Site 91; and

Three temporary shallow monitoring wells (91-TW01 through 91-TW03) and one temporary intermediate monitoring well (91-TW01IW) nested with existing monitoring well MW-1 will be installed at Site 92. The locations of the proposed temporary monitoring wells are shown in Figures 4-1 through 4-3 within the Initial Investigation Area Boundary.

- Groundwater samples will be collected from the temporary monitoring wells and analyzed for TCL VOCs by an on-site laboratory. The locations of other temporary monitoring wells will be based on the contamination levels detected in the initial 23 temporary monitoring wells installed. Possible expanded investigation locations are shown in Figures 4-1 through 4-3 within the Expanded Investigation Area Boundary.
- If no contamination is detected in the initial shallow temporary monitoring wells, additional temporary shallow monitoring wells in the Expanded and Supplemental Investigation Area Boundaries will not be required.
- If there is a substantial decrease in the detected contaminant concentrations between the initial and expanded temporary shallow monitoring wells, additional temporary shallow monitoring wells will be installed between the Initial Investigation Area Boundary and the Expanded Investigation Area Boundary within the Supplemental Investigation Area Boundary (Figures 4-1 through 4-3) to further define the contaminant boundary.
- Temporary shallow monitoring wells will be installed and the investigation area boundaries will be increased in the same pattern as established in Figures 4-1 through 4-3 until the vertical and horizontal extent of the contamination plume has been defined. The North Carolina Water Quality Standards (NCWQS) or the Federal Maximum Contaminant Level (MCLs) will be used as endpoints to determine if the limits of the contamination have been defined. The Expanded Investigation Area Boundary will expand 200-feet in any direction, with the Supplemental Investigation Area Boundary expanding 100-feet in any direction.
- If contamination is found in the temporary intermediate monitoring wells, recommendations for deep monitoring wells will be made for the Phase II field investigation.

A utility clearance will be conducted prior to soil boring and temporary monitoring well installation. The temporary shallow monitoring wells will be installed to a depth approximately 15 to 25 feet bgs. The temporary intermediate monitoring wells will be installed to a depth of approximately 40 to 50 feet bgs. The newly installed temporary monitoring wells will be constructed of 1-inch inside diameter (ID) PVC pipe, with 10 feet of 0.01-inch slot well screen. Section 6.2 presents specific details on temporary monitoring well installation procedures and Appendix B contains the justification for USEPA Region IV to use PVC material.

In the event that groundwater contamination is evident, additional temporary shallow monitoring wells will be required to determine the extent of contamination. The number and locations of the additional Phase I temporary shallow monitoring wells will be determined after the initial groundwater data has been evaluated.



### 4.3.2 Sampling and Analytical Requirements

All existing shallow and intermediate monitoring wells will be redeveloped. Section 6.3 presents specific details on monitoring well development procedures. One groundwater sample will be collected from a total of 33 existing shallow monitoring wells,

- Site 90 - BB90-1 through BB90-15
- Site 91 - BB91-1 through BB91-15
- Site 92 - MW-1 through MW-3

6 existing intermediate monitoring wells,

- Site 90 - BB90-16 through BB90-18
- Site 91 - BB91-16 through BB91-18

17 newly installed temporary shallow monitoring wells,

- Site 90 - 90-TW01 through 90-TW07
- Site 91 - 90-TW01 through 90-TW10
- Site 92 - 92-TW01 through 92-TW03

and 3 newly installed temporary intermediate monitoring wells.

- Site 91 - 91-TW11IW and 91-TW12IW
- Site 92 - 92-TW01IW

Samples will be collected using low flow purging and sampling methodology. Section 6.4 presents specific details on procedures for groundwater sampling. Groundwater measurements will be taken to confirm groundwater flow direction and tidal influence.

All groundwater samples will be analyzed for TCL VOCs by an on-site laboratory in accordance with USEPA Method 8240 (DQO Level III). For Site 90, one temporary shallow monitoring well sample analyzed on-site also will be analyzed for TCL VOCs at a fixed base analytical laboratory to confirm the results of the mobile laboratory on a 28-day turnaround time. Five existing shallow monitoring wells (BB90-4, BB90-5, BB90-6, BB90-12, and BB90-15) and two existing intermediate monitoring wells (BB90-16 and BB90-18) samples analyzed on-site also will be analyzed for full TCL organics (VOC, SVOC, pesticides/PCBs), TAL total metals, and total dissolved solids/total suspended solids (TDS/TSS) at a fixed base analytical laboratory on a 28-day turnaround time.

For Site 91, one temporary shallow and one intermediate monitoring well sample analyzed on-site also will be analyzed for TCL VOCs at a fixed base analytical laboratory to confirm the results of the mobile laboratory on a 28-day turnaround time. Five existing shallow monitoring wells (BB91-4, BB91-6, BB91-8, BB91-9, and BB91-12) and two existing intermediate monitoring wells (BB91-16 and BB91-17) samples analyzed on-site also will be analyzed for full TCL organics, TAL total metals, and TDS/TSS at a fixed base analytical laboratory on a 28-day turnaround time.

For Site 92, one existing shallow monitoring well (MW-1) sample analyzed on-site also will be analyzed for full TCL organics, TAL total metals, and TDS/TSS at a fixed base analytical laboratory on a 28-day turnaround time.

#### **4.4 Surface Water and Sediment Investigation**

A surface water and sediment investigation will be conducted at Site 92 to assess the possible impact of the site, other source areas, and possible groundwater contamination to the adjacent water body (New River) and to confirm contamination previously found. The following subsections provide a description of the proposed investigation.

##### **4.4.1 Sampling Locations**

One surface water sample will be collected from six stations in Courthouse Bay. Two sediment samples will be collected from each sample station (Figure 4-3). The initial sediment sample will be collected from the 0- to 6-inch depth; the second sample will be collected from the 6- to 12-inch depth. The sampling stations will be located approximately 150 feet from the shoreline of Site 92 in Courthouse Bay. Final sampling locations will be determined in the field based on accessibility. Sections 6.5 and 6.6 presents specific details on procedures for surface water and sediment sampling, respectively.

In addition, three staff gauges, one on each side of the point and one at the point into Courthouse Bay, will be installed. These staff gauges will be established for long term monitoring with pressure transducers to determine the amount of tidal influence and whether groundwater is discharging to surface water, surface water is discharging to groundwater, or depending on the tidal influence determine if both are occurring.

##### **4.4.2 Analytical Requirements**

Surface water and sediment samples will be submitted for fixed based analysis of TCL organics and TAL total metals in accordance with CLP methods, DQO Level IV. Additionally, sediment samples will be analyzed for grain size and total organic carbon (TOC). Samples will be analyzed on a 28-day turnaround time.

#### **4.5 Quality Assurance/Quality Control Samples**

QA/QC requirements for this investigation are presented in the QAPP. The following QA/QC samples will be collected during field sampling activities:

- **Trip Blanks**

Trip blanks are defined as samples which originate from the analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the VOC samples. The blanks will only be analyzed for TCL VOCs. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOCs.

- **Equipment Rinsates (Equipment Blanks)**

Equipment rinsates are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. Equipment rinsates will be collected daily during each sampling event. One rinsate per media sampled per day will be collected. For example, if groundwater and soil samples were collected on one given day, two rinsates would be collected. Initially, samples from every other day will be analyzed. If

analytes pertinent to the project are found in the rinsates, the remaining samples must be analyzed. The results from the rinsates will be used to evaluate the decontamination methods. This comparison is made during data validation and the rinsates are analyzed for the same parameters as the related samples. One equipment rinsate will be collected per media sampled per day of field sampling.

- **Field Blanks**

Field blanks consist of the source water used in decontamination. Field blanks will be collected by pouring the water from the container directly into sample bottles. Field blanks should not be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled. One field blank will be prepared at the commencement of the project.

- **Field Duplicates**

Field duplicates for soil samples are collected, homogenized, and split. All samples except VOCs are homogenized and split. Volatiles are not mixed, but select segments of soil are taken from the length of the core and placed in sampling jars. The duplicates for water samples should be collected simultaneously. The water samples will not be composited. Field duplicates will be collected at a frequency of 10 percent.

- **Matrix Spike/Matrix Spike Duplicates**

Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples are collected to evaluate the matrix effect of the sample upon the analytical methodology. A matrix spike and matrix spike duplicate must be performed for each group of samples of a similar matrix. MS/MSD samples will be collected at a frequency of 5 percent.

#### **4.6 Investigation Derived Waste Handling**

Soil cuttings will be collected and contained in a rolloff box if it is determined in the field to be potentially contaminated based on visual observations and HNu photoionization detector (PID) readings. If visual contamination or elevated HNu PID readings (above background) are not exhibited, the cuttings will be placed back into the borehole with the excess soil spread out around the area. One rigid storage tank with a capacity of 1,000 gallons will be available for containing groundwater development and purge water. A composite soil sample from the roll-off box will be collected and analyzed for full toxicity characteristic leaching procedure (TCLP) (organics and inorganics) and Resource Conservation and Recovery Act (RCRA) hazardous waste characterization (corrosivity, reactivity, and ignitability), and PCBs. One sample will be collected from the tank and analyzed for full TCL organics, TAL total metals, and TDS/TSS. Additional details regarding investigation derived waste (IDW) handling and disposal are provided in Section 6.9.

## 5.0 SAMPLE DESIGNATION

In order to identify and accurately track the various samples, all samples collected during this investigation, including QA/QC samples, will be designated with a unique number. The number will serve to identify the investigation, the site, the sample media, sampling location, the depth (soil) or round (groundwater) of sample, and QA/QC qualifiers.

The sample designation format is as follows:

Site#-Media/Station# or QA/QC-Depth/Round

An explanation of each of these identifiers is given below.

|             |                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Site#       | This investigation includes Sites 90, 91, and 92                                                                                                                                                                                                                                                                                                                                           |
| Media       | SB = Soil Boring (soil sample from a boring)<br>TW= Temporary Well (groundwater sample from a temporary well)<br>GW = Groundwater<br>SW = Surface Water<br>SD = Sediment                                                                                                                                                                                                                   |
| Station#    | Each soil boring or monitoring well will be identified with a unique identification number.                                                                                                                                                                                                                                                                                                |
| QA/QC       | (FB) = Field Blank<br>(D) = Duplicate Sample (following depth/round)<br>(TB) = Trip Blank<br>(ER) = Equipment Rinsate                                                                                                                                                                                                                                                                      |
| Depth/Round | Depth indicators will be used for soil samples. The number will reference the depth interval of the sample. For example:<br><br>00 = ground surface to 1 foot bgs<br>01 = 1 to 3 feet bgs<br>02 = 3 to 5 feet bgs<br>03 = 5 to 7 feet bgs<br><br>Round indicator will be used for groundwater samples. For example:<br><br>01 = initial round of sampling<br>02 = second round of sampling |

Under this sample designation format the sample number 91-GW05IW-01D refers to:

|                        |                              |
|------------------------|------------------------------|
| <u>91</u> -GW05IW-01D  | Site 91                      |
| 91- <u>GW</u> 05IW-01D | Groundwater sample           |
| 91-GW <u>05</u> IW-01D | Monitoring well #5           |
| 91-GW05 <u>IW</u> -01D | Intermediate monitoring well |

91-GW05IW-01D Round 1  
91-GW05IW-01D Duplicate (QA/QC) sample

The sample designation 92SB11-00D refers to:

92SB11-00D Site 92  
92SB11-00D Soil sample from a soil boring  
92SB11-00D Soil Boring #11  
92SB11-00D Sample depth interval 0- to 12-inches bgs  
92SB11-00D Duplicate (QA/QC) sample

The sample designation 92SW03-02D refers to:

92SW03-02D Site 92  
92SW03-02D Surface water sample  
92SW03-02D Surface water sample location #3  
92SW03-02D Sample depth interval 3- to 6-feet  
92SW03-02D Duplicate (QA/QC) sample

The sample designation on 92SD03-01D refers to:

92SD03-01D Site 92  
92SD03-01D Sediment sample  
92SD03-01D Sediment sample location #3  
92SD03-01D Sample depth interval 0- to 6-inches  
92SD03-01D Duplicate (QA/QC) sample

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

## 6.0 INVESTIGATIVE PROCEDURES

The investigative procedures to be used for Sites 90, 91, and 92 will be discussed in the following subsections. These procedures include soil sample collection, temporary monitoring well installation, existing monitoring well development, groundwater sample collection, in situ slug tests, surface water sample collection, sediment sample collection, decontamination procedures and handling of site investigation derived wastes. Note that all of these procedures will comply with the field methods described in the USEPA, Region IV, Environmental Services Division (ESD), Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual (ECBSOPQAM), February 1, 1991. Additional guidance from other sources such as American Society for Testing and Materials (ASTM) may be used, but if the ASTM and ESD methods conflict, the ESD procedure will be used. Additionally, in instances where the ESD has no SOP, other guidance sources will be used, such as manufacturer's SOP manuals. Field deviations will be recorded in the field logbook and discussed with the project manager.

### 6.1 Soil Sample Collection

Surface and subsurface soil samples will be collected in the vicinity of Sites 90, 91, and 92 during the Phase I investigation. Soil samples will be collected from borings advanced by a drilling rig during the installation of temporary monitoring wells. Soil borings will either be advanced by a truck mounted drilling rig or by a hand sampler unit. All boring locations will receive utility clearance from the appropriate on-base personnel. Appendix A contains Baker Environmental, Inc. (Baker's) SOP for soil sample acquisition.

Soil samples from soil borings, advanced by a drilling rig using hollow-stem augers, will be collected using a split-spoon sampler. A split-spoon sampler is a steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. This device can be driven into unconsolidated material using a drive weight connected to the drilling rig. A split-spoon sampler (used for performing Standard Penetration Tests) is 2-inches outer diameter (OD) and 1-3/8-inches ID. This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. Split-spoons capable of obtaining 24-inch long samples will be utilized during this investigation.

Split-spoon samples will be collected continuously from the ground surface to the water table in each soil boring. Soil samples that will be converted into temporary shallow monitoring wells will be advanced approximately 12 feet below the top of the water table. Soil borings converted into temporary intermediate monitoring wells will be advanced to a depth of approximately 40-foot bgs based on encountering the upper unit of the Castle Hayne formation. The physical characteristics of the samples will be described by the site geologist. The soil will be classified according to the Unified Soil Classification System (USCS). Soil sample descriptions will be recorded in the field geologist's logbook.

Selected split-spoon samples will be submitted to the laboratory for analysis. Soil samples will be collected continuously in 2-foot increments to the top of the water table. For soil borings only, split-spoon samples will be collected from approximately one foot bgs to the top of the water table; for soil borings advanced for monitoring well installation, split-spoon samples will be collected continuously from one foot bgs to the top of the water table and below the water table, soil samples will be collected at 5-foot intervals.

### 6.1.1 Split-Spoon Sample Collection Procedures

The following procedure will be used for collecting soil samples in split-spoons:

1. The surface soil sample will be collected by a stainless steel spoon used to remove the soil from the ground. The upper inch of soil will be discarded. Soil for volatile organic analysis will be placed directly into the sample jar. Soil for all other analysis will be placed into a stainless-steel bowl, thoroughly mixed, then placed into the remaining sample jar(s).
2. Advance the borehole to the desired depth using hollow-stem auger drilling techniques. The split-spoon will be lowered into the borehole inside the hollow-stem auger (this will ensure that undisturbed material will be sampled).
3. The subsurface soil samples will be collected by driving the split-spoon with blows from a 140-pound hammer falling 30-inches in accordance with SOP F102 Soil and Rock Sample Acquisition (Appendix A). The sampler will be driven 24-inches. Once at the desired depth, the split-spoon will be pulled from the borehole.
4. Record in the field logbook the number of blows required to effect each six inches of penetration or fraction thereof. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance,  $N$ . If the sampler is driven less than 18-inches, the penetration resistance is the number for the last one foot of penetration. (If less than one foot is penetrated, the logs shall state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24-inches, the sum of second and third 6-inch increments will be used to calculate the penetration resistance. (Refusal of the split-spoon will be noted at 50 blows over an interval equal to or less than 6-inches; the interval driven will be noted with the blow count.)
5. Bring the sampler to the surface and remove both ends and one half of the split-spoon such that the soil recovered rests in the remaining half of the barrel. Record the HNu PID measurements. Describe the recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil; then put into sample jars (see below for procedures concerning submitting soil samples to the laboratory).
6. Split-spoon samplers shall be decontaminated after each use and prior to the initial use at a site according to the procedures outlined in Section 6.7.
4. Repeat this operation until the borehole has been advanced to the selected depth. Split-spoon samples will be collected continuously until groundwater is encountered.

### 6.1.2 Soil Sample Laboratory Submission Procedures

The following procedure will be used for submitting soil samples to the laboratory:

1. After sample collection, soil for volatile organic analysis will be placed directly into the sample jar. Small aliquots will be collected from discrete locations over the entire length of the sample interval, representative of the soil types

encountered, and placed in the sample jar with minimum disturbance. The VOC sample jar will be filled completely, without headspace, to minimize volatilization. Sample bottles will be labeled prior to sample collection. Soil samples for VOCs should not be mixed.

3. A small, representative portion of sample will be set aside for description purposes. The remaining soil will be removed from the split-spoon sampler. Prior to filling laboratory containers, the soil sample should be mixed, in a stainless-steel bowl with stainless-steel spoons, as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval.
4. Record all pertinent sampling information such as soil description, sample depth, sample number and location, and the time of sample collection in the field logbook in addition to the above mentioned items. Additionally, the sample bottles will be labeled as outlined in Section 7.0.
5. The sample jars will be stored in a cooler with ice until laboratory shipment.
6. The samples will be packed for shipping. Chain-of-custody seals will be attached to the shipping package. Chain-of-Custody Forms and Sample Request Forms will be properly filled out and enclosed or attached (Section 7.0).
7. Decontaminate the split-spoon sampler as described in Section 6.7. Replace disposable latex gloves between sample stations to prevent cross-contamination of the samples.

## **6.2 Temporary Monitoring Well Installation**

Shallow and intermediate temporary monitoring wells will be installed during the Phase I field program in the vicinity of Sites 90, 91, and 92. The construction of these monitoring wells is somewhat unique based on the goals of the sampling activity. The objective of the sampling effort is to provide a detailed profile of VOC contamination in a well defined area. As such, the monitoring wells installed in the initial investigation will consist of temporary shallow monitoring wells (approximately 15 to 25 feet bgs) screened across the water table and temporary intermediate monitoring wells (approximately 40 to 50 feet bgs) seated in the confining layer and screened across the lower portion of the surficial aquifer. All of these temporary monitoring wells will be constructed with 10 feet of screen. Split spoons will be continuously collected to depth during the advancement of the monitoring well boring.

All temporary monitoring wells will be constructed with 1-inch diameter (ID) schedule 40 PVC casing and #10 slot (0.01-inch) screens.

- Activity personnel will approve all temporary monitoring well locations. These locations shall be free of underground or overhead utility lines.
- A borehole will be advanced with 3-1/4-inch ID augers by a drilling rig using hollow-stem augers into the water table (so that samples can be collected for laboratory analysis).
- Soil (split-spoon) samples will be collected continuously during borehole advancement. Samples will be collected according to the procedures outlined in Section 6.1.



- The borehole for temporary intermediate monitoring wells will be further advanced until completion using mud rotary drilling. The reason mud rotary drilling will be used is because of the unconsolidated formation and drilling depths anticipated. A tricone drill bit with an OD of 7-7/8-inches will be used to advance the borehole.
- Additional split-spoon samples will be collected at approximately 5 to 10-foot intervals during borehole advancement (mud rotary drilling). If a clay layer is encountered which may serve as a potential confining unit, continuous samples will be collected to determine the thickness of the layer. Samples will be collected according to the procedures outlined in Section 6.1.
- Upon completion of the borehole to the desired depth, monitoring well construction materials will be installed.
- Temporary monitoring wells will be constructed of PVC. It was selected on the basis of its low cost, ease of use, and flexibility. USEPA Region IV justification for PVC use is included in Appendix B.
- Ten feet of 1-inch ID, schedule 40, # 10 slot (0.01 inch) screen with a bottom cap will be installed. The screen will be connected to threaded, flush-joint, PVC riser. The riser will extend 2- to 3-feet above the ground surface. A PVC slip-cap, vented to the atmosphere, will be placed at the top of the riser. For shallow monitoring well installation, the top of the monitoring well screen will be placed such that two feet of the screen (as subsurface conditions permit) extends above the water table.
- Development of the temporary monitoring wells is not required. However, the same volume of water introduced into the borehole during construction to prevent heaving sands must be removed prior to purging and sampling.
- Temporary monitoring wells will be removed manually and any remaining open boreholes will be backfilled with bentonite to 2-feet above the water table and then backfilled with the original soil cuttings from that soil boring with the excess soil spread around the area.

### 6.3 Well Development

All existing monitoring wells which are to be sampled during Phase I will be developed as specified in the ECBSOPQAM. The purpose of monitoring well development is to stabilize and increase the permeability of the filter pack around the well screen, to restore the permeability of the formation which may have been reduced by the drilling operations, and to remove fine-grained materials that may have entered the monitoring well or filter pack during installation. The selection of the monitoring well development method typically is based on drilling methods, monitoring well construction and installation details, and the characteristics of the formation.

Shallow monitoring wells typically are developed using bailers or low-yield pumping in combination with surging using a surge block. Intermediate monitoring wells are developed using compressed air (equipped with an air filter) in combination with surging. Selection of a development device will be dependent on conditions encountered during monitoring well installation.

Thirty-three existing shallow monitoring wells (15 at Site 90, 15 at Site 91, and 3 at Site 92) and six existing intermediate monitoring wells (3 at Site 90 and 3 at Site 91) will be re-developed as they have not been sampled since 1994 at Sites 90 and 91 and 1995 at Site 92. The purpose of this development effort is to re-establish good communication between the monitoring well (and sand pack) and the surrounding aquifer.

All monitoring wells will be developed until well water runs clear of fine-grained materials. Note that the water in some monitoring wells does not clear with continued development. Typical limits placed on monitoring well development may include any one of the following:

- Clarity of water based on visual determination
- A maximum time period (typically one hour for shallow monitoring wells)
- Stability of pH, specific conductance, and temperature measurements (typically less than 10 percent variation between three successive measurements)
- Clarity based on turbidity measurements (typically less than 10 Nephelometric Turbidity Units [NTU])

A record of the monitoring well development will be completed to document the development process. Section 6.8 provides information on the use of monitoring and data collection equipment for water level measurements, pH, specific conductance, and temperature.

Usually, a minimum of one week should elapse between the end of development and the first sampling event for a monitoring well. This equilibration period allows groundwater unaffected by the installation of the monitoring well to occupy the screened interval vicinity.

#### **6.4 Groundwater Sample Collection**

The temporary and existing monitoring wells will be sampled via low-flow methods. Low-flow is defined as a flow rate similar to the ambient flow rate in the screened formation.

A peristaltic pump will be used to purge the monitoring wells and collect the samples. VOC loss through suction degassing is expected to be insignificant due to the very slow flow rates to be used. Baker personnel report observance of minimal bubbling in the groundwater stream during recent peristaltic pump use. The procedure for collecting groundwater samples is detailed in this section, and has been assembled from ESD guidance and recently published papers and other documents.

##### **6.4.1 Low-Flow Purging vs. High-Flow Purging**

A number of recent studies have demonstrated that low-flow purging and sampling is a preferable to bailing or high-flow purging and sampling. High-rate pumping is described as a rate greater than, or similar to, the development rate. Some findings include:

- High-flow pumping and bailing may overdevelop a monitoring well, causing damage to the monitoring well and filter pack (USEPA, 1992).
- High-flow pumping and bailing may disturb accumulated corrosion/reaction products, or sediment (USEPA, 1992), or potentially mobilize particulate or colloidal matter from the formation (Barcelona, Wehrmann and Varljen, 1994).

- High-flow pumping may induce flow into the monitoring well from groundwater in the formation above the well screen (USEPA 1992).
- High-flow pumping and bailing may cause loss of VOCs. The velocities at which groundwater enters a bailer can actually correspond to unacceptably high purge rates (USEPA, 1992).
- Bailer use can result in composite averaging by mixing of water across the screen interval (Barcelona, Wehrmann and Varljen, 1994), resulting in unreproducible and unrepresentative data.

#### **6.4.2 Selection of Water Quality Indicator Parameters**

The water quality indicator parameters (WQP) for stabilization includes dissolved oxygen, turbidity, pH, and specific conductance. Use of these WQPs has precedence in recent studies. Dissolved oxygen and turbidity are more sensitive indicators of "fresh" groundwater than pH, specific conductance, and temperature (Puls and Powell, 1995). Barcelona, Wehrmann and Varljen, 1994, suggest that dissolved oxygen and specific conductance are good indicators of stabilization with respect to VOC sampling. Puls and Paul, 1995 used dissolved oxygen, turbidity, pH, and specific conductance as indicators of stabilization.

#### **6.4.3 Purging and Sampling Procedure**

The following is the low-flow purge and sampling procedure that will be used at Sites 90, 91, and 92:

1. The protective casing (for existing monitoring wells) will be unlocked, the well cap will be removed, and escaping gases will be measured at the well head using a PID or flame ionization detector (FID). This will determine the need for respiratory protection.
2. The monitoring well will be allowed to equilibrate to atmospheric pressure in the event that a vent hole was not installed in the monitoring well.
3. The static water level will be measured. The total depth of the monitoring well will not be measured, as not to stir up any sediment. The total depth will be obtained from soil boring logs. The water volume in the monitoring well will then be calculated.
4. The sampling device intake (virgin, 1/4-inch ID polypropylene or polyethylene tubing) will be slowly lowered until the bottom end is 2 to 3 feet below the top of water level. Based on historical water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the monitoring well just above the water.
5. Purging will then begin with a peristaltic pump, if possible. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the monitoring well.) Flow rates of less than 1 liter per minute (L/min) are expected.
6. The WQPs, including turbidity, pH, and specific conductance will be measured frequently (e.g., every 2 minutes). Temperature and oxidation-reduction potential (Eh) also will be measured.

7. Purging will be complete when a minimum of three well volumes have been removed and three successive WQP readings have stabilized within 10 percent, or there is no further discernable upward or downward trend. It is Baker's experience that at low values, certain WQPs (such as turbidity) may vary by more than 10 percent, but have reached a stable plateau. Also, purging will continue until turbidity reaches 10 NTU or less. If this cannot be reasonably achieved, it will be noted in the field logbook and discussed in the RI report.
8. Upon WQP stabilization, groundwater samples will be collected from the end of the tubing into the sample bottle. VOC samples will be collected first, followed by semivolatiles, pesticides and PCBs, total metals, and TDS/TSS. Sample bottles will be labeled prior to sample collection and filled in the same order for all monitoring wells.
9. The following information will be recorded in the field logbook:
  - Project location, date, and time
  - Weather
  - Sample location, number, round, and identification number
  - Static water level
  - Calculation of amount of water to be purged
  - Water quality parameters during purging
  - Visual description of water (i.e., clear, cloudy, muddy, etc.)
  - Names of sampling personnel
  - Names of visitors on site
  - Purging and sampling technique, procedure and equipment used
  - Sampling remarks and observations
  - QA/QC samples collected
10. The sample jars will be stored in a cooler with ice until laboratory shipment.
11. The samples will be packed for shipping. Chain-of-custody seals will be attached to the shipping package. Chain-of-Custody Forms and Sample Request Forms will be properly filled out and enclosed or attached (Section 7.0).

Sample preservation and handling procedures are outlined in Section 7.0. Appendix C presents a SOP for groundwater sampling.

### **6.5 Surface Water Sample Collection**

Six surface water stations are to be sampled as part of this investigation from Courthouse Bay surrounding the peninsula. The following procedure will be used to collect all surface water samples:

1. One surface water sample from mid-depth will be collected from each station. Surface water samples will be collected from a depositional area, if encountered.
2. Surface water samples will be collected from downstream to upstream locations to prevent potential migration of contaminants to downstream stations before sampling has been conducted, if required. Sediment samples will be collected after the surface water samples to minimize sediment disturbance and suspension.

3. Surface samples will be collected by dipping the sample bottles directly into the water. An unpreserved, laboratory-decontaminated transfer bottle (amber sample bottle) will be used to fill preserved bottles. Additionally, a transfer bottle will be used to fill all bottles if surface water is too shallow. This transfer bottle also will be used as a sample bottle for the location sampled, or discarded. Care will be taken when collecting for VOCs to avoid excessive agitation that could result in the loss of volatiles. Samples will be collected in the following order: Volatile organics, semivolatile organics, pesticides, PCBs, and total metals. Sample bottles will be filled in the same order at all the sampling stations. Sample bottles will be labeled prior to sample collection.
4. All sample containers not containing preservative will be rinsed at least once with the sample water prior to final sample collection. In addition, the sampling container used to transfer the surface water into the sample bottles containing preservative will be rinsed once with the sample water.
5. Temperature, pH, specific conductance, and dissolved oxygen will be measured in the field at each sampling station immediately following sample collection.
6. The sampling station will be marked by placing a wooden stake and bright colored flagging at the nearest bank or shore. The sampling station number will be marked with indelible ink on the stake. In addition, the distance from the shore and the approximate location will be estimated and recorded and sketched in the field logbook. If permission is granted, photographs will be taken to document the physical and biological characteristics of the sampling station.
7. The following information will be recorded in the field logbook:
  - Project location, date, and time
  - Weather
  - Sample location, number, and identification number
  - Flow conditions (i.e., high, low, in flood, etc.)
  - On site water quality measurements
  - Visual description of water (i.e., clear, cloudy, muddy, etc.)
  - Sketch of sampling location including boundaries of the water body, sample location (and depth), relative position with respect to the site, location of wood identifier stake
  - Names of sampling personnel
  - Names of visitors on site
  - Sampling technique, procedure, and equipment used
  - Sampling remarks and observations
  - QA/QC samples collected
8. The sample jars will be stored in a cooler with ice until laboratory shipment.
9. The samples will be packed for shipping. Chain-of-custody seals will be attached to the shipping package. Chain-of-Custody Forms and Sample Request Forms will be properly filled out and enclosed or attached (Section 7.0).

Sample preservation and handling procedures are outlined on Section 7.0. Appendix D presents a SOP for surface water sampling.

## 6.6 Sediment Sample Collection

Six sediment stations are to be sampled as part of this investigation. The following procedure will be used to collect all sediment samples:

1. Sediment samples will be collected after the surface water sample has been collected.
2. Sediment samples will be collected from downstream to upstream locations to prevent potential migration of contaminants to downstream stations before sampling has been conducted.
3. Two sediment samples will be collected from each station, one from 0- to 6-inches and the other from 6- to 12-inches bgs.
4. The sediment sample interval at each station will be collected with a stainless-steel hand-held coring instrument (sediment sleeve). A disposable clear plastic liner tube, fitted with an eggshell catcher to prevent sample loss, will be used at each station.
5. The coring sleeve will be pushed into the sediment to a depth of 12-inches, or until refusal, whichever is encountered first. The sediment in the 0- to 6-inch interval and the 6- to 12-inch interval will be extruded from the liner with a decontaminated extruder into separate stainless-steel bowls and the sample homogenized prior to being transferred to the laboratory containers. Samples for VOC analysis will not be homogenized.
6. If less than 12-inches of sediment is obtained, the first 6-inches will be placed in a stainless-steel bowl and the remaining sediment will be placed into a second stainless-steel bowl.
7. Sediment for volatile organic analysis will be placed directly into the sample jar. The VOC sample jar will be filled completely, without headspace, to minimize volatilization. Precautions will be taken when collecting the VOC analysis not to disturb the sample (which will promote volatilization). The remaining soil will be placed into a stainless-steel bowl and thoroughly mixed utilizing stainless-steel spoons. The sample jar(s) for all other analysis will then be filled. Sample jars will be labeled prior to sample collection.
8. The sampling station will be marked by placing a wooden stake and bright colored flagging at the nearest bank or shore. The sampling station number will be marked with indelible ink on the stake. In addition, the distance from the shore and the approximate location will be estimated and recorded and sketched in the field logbook. If permission is granted, photographs will be taken to document the physical and biological characteristics of the sampling station.
9. The following information will be recorded in the field logbook:
  - Project location, date, and time
  - Weather
  - Sample location, number, and identification number
  - Flow conditions (i.e., high, low, in flood, etc.)
  - On site water quality measurements

- Visual description of water (i.e., clear, cloudy, muddy, etc.)
- Sketch of sampling location including boundaries of the water body, sample location (and depth), relative position with respect to the site, location of wood identifier stake
- Names of sampling personnel
- Names of visitors on site
- Sampling technique, procedure, and equipment used
- Sampling remarks and observations
- QA/QC samples collected

10. The sample jars will be stored in a cooler with ice until laboratory shipment.
11. The samples will be packed for shipping. Chain-of-custody seals will be attached to the shipping package. Chain-of-Custody Forms and Sample Request Forms will be properly filled out and enclosed or attached (Section 7.0).

Sample preservation and handling procedures are outlined on Section 7.0. Appendix D also presents a SOP for sediment sampling.

#### 6.7 Decontamination

Equipment and materials that require decontamination fall into two broad categories:

1. Field measurement, sampling, and monitoring equipment (e.g. water level meters, stainless-steel spoons, etc.)
2. Machinery, equipment, and materials (e.g. drilling rigs, backhoes, drilling equipment, monitoring well materials, etc.)

Appendices E and F detail procedures for decontaminating the two categories of equipment and materials, respectively.

#### 6.8 Monitoring and Data Collection Equipment

Field support activities and investigations will require the use of monitoring and data collection equipment. Turbidity, specific conductance, temperature, pH, and Eh readings will be recorded during groundwater sample collection. Dissolved oxygen, specific conductance, temperature, and pH readings will be recorded during surface water sample collection. Appendix G, On-Site Water Quality Testing, provides specific procedures for collecting conductance, temperature, and pH readings.

Additional monitoring well information may be obtained using water level meters, water-product level meters, and well depth meters. The operation and various uses of this data collection equipment is provided in Appendix H.

Health and safety monitoring and environmental media screening will be conducted using a PID and an oxygen/combustible gas meter (O<sub>2</sub>/LEL). The operation and use of the PID is described in Appendix I. The Bacharach O<sub>2</sub>/LEL meter also will be used during the sampling program, primarily to monitor health and safety conditions. Appendix J provides a description of the Bacharach O<sub>2</sub>/LEL meter and operating procedures.

## **6.9 Investigation Derived Waste Handling**

The following sections discuss the responsibilities, sources, containerization, sampling and analysis, and disposal of Investigation Derived Wastes (IDW). These wastes include soil from borings, groundwater from developing and purging of monitoring wells, decontamination fluids, and personal protection equipment.

### **6.9.1 Responsibilities**

LANTDIV - Atlantic Division, Naval Facilities Engineering Command (LANTDIV) or the facility must ultimately be responsible for the final disposition of site wastes. As such, a LANTDIV or MCB Camp Lejeune representative will sign waste disposal manifests as the generator of the material, in the event off-site disposal is required. However, it may be the responsibility of Baker, depending on the contingency discussions during execution of the investigation, to provide assistance to LANTDIV in arranging for final disposition and preparing manifests.

Baker Project Manager - It is the responsibility of the Baker Project Manager to work with the LANTDIV-Technical Representative in determining the final disposition of site investigation wastes. The Baker Project Manager will relay the results and implications of the chemical analysis of waste or associated material, and advise on the regulatory requirements and prudent measures appropriate to the disposition of the material. The Baker Project Manager also is responsible for ensuring that field personnel involved in site investigation waste handling are familiar with the procedures to be implemented in the field, and that all required field documentation has been completed.

Baker Field Team Leader - The Baker Field Team Leader or Site Manager is responsible for the on site supervision of the waste handling procedures during the site investigations. The Baker Field Team Leader also is responsible for ensuring that all other field personnel are familiar with these procedures.

### **6.9.2 Sources of Investigation Derived Wastes**

Field investigation activities often result in the generation and handling of potentially contaminated materials that must be properly managed to protect the public and the environment, as well as to meet legal requirements. These wastes may be either hazardous or nonhazardous in nature. The nature of the waste (i.e., hazardous or nonhazardous) will determine how the wastes will be handled during the field investigation.

The sources of waste material depend on the site activities planned for the project. The following types of activities or sources, typical of site investigations, may result in the generation of waste material which must be properly handled:

- Subsurface soil sampling and monitoring well construction (soil cuttings)
- Monitoring well development (development water)
- Groundwater sampling (purge water)
- Heavy equipment decontamination (decontamination fluids)
- Sampling equipment decontamination (decontamination fluids)
- Personal protection equipment (health and safety disposables)



### **6.9.3 Designation of Potentially Hazardous and Nonhazardous Investigation Derived Wastes**

Wastes generated during the field investigation can be categorized as either potentially hazardous or nonhazardous in nature. The designation of such wastes will determine how the wastes are handled. The criteria for determining the nature of the waste and the subsequent handling of the waste is described below for each type of anticipated investigative waste.

#### **6.9.3.1 Soil Cuttings**

Soil cuttings will be generated during the augering of soil borings and monitoring well borings. As the borehole is augered, collected soil samples will be monitored with an HNu PID unit for organic vapors and notes made on the physical appearance of the soil. Soil cuttings that do not indicate elevated levels of organics (above background) or have visual signs of contamination will be placed on polyethylene sheeting and backfilled into the borehole following completion of the drilling. Cuttings which, by their appearance or organic vapor readings, appear to be contaminated will be containerized in a rolloff box for analytical testing, temporary storage on site, and subsequent treatment and/or disposal.

#### **6.9.3.2 Monitoring Well Development and Purge Water**

All development and purge water shall be containerized in one 1,000 gallon tank. Groundwater development/purge water that exhibits elevated HNu PID readings should be kept separate from water that does not exhibit elevated levels in Department of Transportation (DOT-approved) drums for purposes of subsequent treatment and/or disposal.

#### **6.9.3.3 Decontamination Fluids**

Equipment and personal decontamination fluids shall be containerized in DOT-approved 55-gallon drums. The fluids shall be collected from the decontamination/wash pads.

#### **6.9.3.4 Personal Protective Equipment**

All personal protective equipment (i.e., tyveks, gloves, and other health and safety disposables) shall be placed in garbage bags and disposed of in trash dump boxes.

### **6.9.4 Investigation Derived Waste Sampling and Analysis**

A composite sample shall be collected from the rolloff box containing soil cuttings from the three individual sites. These samples will be analyzed for full TCLP (organics and inorganics), TCL PCBs, and RCRA hazardous waste characterization (corrosivity, reactivity, and ignitability). Appendix K contains procedures for collecting samples from drums, if required.

For each container of development/purge water (drums or tank), a sample shall be collected for full TCL organic and TAL total metal analyses. Procedures for collecting waste water samples are presented in Appendix L.

Decontamination fluids collected during the investigation shall be sampled and analyzed for full TCL organics and TAL total metals.

### **6.9.5 Labeling**

If DOT-approved 55-gallon drums are used to containerize soil cuttings, the containers will be numbered and labeled by the field team during the site investigation. Information shall be stenciled in paint on both the container lid and side. Container labels shall include, at a minimum:

- LANTDIV Contract Task Order (CTO) (number)
- Project name
- Drum number
- Soil boring or monitoring well number
- Date
- Source
- Contents

If laboratory analysis reveals that containerized materials are hazardous or contain PCBs, additional labeling of containers may be required. The Project Manager will assist LANTDIV in additional labeling procedures, if necessary, after departure of the field team from the facility. These additional labeling procedures will be based upon the identification of material present; USEPA regulations applicable to labeling hazardous and PCB containing wastes are contained in 40 CFR Parts 261, 262, and 761.

### **6.9.6 Container Log**

A container log shall be maintained in the site logbook. The container log shall contain the same information as the container label plus any additional remarks or information. Such additional information may include the identification number of a representative laboratory sample.

### **6.9.7 Container Storage**

Containers of site investigative wastes shall be stored on site or in a specially designated secure area that is managed by the MCB Camp Lejeune Environmental Management Division (EMD) until disposition is determined. All containers shall be covered with plastic sheeting to provide protection from the weather.

If the laboratory analysis reveals that the containers contain hazardous or PCB wastes, additionally required storage security may be implemented; in the absence of the investigative team, these will be the responsibility of LANTDIV or the facility, as confirmed by the contingency discussions.

Baker will assist LANTDIV in devising the storage requirements, which may include the drums being staged on wooden pallets or other structures to prevent contact with the ground and being staged to provide easy access. Weekly inspections by facility personnel of the temporary storage area also may be required. These inspections may assess the structural integrity of the containers and proper container labeling. Also, precipitation that may accumulate in the storage area may need to be removed. These weekly inspections and whatever precipitation removal is necessary shall be recorded in the site logbook.

### **6.9.8 Container Disposition**

The disposition of the containers of site investigation generated wastes shall be determined by LANTDIV, with the assistance of Baker, as necessary. Container disposition shall be based on quantity of materials, types of materials, and analytical results. If necessary, specific samples of

contained materials may be collected to identify further characteristics which may affect disposition. Typically, container disposition will not be addressed until after receipt of applicable analytical results; these results are usually not available until long after completion of the field investigation at the facility.

#### **6.9.9 Disposal of Contaminated Materials**

Actual disposal methods for IDW will be determined following receipt of chemical analyses. The usual course will be a contractor specialist retained to conduct the disposal. However, regardless of the mechanism used, all applicable Federal, state, and local regulations shall be observed. USEPA regulations applicable to generating, storing, and transporting PCB or hazardous wastes are contained in 40 CFR Parts 262, 263, and 761.

Another consideration in selecting the method of disposal of contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable on-site disposal or treatment structure is expected, contaminated materials generated during the site investigation may be stored at the site for treatment/disposal with other site materials. In this case, the initial containment (i.e., drums or other containers) shall be evaluated for use as long-term storage. Also, other site conditions, such as drainage control, security, and soil types must be considered in order to provide proper storage.

At Sites 90, 91, and 92, any soil determined to be nonhazardous will be returned to the site. Soil determined to be hazardous will be taken to a Treatment Storage and Disposal Facility (TSDF). All water will be taken to the Site 82 treatment plant if determined not to contain petroleum/oil/lubricant (POL) constituents.

## **7.0 SAMPLE HANDLING AND ANALYSIS**

Field activities will be conducted in accordance with the USEPA Region IV ESD's ECBSOPQAM (February 1, 1991). Procedures for sample preservation, labeling, handling, and maintaining a field logbook are detailed in SOPs. Because these procedures are not specific to this project, they are provided as appendices, rather than detailed herein. Major components of sample handling and analysis are discussed in the following subsections.

The number of samples, analytical methods, data quality objectives, and laboratory turnaround times are presented in Table 7-1.

### **7.1 Sample Preservation and Handling**

Sample preservation, sample bottle packing and shipping are important components to maintaining the integrity of the samples. Preservation and handling procedures to be used in this investigation are detailed in Appendix M and Section 6.1 of the QAPP.

### **7.2 Chain-of-Custody**

Chain-of-custody is another important component to maintaining sample integrity. Chain-of-custody procedures to be followed during this investigation are detailed in Appendix N. This SOP details sample bottle labeling and chain-of-custody procedures.

Chain-of-custody procedures ensure a documented, traceable link between measurement results and the sample or parameter they represent. These procedures are intended to provide a legally acceptable record of sample collection, identification, preparation, storage, shipping, and analysis.

### **7.3 Field Logbook**

Field logbooks will be used to record sampling activities and information. Entries will include general and specific sampling information so that site activities may be reconstructed. In addition to the logbook, field forms, such as boring and monitoring well development logs, will be completed as support documentation for the logbook. Appendix O describes a general format for the field logbook.

Each field person will have and maintain a logbook. Logbooks will be copied daily and stored at the field trailer as back-up in case the original is lost or destroyed. Additionally, copies of completed logbooks will be filed in the project files.

## **8.0 SITE MANAGEMENT**

This section outlines the responsibilities and reporting requirements of on-site personnel.

### **8.1 Field Team Responsibilities**

The field investigation portion of this project will consist of one field team. All field activities will be coordinated by a Site Manager. The Site Manager will ensure that all field activities are conducted in accordance with the project plans (the Work Plan, this FSAP, the QAPP, and the HASP).

The Field Team will employ one or more drilling rigs for soil boring and temporary monitoring well installation. The drilling rig will be supervised by a Baker geologist. Two sampling technicians will be assigned to the field team for groundwater, surface water, and sediment sampling. One of the sampling technicians will serve as the Site Health and Safety Officer.

### **8.2 Reporting Requirements**

The Site Manager will report a summary of each day's field activities to the Project Manager or his/her designee. This may be done by telephone or telefax. The Site Manager will include, at a minimum, the following in his/her daily report:

- Baker personnel on site
- Other personnel on site
- Major activities of the day
- Subcontractor quantities (e.g., drilling footage)
- Samples collected
- Problems encountered
- Planned activities

The Site Manager will receive direction from the Project Manager regarding changes in scope of the investigation. All changes in scope will be discussed and agreed upon by LANTDIV, Camp Lejeune EMD, USEPA Region IV, and the North Carolina Department of Environment, Health, and Natural Resources (DEHNR).

## 9.0 REFERENCES

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- Water and Air Research, Inc. (WAR), 1983. Initial Assessment Study of Marine Corps Base Camp Lejeune, North Carolina. Prepared for Naval Energy and Environmental Support Activity. April 1983.

Trip 1/cooler TCL VOCs  
 Equip 1/day/media all  
 Field 1 @ end  
 Dup 10%  
 Matrix 50%

TABLE 7-1

SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS  
 OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)  
 REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344  
 MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

| Study Area        | Investigation | Baseline Number Of Samples <sup>(1)</sup>                                                                                                    | Analysis                                                                | Analytical Method                     | Data Quality Objective | Laboratory Turnaround             |
|-------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------|------------------------|-----------------------------------|
| Site 90 - Phase I | Soil          | 7 subsurface soil borings (7 soil samples)                                                                                                   | TCL VOAs - Mobile Laboratory                                            | EPA 8240                              | III                    | One Day                           |
|                   |               | 3 subsurface soil samples (1 high/1 med/1 low detection)                                                                                     | TCL Organics <sup>(2)</sup> - VOAs<br>TAL Metals <sup>(3)</sup> - SVOCs | CLP/SOW<br>CLP/SOW                    | IV<br>IV               | Routine <sup>(4)</sup><br>Routine |
|                   |               | Expanded soil borings/temporary shallow monitoring wells                                                                                     | TCL VOAs - Mobile Laboratory                                            | EPA 8240                              | IV                     | One Day                           |
|                   | Groundwater   | 22 shallow monitoring wells (15 existing, 7 new initial temporary)<br>3 existing intermediate monitoring wells                               | TCL VOAs - Mobile Laboratory<br>133                                     | EPA 8240                              | IV                     | One Day                           |
|                   |               | 1 temporary shallow monitoring well                                                                                                          | TCL VOAs                                                                | CLP/SOW                               | IV                     | Routine                           |
|                   |               | 5 existing shallow monitoring wells (BB-4, 5, 6, 12, 15)<br>2 existing intermediate monitoring wells (BB-16, 18)                             | TCL Organics<br>TAL Total Metals<br>TDS/TSS                             | CLP/SOW<br>CLP/SOW<br>EPA 160.1/160.2 | IV<br>IV<br>IV         | Routine<br>Routine<br>Routine     |
|                   |               | Expanded temporary shallow monitoring wells                                                                                                  | TCL VOAs - Mobile Laboratory                                            | EPA 8240                              | IV                     | One Day                           |
| Site 91 - Phase I | Soil          | 12 subsurface soil borings (12 soil samples - 10 shallow and 2 intermediate soil borings)                                                    | TCL VOAs - Mobile Laboratory                                            | EPA 8240                              | IV                     | One Day                           |
|                   |               | 3 subsurface soil samples (1 high/1 med/1 low detection)                                                                                     | TCL Organics<br>TAL Metals                                              | CLP/SOW<br>CLP/SOW                    | IV<br>IV               | Routine<br>Routine                |
|                   |               | Expanded soil borings/temporary shallow monitoring wells                                                                                     | TCL VOAs - Mobile Laboratory                                            | EPA 8240                              | IV                     | One Day                           |
|                   | Groundwater   | 25 shallow monitoring wells (15 existing, 10 new initial temporary)<br>5 intermediate monitoring wells (3 existing, 2 new initial temporary) | TCL VOAs - Mobile Laboratory                                            | EPA 8240                              | IV                     | One Day                           |
|                   |               | 1 temporary shallow monitoring well<br>1 temporary intermediate monitoring well                                                              | TCL VOAs                                                                | CLP/SOW                               | IV                     | Routine                           |

Now many →  
 All good by now →

TABLE 7-1 (Continued)

SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS  
 OPERABLE UNIT NO. 17 (SITES 90, 91, and 92)  
 REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344  
 MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

| Study Area                       | Investigation                  | Baseline Number Of Samples <sup>(1)</sup>                                                                                | Analysis                                        | Analytical Method                             | Data Quality Objective | Laboratory Turnaround                    |
|----------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|-----------------------------------------------|------------------------|------------------------------------------|
| Site 91 - Phase I<br>(continued) | Groundwater<br>(continued)     | 5 existing shallow monitoring wells (BB-4, 6, 8, 9, 12)<br>2 existing intermediate monitoring wells (BB-16, 17)          | TCL Organics<br>TAL Total Metals<br>TDS/TSS     | CLP/SOW<br>CLP/SOW<br>EPA 160.1/160.2         | IV<br>IV<br>IV         | Routine<br>Routine<br>Routine            |
|                                  |                                | Expanded temporary shallow monitoring wells                                                                              | TCL VOAs - Mobile Laboratory                    | EPA 8240                                      | IV                     | One Day                                  |
| Site 92 - Phase I                | Soil                           | 4 subsurface soil borings (4 soil samples - 3 shallow and 1 intermediate soil boring)                                    | TCL VOAs - Mobile Laboratory                    | EPA 8240                                      | IV                     | One Day                                  |
|                                  |                                | 3 subsurface soil samples (1 high/1 med/1 low detection)                                                                 | TCL Organics<br>TAL Metals                      | CLP/SOW<br>CLP/SOW                            | IV<br>IV               | Routine<br>Routine                       |
|                                  |                                | Expanded soil borings/temporary shallow monitoring wells                                                                 | TCL VOAs - Mobile Laboratory                    | EPA 8240                                      | IV                     | One Day                                  |
|                                  | Groundwater                    | 6 shallow monitoring wells (3 existing, 3 new initial temporary)<br>1 new initial temporary intermediate monitoring well | TCL VOAs - Mobile Laboratory                    | EPA 8240                                      | IV                     | One Day                                  |
|                                  |                                | 1 existing shallow monitoring well (MW-1)                                                                                | TCL Organics<br>TAL Total Metals<br>TDS/TSS     | CLP/SOW<br>CLP/SOW<br>EPA 160.1/160.2         | IV<br>IV<br>IV         | Routine<br>Routine<br>Routine            |
|                                  |                                | Expanded temporary shallow monitoring wells                                                                              | TCL VOAs - Mobile Laboratory                    | EPA 8240                                      | IV                     | One Day                                  |
|                                  | Surface Water - Courthouse Bay | 6 stations/1 sample per station                                                                                          | TCL Organics<br>TAL Total Metals                | CLP/SOW<br>CLP/SOW                            | IV<br>IV               | Routine<br>Routine                       |
|                                  | Sediment - Courthouse Bay      | 6 stations/ 2 samples per station                                                                                        | TCL Organics<br>TAL Metals<br>TOC<br>Grain Size | CLP/SOW<br>CLP/SOW<br>EPA 415.1<br>ASTMD 1140 | IV<br>IV<br>IV<br>IV   | Routine<br>Routine<br>Routine<br>Routine |



TABLE 7-1 (Continued)

**SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS  
OPERABLE UNIT NO. 17 (SITES 90, 91, and 92)  
REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344  
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA**

| Study Area                  | Investigation               | Baseline Number Of Samples <sup>(1)</sup> | Analysis                                    | Analytical Method                     | Data Quality Objective | Laboratory Turnaround         |
|-----------------------------|-----------------------------|-------------------------------------------|---------------------------------------------|---------------------------------------|------------------------|-------------------------------|
| Investigation Derived Waste | Development/<br>Purge Water | 1 sample                                  | TCL Organics<br>TAL Total Metals<br>TSS/TDS | CLP/SOW<br>CLP/SOW<br>EPA 160.1/160.2 | IV<br>IV<br>IV         | Routine<br>Routine<br>Routine |
|                             | Soil                        | 1 sample                                  | TCLP<br>RCRA<br>TCL PCBs                    | SW 846<br>SW846<br>CLP/SOW            | IV<br>IV<br>IV         | Routine<br>Routine<br>Routine |

Notes:

<sup>(1)</sup> Baseline Number of samples does not include QA/QC.

<sup>(2)</sup> Target Compound List (TCL) Organics:  
VOAs - volatile organic analysis  
SVOAs - semivolatile organic analysis  
Pesticides/PCBs - Pesticides and polychlorinated biphenyls

<sup>(3)</sup> Target Analyte List (TAL) Metals:

|           |                    |           |                    |           |                    |
|-----------|--------------------|-----------|--------------------|-----------|--------------------|
| Aluminum  | EPA 3010/EPA 200.7 | Cobalt    | EPA 3010/EPA 200.7 | Potassium | EPA 3010/EPA 200.7 |
| Antimony  | EPA 3010/EPA 200.7 | Copper    | EPA 3010/EPA 200.7 | Selenium  | EPA 3020/EPA 270.2 |
| Arsenic   | EPA 3020/EPA 206   | Iron      | EPA 3010/EPA 200.7 | Silver    | EPA 3010/EPA 200.7 |
| Barium    | EPA 3010/EPA 200.7 | Lead      | EPA 3020/EPA 239   | Sodium    | EPA 3010/EPA 200.7 |
| Beryllium | EPA 3010/EPA 200.7 | Magnesium | EPA 3010/EPA 200.7 | Thallium  | EPA 3020/EPA 279   |
| Cadmium   | EPA 3010/EPA 200.7 | Manganese | EPA 3010/EPA 200.7 | Vanadium  | EPA 3010/EPA 200.7 |
| Calcium   | EPA 3010/EPA 200.7 | Mercury   | EPA 3010/EPA 245.1 | Zinc      | EPA 3010/EPA 200.7 |
| Chromium  | EPA 3010/EPA 200.7 | Nickel    | EPA 3010/EPA 200.7 |           |                    |

<sup>(4)</sup> Routine analytical turnaround is 28-days following receipt of samples.

ASTM - American Society for Texting and Materials

CLP - Contract Laboratory Program

EPA - United States Environmental Protection Agency

RCRA - Resource Conservation and Recovery Act (Corrosivity, Reactivity [reactive sulfide and cyanide], and Ignitability)

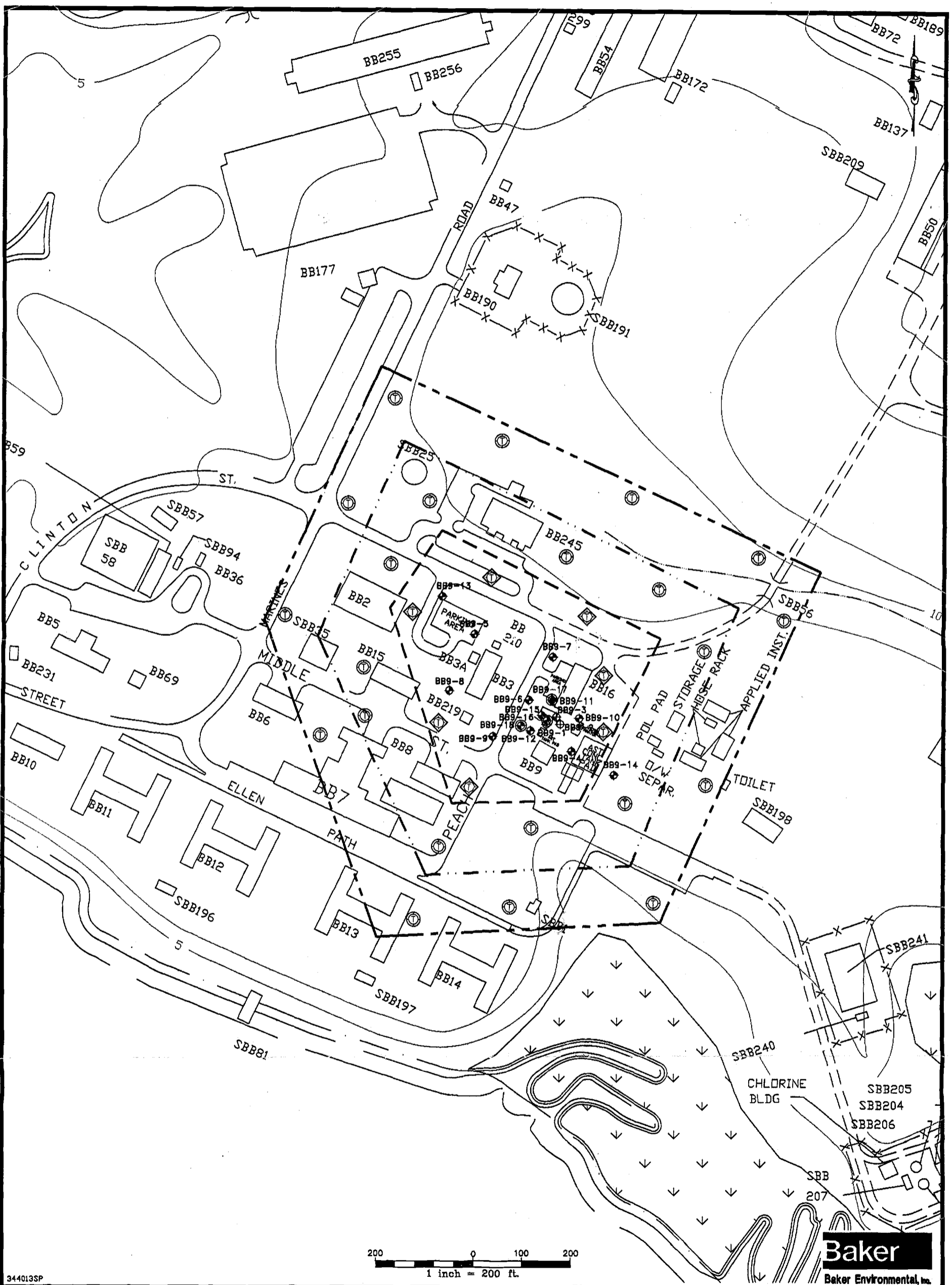
SOW - Statement of Work

TCLP - Toxicity Characteristic Leaching Procedure (analysis of volatile organics, semivolatile organics, pesticides, herbicides, and metals on a leachate)

TDS - Total Dissolved Solids

TOC - Total Organic Carbon

TSS - Total Suspended Solids



344013SP

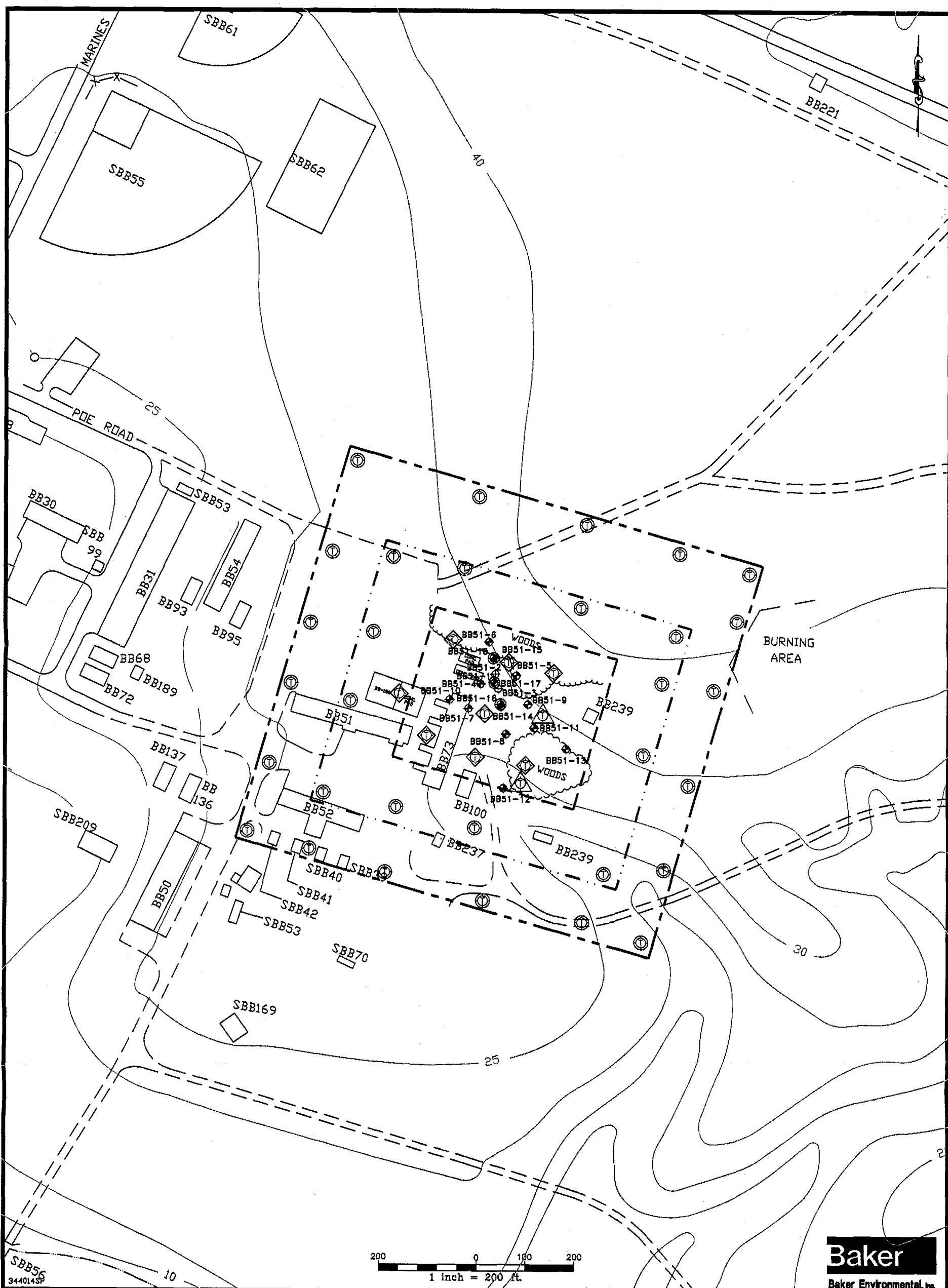
**LEGEND**

|  |                                          |
|--|------------------------------------------|
|  | EXISTING TYPE II MONITORING WELL         |
|  | PRE-EXISTING TYPE II MONITORING WELL     |
|  | EXISTING TYPE III MONITORING WELL        |
|  | PROPOSED TEMPORARY SHALLOW WELL          |
|  | EXPANDED PROPOSED TEMPORARY WELL         |
|  | INITIAL INVESTIGATION AREA BOUNDARY      |
|  | SUPPLEMENTAL INVESTIGATION AREA BOUNDARY |
|  | EXPANDED INVESTIGATION AREA BOUNDARY     |

SOURCE: LANTDIV, OCT. 1991

**FIGURE 4-1**  
**SITE 90 (BB9)**  
**EXISTING AND PROPOSED SOIL BORING/  
 MONITORING WELL SAMPLING LOCATIONS**  
 MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

00151014Z



**LEGEND**

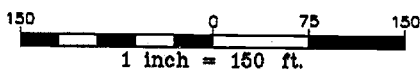
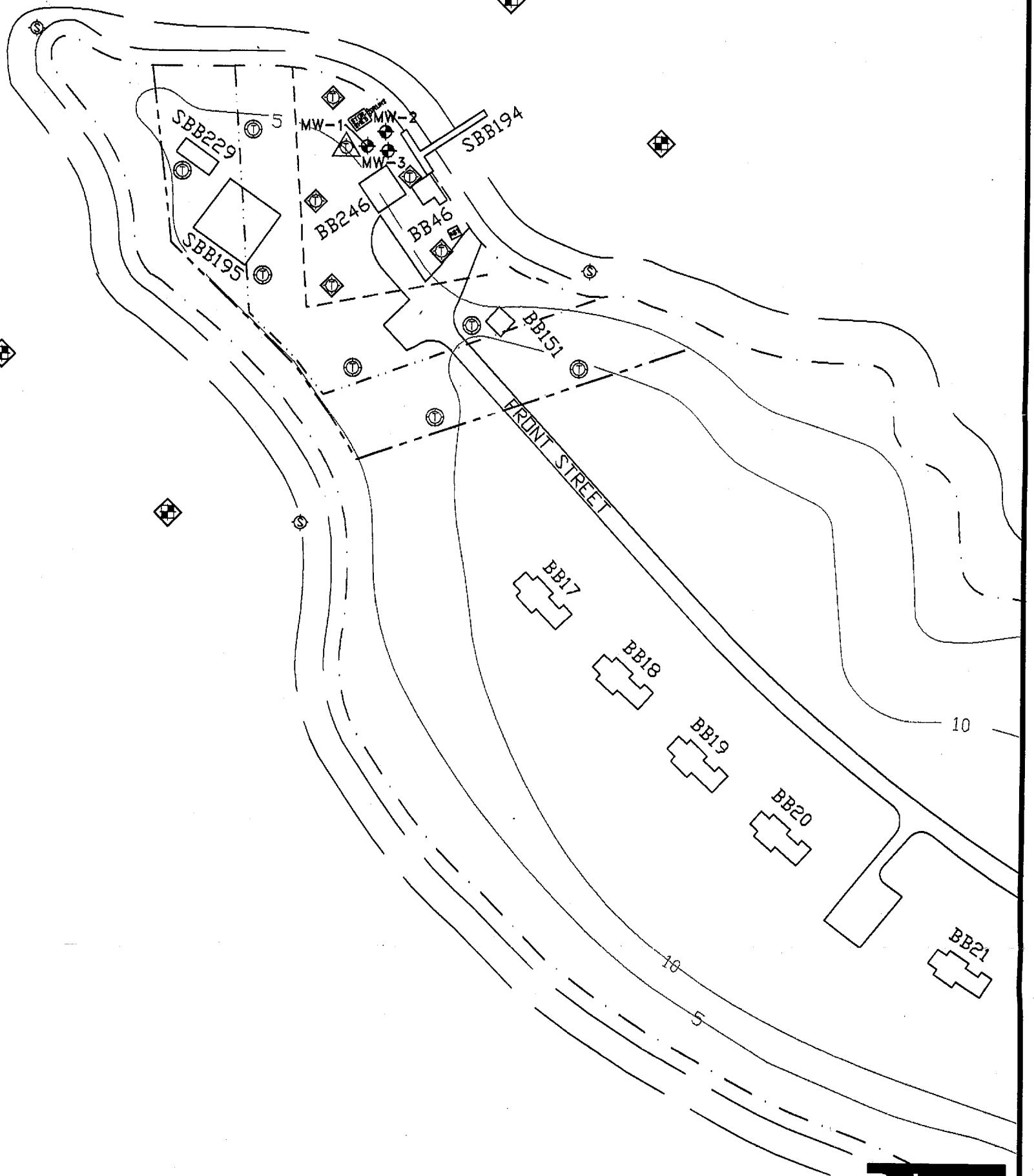
|  |                                                            |  |                                   |
|--|------------------------------------------------------------|--|-----------------------------------|
|  | EXISTING TYPE II MONITORING WELL                           |  | EXISTING TYPE III MONITORING WELL |
|  | PRE-EXISTING TYPE II MONITORING WELL                       |  |                                   |
|  | PROPOSED TEMPORARY SHALLOW WELL                            |  |                                   |
|  | EXPANDED PROPOSED TEMPORARY WELL                           |  |                                   |
|  | PROPOSED TEMPORARY WELL CLUSTER - SHALLOW AND INTERMEDIATE |  |                                   |
|  | INITIAL INVESTIGATION AREA BOUNDARY                        |  |                                   |
|  | SUPPLEMENTAL INVESTIGATION AREA BOUNDARY                   |  |                                   |
|  | EXPANDED INVESTIGATION AREA BOUNDARY                       |  |                                   |

SOURCE: LANTDIV, OCT. 1991

**FIGURE 4-2**  
**SITE 91 (BB-51)**  
**EXISTING AND PROPOSED SOIL BORING/  
 MONITORING WELL SAMPLING LOCATIONS**  
 MARINE CORPS BASE, CAMP LEJEUNE  
 NORTH CAROLINA

00151015Z

COURTHOUSE  
BAY



**Baker**  
Baker Environmental, Inc.

344012SP

**LEGEND**

- EXISTING MONITORING WELL
  - ◆ PROPOSED TEMPORARY SHALLOW WELL
  - ⊕ EXPANDED PROPOSED TEMPORARY WELL
  - ▲ PROPOSED TEMPORARY WELL CLUSTER - SHALLOW AND INTERMEDIATE
  - INITIAL INVESTIGATION AREA BOUNDARY
  - - - SUPPLEMENTAL INVESTIGATION AREA BOUNDARY
  - EXPANDED INVESTIGATION AREA BOUNDARY
  - ◆ PROPOSED SURFACE WATER/SEDIMENT SAMPLE
  - ⊙ STAFF GAUGE
- SOURCE: LANTDIV, OCT. 1991

FIGURE 4-3  
SITE 92 (BB-46)  
EXISTING AND PROPOSED SOIL BORING/  
MONITORING WELL SAMPLING LOCATIONS

MARINE CORPS BASE, CAMP LEJEUNE  
NORTH CAROLINA

001510162

**APPENDIX A**  
**SOIL SAMPLE ACQUISITION**

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## SOIL AND ROCK SAMPLE ACQUISITION

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**2.0 SCOPE**

**3.0 DEFINITIONS**

**4.0 RESPONSIBILITIES**

**5.0 PROCEDURES**

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  - 5.1.1 Split-Barrel (Split-Spoon) Samples
  - 5.1.2 Thin-Wall (shelby Tube) Sampling
  - 5.1.3 Bucket (Hand) Auger Sampling

5.2 Surface Soil Samples

5.3 Rock Cores

**6.0 QUALITY ASSURANCE RECORDS**

**7.0 REFERENCE**

**ATTACHMENTS**

- A ASTM D1586-84, Standard Method for Penetration Test and Split-Barrel Sampling of Soils
- B ASTM D1587-83, Standard Practice for Thin-Walled Tube Sampling of Soils
- C ASTM D2113-83 (1987), Standard Practice for Diamond Core Drilling for Site Investigation

## SOIL AND ROCK SAMPLE ACQUISITION

### 1.0 PURPOSE

The purpose of this procedure is to describe the handling of rock cores and subsurface soil samples collected during drilling operations. Surface soil sampling also is described.

### 2.0 SCOPE

The methods described in this SOP are applicable for the recovery of subsurface soil and rock samples acquired by coring operations or soil sampling techniques such as split-barrel sampling and thin-walled tube sampling. Procedures for the collection of surface soil samples also are discussed. This SOP does not discuss drilling techniques or well installation procedures. ASTM procedures for "Penetration Test and Split-Barrel Sampling of Soils," "Thin-Walled Tube Sampling of Soils," and "Diamond Core Drilling for Site Investigation" have been included as Attachments A through C, respectively.

### 3.0 DEFINITIONS

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

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into unconsolidated materials using a drive weight mounted on the drilling string. A standard split-spoon sampler (used for performing Standard Penetration Tests) is two inches O.D. and 1-3/8-inches inner diameter (I.D.). This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively.

Grab Sample - An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water, groundwater, wastewater, waste, contaminated surfaces, soil, and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time.

Composite Samples - A sample collected over time that typically consists of a series of discrete samples which are combined or "composited". Two types of composite samples are listed below:

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.
- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes and estuaries.

#### 4.0 RESPONSIBILITIES

**Project Manager** - The Project Manager is responsible for ensuring that, where applicable, project-specific plans are in accordance with these procedures, or that other approved procedures are developed. Furthermore, the Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

**Field Team Leader** - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.



Drilling Inspector – It is the responsibility of the drilling inspector to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The Drilling Inspector is responsible for the proper acquisition of rock cores and subsurface soil samples.

Sampling Personnel – It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of samples.

## 5.0 PROCEDURES

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

Surface soil samples serve to characterize the extent of surface contamination at various sites. These samples may be collected during initial site screening to determine gross contamination levels and levels of personal protection required as part of more intensive field sampling activities, to gather more detailed site data during design, or to determine the need for, or success of, cleanup actions.

Site construction activities may require that the engineering and physical properties of soil and rock be determined. Soil types, bearing strength, compressibility, permeability, plasticity, and moisture content are some of the geotechnical characteristics that may be determined by laboratory tests of soil samples. Rock quality, strength, stratigraphy, structure, etc. often are needed to design and construct deep foundations or remedial components.

## **5.1 Subsurface Soil Samples**

This section discusses three methods for collecting subsurface soil samples: (1) split-spoon sampling; (2) shelly tube sampling; and, (3) bucket auger sampling. All three methods yield samples suitable for laboratory analysis. Copies of the ASTM procedures for split-spoon sampling and shelly-tube sampling are provided in Attachments A and B, respectively.

### **5.1.1 Split-Barrel (Split-Spoon) Sampling**

The following procedures are to be used for split-spoon, geotechnical soil sampling:

1. Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation.
2. Side-discharge bits are permissible. A bottom-discharge bit should not be used. The process of jetting through the sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.
3. The two-inch O.D. split-barrel (not for geotech) sampler should be driven with blows from a 140-pound hammer falling 30 inches in accordance with ASTM D1586-84, Standard Penetration Test.
4. Repeat this operation at intervals not longer than 5 feet in homogeneous strata, or as specified in the Sampling and Analysis Plan.
5. Record on the Field Test Boring Record or field logbook the number of blows required to effect each six inches of penetration or fraction thereof. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance,  $N$ . If the sampler is driven less than 18 inches, the penetration resistance is that for the last one foot of penetration. (If less than one foot is penetrated, the

logs shall state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24 inches, the sum of second and third six-inch increments will be used to calculate the penetration resistance. (Refusal of the SPT will be noted as 50 blows over an interval equal to or less than 6 inches; the interval driven will be noted with the blow count.)

6. Bring the sampler to the surface and remove both ends and one half of the split-spoon such that the soil recovered rests in the remaining half of the barrel. Describe carefully the recovery (length), composition, structure, consistency, color, condition, etc. of the recovered soil according to SOP F101; then put into jars without ramming. Jars with samples not taken for chemical analysis should be tightly closed, to prevent evaporation of the soil moisture. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms (see SOP F302). Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area.

In addition to collecting soils for geotechnical purposes, split-spoon sampling can be employed to obtain samples for environmental analytical analysis. The following procedures are to be used for split-spoon, environmental soil sampling:

1. Follow sample collection procedures 1 through 6 as outlined in Section 5.2.1.
2. After sample collection, remove the soil from the split-spoon sampler. Prior to filling laboratory containers, the soil sample should be mixed thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. Soil samples for volatile organic compounds should not be mixed. Further, sample containers for volatile organic compounds analyses should be filled completely without head space remaining in the container to minimize volatilization.
3. Record all pertinent sampling information such as soil description, sample depth, sample number, sample location, and time of sample collection in the Field Test

Boring Record or field logbook. In addition, label, tag, and number the sample bottle(s).

4. Pack the samples for shipping (see SOP F300). Attach seal to the shipping package. Make sure that Chain-of-Custody Forms and Sample Request Forms are properly filled out and enclosed or attached (see SOP F301).
5. Decontaminate the split-spoon sample as described in SOP F501. Replace disposable latex gloves between sample stations to prevent cross-contaminating samples.

For obtaining composite soil samples (see Definitions), a slightly modified approach is employed. Each individual discrete soil sample from the desired sample interval will be placed into a stainless-steel, decontaminated bowl (or other appropriate container) prior to filling the laboratory sample containers. Special care should be taken to cover the bowl between samples with aluminum foil to minimize volatilization. Immediately after obtaining soils from the desired sampling interval, the sample to be analyzed for Volatile Organic Compounds (VOCs) should be collected. In the event that a composite sample is required, care should be taken to obtain a representative sampling of each sample interval. The remaining soils should be thoroughly mixed. Adequate mixing can be achieved by stirring in a circular fashion and occasionally turning the soils over. Once the remaining soils have been thoroughly combined, samples for analyses other than VOCs should be placed into the appropriate sampling containers.

#### **5.1.2 Thin-Wall (Shelby Tube) Sampling**

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

1. Clean out the hole to the sampling elevation, being careful to minimize the chance for disturbance or contamination of the material to be sampled.

2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.
3. The sampler must be of a stationary piston-type, to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.
4. With the sampling tube resting on the bottom of the hole and the water level in the boring at the natural groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed further than the length provided for the soil sample. Allow a free space in the tube for cuttings and sludge.
5. After pushing the tube, the sample should sit 5 to 15 minutes prior to removal. Immediately before removal, the sample must be sheared by rotating the rods with a pipe wrench a minimum of two revolutions.
6. Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil, from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape them into place and then dip the ends in wax to seal them.

7. Affix labels to the tubes and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and indicate the top of the sample. Complete chain-of-custody and other required forms (see SOP F302). Do not allow tubes to freeze, and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.
8. From soil removed from the ends of the tube, make a careful description using the methods presented in SOP F101.
9. When thin-wall tube samplers are used to collect soil for certain chemical analyses, it may be necessary to avoid using wax, newspaper, or other fillers. The SAP for each site should address specific materials allowed dependent on analytes being tested.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dension or Pitcher cores can be used in conjunction with the tube samplers to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and, therefore, their use should be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt should be made with a split-spoon sampler at the same depth so that at least one sample can be obtained for classification purposes.

### **5.1.3 Bucket (Hand) Auger Sampling**

Hand augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of

investigation using a hand auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required.

When a vertical sampling interval has been established, one auger bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a decontaminated bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole. The bucket auger should be decontaminated between samples as outlined in SOP F502.

In addition to hand augering, powered augers can be used to advance a boring for subsurface soil collection. However, this type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sample depth, at which point a hand auger is usually used to collect the sample.

## **5.2 Surface Soil Samples**

Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. For loosely packed surface soils, stainless steel (organic analyses) or plastic (inorganic analyses) scoops or trowels, can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

1. Use a soil auger for deep samples (greater than 12 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collecting the sample.
2. Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, chain-of-custody record, and other required forms.
3. Classify and record a description of the sample, as discussed in SOP F101. Descriptions for surface soil samples should be recorded in the field logbook; descriptions for soil samples collected with power or hand augers shall be recorded on a Field Test Boring Record.
4. Store the sampling utensil in a plastic bag until decontamination or disposal. Use a new or freshly-decontaminated sampling utensil for each sample taken.
5. Pack and ship as described in SOP F304.
6. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site or on a sketch in the field logbook.
7. When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles should be full) should be placed in a stainless steel bucket (or other appropriate container), mixed thoroughly using a decontaminated stainless steel spatula or trowel, and a composite sample collected. In some cases, as delineated in project-specific sampling and analysis plans, laboratory compositing of the samples may be more appropriate than field compositing. Samples to be analyzed for parameters sensitive to volatilization



should be composited and placed into the appropriate sample bottles immediately upon collection.

### 5.3 Rock Cores

Once rock coring has been completed and the core recovered, the rock core must be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery, as well as the rock quality designation (RQD) (see SOP F101). If split-barrels are used, the core may be measured and classified in the split barrel after opening and then transferred to a core box.

Each core shall be described and classified on a Field Test Boring Record using a uniform system as presented in SOP F101. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of hydrated formations) or oxidation of the core, the core must be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores must be placed in the sequence of recovery in wooden or plastic core boxes provided by the drilling contractor. Rock cores from different borings shall not be placed in the same core box. The core boxes should be constructed to accommodate 10 to 20 linear feet of core and should be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and the run number shall be marked on the wooden partitions with indelible ink. The order of placing cores shall be the same in all core boxes. The top of each core obtained should be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, any empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data pertaining to the box's contents. At a minimum, the following information must be included:

- Project name
- Date
- CTO number
- Boring number
- Footage (depths)
- Run number(s)
- Recovery
- Rock Quality Designation (RQD)
- Box number (x of x)

It is also useful to draw a large diagram of the core in the box, on the inside of the box top. This provides more room for elevations, run numbers, recoveries, comments, etc., than could be entered on the upper edges of partitions or spaces in the core box.

For easy retrieval when core boxes are stacked, the sides and ends of the box should also be labeled and include CTO number, boring number, top and bottom depths of core and box number.

Due to the weight of the core, a filled core box should always be handled by two people. Core boxes stored on site should be protected from the weather. The core boxes should be removed from the site in a careful manner as soon as possible. Exposure to extreme heat or cold should be avoided whenever possible. Arrangements should be made to dispose of or return the core samples to the client for completion of the project.

## 6.0 QUALITY ASSURANCE RECORDS

Where applicable, Field Test Boring Records and Test Boring Records will serve as the quality assurance records for subsurface soil samples, rock cores and near surface soil samples collected with a hand or power auger. Observations shall be recorded in the Field Logbook as described in SOP F303. Chain-of-Custody records shall be completed for samples collected for laboratory analysis as described in SOP F101 and SOP F302.

## 7.0 REFERENCES

1. American Society for Testing and Materials, 1987. Standard Method for Penetration Test and Split-Barrel Sampling of Soils. ASTM Method D1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.
2. American Society for Testing and Materials, 1987. Standard Practice for Thin-Walled Tube Sampling of Soils. Method D1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.
3. American Society for Testing and Materials, 1987. Standard Practice for Diamond Core Drilling for Site Investigation. Method D2113-83 (1987), Annual Book of Standards ASTM, Philadelphia, Pennsylvania.
4. U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

**ATTACHMENT A**

**ASTM D1586-84**

**STANDARD METHOD FOR PENETRATION TEST AND  
SPLIT-BARREL SAMPLING OF SOILS**



## Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils<sup>1</sup>

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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense. Consult the DOD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

<sup>1</sup>NOTE—Editorial changes were made throughout October 1992.

### 1. Scope

1.1 This test 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 does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to 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. Referenced Documents

#### 2.1 ASTM Standards:

D 2487 Test Method for Classification of Soils for Engineering Purposes<sup>2</sup>

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>2</sup>

D 4220 Practices for Preserving and Transporting Soil Samples<sup>2</sup>

D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems<sup>2</sup>

### 3. Terminology

#### 3.1 Descriptions of Terms Specific to This Standard

3.1.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.1.2 *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.

3.1.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *drive-weight assembly*—a device consisting of the

hammer, hammer fall guide, the anvil, and any hammer drop system.

3.1.5 *hammer*—that portion of the drive-weight assembly consisting of the  $140 \pm 2$  lb ( $63.5 \pm 1$  kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.1.6 *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.

3.1.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.1.8 *N-value*—the blowcount 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).

3.1.9  $\Delta N$ —the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.1.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by  $360^\circ$  (see Fig. 1).

3.1.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.1.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

### 4. Significance and Use

4.1 This test 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 test 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

<sup>1</sup> 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).

<sup>2</sup> Annual Book of ASTM Standards, Vol 04.08.

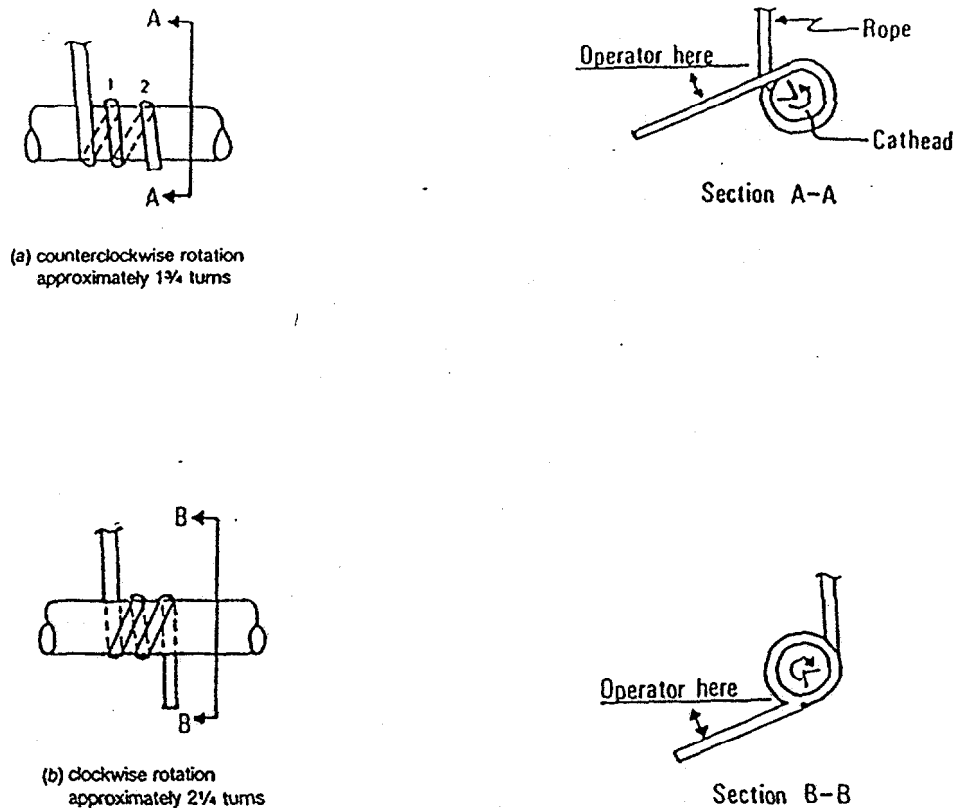


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

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 conjunction 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 1½ in. (41.2 mm) and an inside diameter of 1¼ 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 1½ 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.

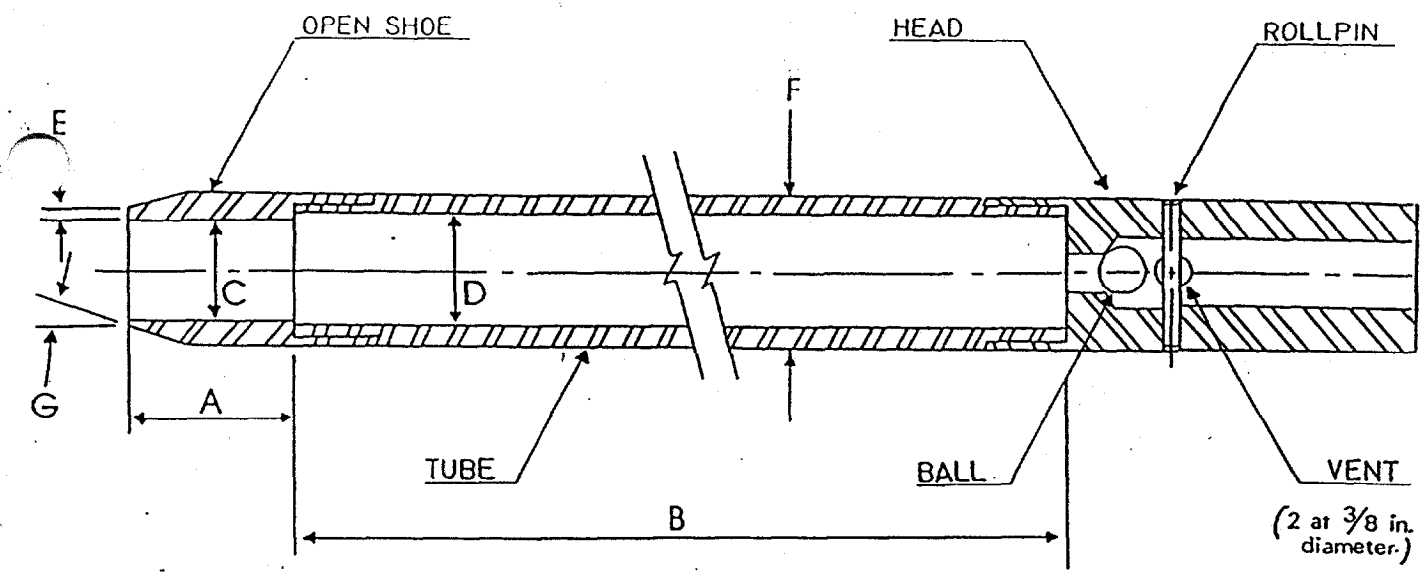
NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

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



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

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

FIG. 2 Split-Barrel Sampler

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 m) 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 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  $30 \pm 1.0$  in. ( $0.76 \text{ m} \pm 25 \text{ mm}$ ) 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  $2\frac{1}{4}$  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  $1\frac{1}{4}$  or  $2\frac{1}{4}$  rope turns, depending upon whether or not the rope comes off the top ( $1\frac{1}{4}$  turns) or the bottom ( $2\frac{1}{4}$  turns) of the cathead. It is generally known and accepted that  $2\frac{1}{4}$  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 its 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 rod 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 *Precision*—A valid estimate of test precision has not been determined because it is too costly to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development of a valid precision statement.

9.2 *Bias*—Because there is no reference material for this test method, there can be no bias statement.

9.3 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 %.

9.4 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.



9.5 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 given in Test Method D 4633.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; split-barrel sampling; standard penetration test

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*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.*

**ATTACHMENT B**

**ASTM D1587-83**

**STANDARD PRACTICE FOR THIN-WALLED TUBE SAMPLING OF SOILS**



## Standard Practice for Thin-Walled Tube Sampling of Soils<sup>1</sup>

This standard is issued under the fixed designation D 1587; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

This practice 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 practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of structural properties. Thin-walled tubes used in piston, plug, or rotary-type samplers, such as the Denison or Pitcher, must comply with the portions of this practice which describe the thin-walled tubes (5.3).

NOTE 1—This practice does not apply to liners used within the above samplers.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>2</sup>

D 3550 Practice for Ring-Lined Barrel Sampling of Soils<sup>2</sup>

D 4220 Practices for Preserving and Transporting Soil Samples<sup>2</sup>

### 3. Summary of Practice

3.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil, removing the soil-filled tube, and sealing the ends to prevent the soil from being disturbed or losing moisture.

### 4. Significance and Use

4.1 This practice, or Practice D 3550, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of structural properties or other tests that might be influenced by soil disturbance.

### 5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment may be used that provides a reasonably clean hole; that does not disturb the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

5.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For

hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

5.3 *Thin-Walled Tubes*, should be manufactured as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. and be made of metal having adequate strength for use in the soil and formation intended. Tubes shall be clean and free of all surface irregularities including projecting weld seams.

5.3.1 *Length of Tubes*—See Table 1 and 6.4.

5.3.2 *Tolerances*, shall be within the limits shown in Table 2.

5.3.3 *Inside Clearance Ratio*, should be 1 % or as specified by the engineer or geologist for the soil and formation to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled. See Fig. 1 for definition of inside clearance ratio.

5.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating. Tubes which will contain samples for more than 72 h shall be coated. The type of coating to be used may vary depending upon the material to be sampled. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, and others. Type of coating must be specified by the engineer or geologist if storage will exceed 72 h. Plating of the tubes or alternate base metals may be specified by the engineer or geologist.

5.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a suitable check valve and a venting area to the outside equal to or greater than the area through the check valve. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

### 6. Procedure

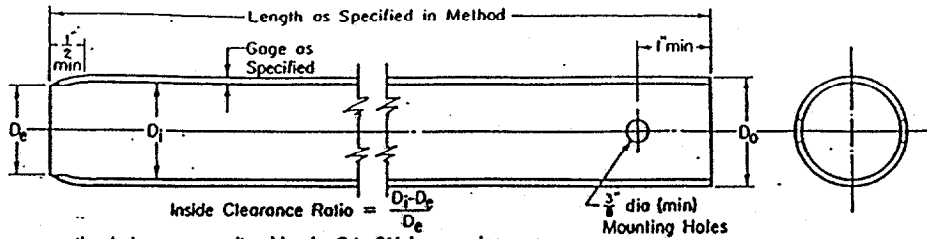
6.1 Clean out the borehole to sampling elevation using whatever method is preferred that will ensure the material to be sampled is not disturbed. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the sampling operation.

6.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted. Remove loose material from the center of a casing or hollow stem auger as carefully as

<sup>1</sup> This practice 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.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.08.



- NOTE 1—Minimum of two mounting holes on opposite sides for 2 to 3½ in. sampler.  
 NOTE 2—Minimum of four mounting holes spaced at 90° for samplers 4 in. and larger.  
 NOTE 3—Tube held with hardened screws.  
 NOTE 4—Two-inch outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for “undisturbed samples.” Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalents

| in. | mm    |
|-----|-------|
| ¾   | 6.77  |
| ½   | 12.7  |
| 1   | 25.4  |
| 2   | 50.8  |
| 3½  | 88.9  |
| 4   | 101.6 |

FIG. 1 Thin-Walled Tube for Sampling

TABLE 1 Suitable Thin-Walled Steel Sample Tubes<sup>A</sup>

| Outside diameter:  | 2     | 3     | 5     |
|--------------------|-------|-------|-------|
| in.                |       |       |       |
| mm                 | 50.8  | 76.2  | 127   |
| Wall thickness:    |       |       |       |
| Bwg                | 18    | 16    | 11    |
| in.                | 0.049 | 0.065 | 0.120 |
| mm                 | 1.24  | 1.65  | 3.05  |
| Tube length:       |       |       |       |
| in.                | 36    | 36    | 54    |
| .m                 | 0.91  | 0.91  | 1.45  |
| Clearance ratio, % | 1     | 1     | 1     |

<sup>A</sup> The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

| Size Outside Diameter | Nominal Tube Diameters from Table 1 <sup>A</sup> Tolerances, in. |                  |                  |
|-----------------------|------------------------------------------------------------------|------------------|------------------|
|                       | 2                                                                | 3                | 5                |
| Outside diameter      | +0.007<br>-0.000                                                 | +0.010<br>-0.000 | +0.015<br>-0.000 |
| Inside diameter       | +0.000<br>-0.007                                                 | +0.000<br>-0.010 | +0.000<br>-0.015 |
| Wall thickness        | ±0.007                                                           | ±0.010           | ±0.015           |
| Ovality               | 0.015                                                            | 0.020            | 0.030            |
| Straightness          | 0.030/ft                                                         | 0.030/ft         | 0.030/ft         |

<sup>A</sup> Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three tolerances; that is, O.D. and I.D., or O.D. and Wall, or I.D. and Wall.

possible to avoid disturbance of the material to be sampled.

NOTE 2—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

6.3 Place the sample tube so that its bottom rests on the bottom of the hole. Advance the sampler without rotation by continuous relatively rapid motion.

6.4 Determine the length of advance by the resistance and condition of the formation, but the length shall never exceed

5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays.

NOTE 3—Weight of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

6.5 When the formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. Other methods, as directed by the engineer or geologist, may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a “driven sample.”

6.6 In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. for sludge-end cuttings.

NOTE 4—The tube may be rotated to shear bottom of the sample after pressing is complete.

6.7 Withdraw the sampler from the formation as carefully as possible in order to minimize disturbance of the sample.

## 7. Preparation for Shipment

7.1 Upon removal of the tube, measure the length of sample in the tube. Remove the disturbed material in the upper end of the tube and measure the length again. Seal the upper end of the tube. Remove at least 1 in. of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube if so directed by the engineer or geologist.

NOTE 5—Field extrusion and packaging of extruded samples under the specific direction of a geotechnical engineer or geologist is permitted.

NOTE 6—Tubes sealed over the ends as opposed to those sealed with expanding packers should contain end padding in end voids in order to prevent drainage or movement of the sample within the tube.

7.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample. Assure that the

markings or labels are adequate to survive transportation and storage.

## 8 Report

8.1 The appropriate information is required as follows:

- 8.1.1 Name and location of the project,
- 8.1.2 Boring number and precise location on project,
- 8.1.3 Surface elevation or reference to a datum,
- 8.1.4 Date and time of boring—start and finish,
- 8.1.5 Depth to top of sample and number of sample,
- 8.1.6 Description of sampler: size, type of metal, type of coating,
- 8.1.7 Method of sampler insertion: push or drive,

8.1.8 Method of drilling, size of hole, casing, and drilling fluid used,

8.1.9 Depth to groundwater level: date and time measured,

8.1.10 Any possible current or tidal effect on water level,

8.1.11 Soil description in accordance with Practice D 2488,

8.1.12 Length of sampler advance, and

8.1.13 Recovery: length of sample obtained.

## 9. Precision and Bias

9.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

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**ATTACHMENT C**

**ASTM D2113-83 (1987)**

**STANDARD PRACTICE FOR DIAMOND CORE DRILLING FOR  
SITE INVESTIGATION**



## Standard Practice for Diamond Core Drilling for Site Investigation<sup>1</sup>

This standard is issued under the fixed designation D 2113; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice describes equipment and procedures for diamond core drilling to secure core samples of rock and some soils that are too hard to sample by soil-sampling methods. This method is described in the context of obtaining data for foundation design and geotechnical engineering purposes rather than for mineral and mining exploration.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils<sup>2</sup>
- D 1587 Practice for Thin-Walled Tube Sampling of Soils<sup>2</sup>
- D 3550 Practice for Ring-Lined Barrel Sampling of Soils<sup>2</sup>

### 3. Significance and Use

3.1 This practice is used to obtain core specimens of superior quality that reflect the in-situ conditions of the material and structure and which are suitable for standard physical-properties tests and structural-integrity determinations.

### 4. Apparatus

4.1 *Drilling Machine*, capable of providing rotation, feed, and retraction by hydraulic or mechanical means to the drill rods.

4.2 *Fluid Pump or Air Compressor*, capable of delivering sufficient volume and pressure for the diameter and depth of hole to be drilled.

4.3 *Core barrels*, as required:

4.3.1 *Single Tube Type, WG Design*, consisting of a hollow steel tube, with a head at one end threaded for drill rod, and a threaded connection for a reaming shell and core bit at the other end. A core lifter, or retainer located within the core bit is normal, but may be omitted at the discretion of the geologist or engineer.

4.3.2 *Double Tube, Swivel-Type, WG Design*—An assembly of two concentric steel tubes joined and supported at the upper end by means of a ball or roller-bearing swivel arranged to permit rotation of the outer tube without causing rotation of the inner tube. The upper end of the outer tube, or removable head, is threaded for drill rod. A threaded connection is provided on the lower end of the outer tube for

a reaming shell and core bit. A core lifter located within the core bit is normal but may be omitted at the discretion of the geologist or engineer.

4.3.3 *Double-Tube, Swivel-Type, WT Design*, is essentially the same as the double tube, swivel-type, WG design, except that the WT design has thinner tube walls, a reduced annular area between the tubes, and takes a larger core from the same diameter bore hole. The core lifter is located within the core bit.

4.3.4 *Double Tube, Swivel Type, WM Design*, is similar to the double tube, swivel-type, WG design, except that the inner tube is threaded at its lower end to receive a core lifter case that effectively extends the inner tube well into the core bit, thus minimizing exposure of the core to the drilling fluid. A core lifter is contained within the core lifter case on the inner tube.

4.3.5 *Double Tube Swivel-Type, Large-Diameter Design*, is similar to the double tube, swivel-type, WM design, with the addition of a ball valve, to control fluid flow, in all three available sizes and the addition of a sludge barrel, to catch heavy cuttings, on the two larger sizes. The large-diameter design double tube, swivel-type, core barrels are available in three core per hole sizes as follows: 2 $\frac{3}{4}$  in. (69.85 mm) by 3 $\frac{1}{2}$  in. (98.43 mm), 4 in. (101.6 mm) by 5 $\frac{1}{2}$  in. (139.7 mm), and 6 in. (152.4 mm) by 7 $\frac{1}{4}$  in. (196.85 mm). Their use is generally reserved for very detailed investigative work or where other methods do not yield adequate recovery.

4.3.6 *Double Tube, Swivel-Type, Retrievable Inner-Tube Method*, in which the core-laden inner-tube assembly is retrieved to the surface and an empty inner-tube assembly returned to the face of the borehole through the matching large-bore drill rods without need for withdrawal and replacement of the drill rods in the borehole. The inner-tube assembly consists of an inner tube with removable core lifter case and core lifter at one end and a removable inner-tube head, swivel bearing, suspension adjustment, and latching device with release mechanism on the opposite end. The inner-tube latching device locks into a complementary recess in the wall of the outer tube such that the outer tube may be rotated without causing rotation of the inner tube and such that the latch may be actuated and the inner-tube assembly transported by appropriate surface control. The outer tube is threaded for the matching, large-bore drill rod and internally configured to receive the inner-tube latching device at one end and threaded for a reaming shell and bit, or bit only, at the other end.

4.4 *Longitudinally Split Inner Tubes*—As opposed to conventional cylindrical inner tubes, allow inspection of, and access to, the core by simply removing one of the two halves. They are not standardized but are available for most core barrels including many of the retrievable inner-tube types.

<sup>1</sup> This practice 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.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.08.

**4.5 Core Bits**—Core bits shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide slugs, or strips, hard-faced with various hard surfacing materials or furnished in saw-tooth form, all as appropriate to the formation being cored and with concurrence of the geologist or engineer. Bit matrix material, crown shape, water-way type, location and number of water ways, diamond size and carat weight, and bit facing materials shall be for general purpose use unless otherwise approved by the geologist or engineer. Nominal size of some bits is shown in Table 1.

**NOTE 1**—Size designation (letter symbols) used throughout the text and in Tables 1, 2, and 3 are those standardized by the Diamond Core Drill Manufacturers' Assoc. (DCDMA). Inch dimensions in the tables have been rounded to the nearest hundredth of an inch.

**4.6 Reaming Shells**, shall be surface set with diamonds, impregnated with small diamond particles, inserted with tungsten carbide strips or slugs, hard faced with various types of hard surfacing materials, or furnished blank, all as appropriate to the formation being cored.

**4.7 Core Lifters**—Core lifters of the split-ring type, either plain or hard-faced, shall be furnished and maintained, along with core-lifter cases or inner-tube extensions or inner-tube shoes, in good condition. Basket or finger-type lifters, together with any necessary adapters, shall be on the job and available for use with each core barrel if so directed by the geologist or engineer.

**4.8 Casings:**

**4.8.1 Drive Pipe or Drive Casing**, shall be standard weight (schedule 40), extra-heavy (schedule 80), double extra-heavy (schedule 160) pipe or W-design flush-joint casing as re-

quired by the nature of the overburden or the placement method. Drive pipe or W-design casing shall be of sufficient diameter to pass the largest core barrel to be used, and it shall be driven to bed rock or to firm seating at an elevation below water-sensitive formation. A hardened drive shoe is to be used as a cutting edge and thread protection device on the bottom of the drive pipe or casing. The drive shoe inside diameter shall be large enough to pass the tools intended for use, and the shoe and pipe or casing shall be free from burrs or obstructions.

**4.8.2 Casing**—When necessary to case through formations already penetrated by the borehole or when no drive casing has been set, auxiliary casing shall be provided to fit inside the borehole to allow use of the next smaller core barrel. Standard sizes of telescoping casing are shown in Table 2. Casing bits have an obstruction in their interior and will not pass the next smaller casing size. Use a casing shoe if additional telescoping is anticipated.

**4.8.3 Casing Liner**—Plastic pipe or sheet-metal pipe may be used to line an existing large-diameter casing. Liners, so used, should not be driven, and care should be taken to maintain true alignment throughout the length of the liner.

**4.8.4 Hollow Stem Auger**—Hollow stem auger may be used as casing for coring.

**4.9 Drill Rods:**

**4.9.1 Drill Rods of Tubular Steel Construction** are normally used to transmit feed, rotation, and retraction forces from the drilling machine to the core barrel. Drill-rod sizes that are presently standardized are shown in Table 3.

**4.9.2 Large bore drill rods** used with retrievable inner-tube core barrels are not standardized. Drill rods used with retrievable inner-tube core barrels should be those manufactured by the core-barrel manufacturer specifically for the core barrel.

**4.9.3 Composite Drill Rods** are specifically constructed from two or more materials intended to provide specific properties such as light weight or electrical nonconductivity.

**4.9.4 Nonmagnetic Drill Rods** are manufactured of nonferrous materials such as aluminum or brass and are used primarily for hole survey work. Some nonmagnetic rods have left-hand threads in order to further their value in survey work. No standard exists for nonmagnetic rods.

**4.10 Auxiliary Equipment**, shall be furnished as required by the work and shall include: roller rock bits, drag bits, chopping bits, boulder busters, fishtail bits, pipe wrenches, core barrel wrenches, lubrication equipment, core boxes, and marking devices. Other recommended equipment includes:

TABLE 1 Core Bit Sizes

| Size Designation | Outside Diameter |       | Inside Diameter |       |
|------------------|------------------|-------|-----------------|-------|
|                  | in.              | mm    | in.             | mm    |
| RWT              | 1.10             | 29.5  | 0.375           | 18.7  |
| EWT              | 1.47             | 37.3  | 0.905           | 22.9  |
| EWG, EWM         | 1.47             | 37.3  | 0.845           | 21.4  |
| AWT              | 1.88             | 47.8  | 1.281           | 32.5  |
| AWG, AWM         | 1.88             | 47.8  | 1.185           | 30.0  |
| BWT              | 2.35             | 59.5  | 1.750           | 44.6  |
| BWG, BWM         | 2.35             | 59.5  | 1.655           | 42.0  |
| NWT              | 2.97             | 75.3  | 2.313           | 58.7  |
| NWG, NWM         | 2.97             | 75.3  | 2.155           | 54.7  |
| 2 1/4 x 3/4      | 3.84             | 97.5  | 2.69            | 68.3  |
| HWT              | 3.89             | 98.8  | 3.187           | 80.9  |
| HWG, ...         | 3.89             | 98.8  | 3.000           | 76.2  |
| 4 x 5/8          | 5.44             | 138.0 | 3.97            | 100.8 |
| 6 x 7/8          | 7.66             | 194.4 | 5.97            | 151.6 |

TABLE 2 Casing Sizes

| Size Designation | Outside Diameter |       | Inside Diameter |       | Threads per in. | WM FR Hole Drilled with Core Bit Size |
|------------------|------------------|-------|-----------------|-------|-----------------|---------------------------------------|
|                  | in.              | mm    | in.             | mm    |                 |                                       |
| RW               | 1.144            | 36.5  | 1.19            | 30.1  | 5               | EW, EWT, EWG, EWM                     |
| EW               | 1.81             | 46.0  | 1.50            | 38.1  | 4               | AWT, AWG, AWM                         |
| AW               | 2.25             | 57.1  | 1.91            | 48.4  | 4               | BWT, BWG, BWM                         |
| BW               | 2.88             | 73.0  | 2.38            | 60.3  | 4               | NWT, NWG, NWM                         |
| NW               | 3.50             | 88.9  | 3.00            | 76.2  | 4               | HWT, HWG                              |
| HW               | 4.50             | 114.3 | 4.00            | 101.6 | 4               | 4 x 5/8                               |
| PW               | 5.50             | 139.7 | 5.00            | 127.0 | 3               | 6 x 7/8                               |
| SW               | 6.63             | 168.2 | 6.00            | 152.4 | 3               | 6 x 7/8                               |
| UW               | 7.63             | 193.6 | 7.00            | 177.8 | 2               | ...                                   |
| ZW               | 8.83             | 219.0 | 8.00            | 203.2 | 2               | ...                                   |



TABLE 3 Drill Rods

| Size Designation | Rod and Coupling Outside Diameter |      | Rod Inside Diameter |      | Coupling Bore, Threads |      |         |
|------------------|-----------------------------------|------|---------------------|------|------------------------|------|---------|
|                  | in.                               | mm   | in.                 | mm   | in.                    | mm   | per in. |
| RW               | 1.09                              | 27.7 | 0.72                | 18.2 | 0.41                   | 10.3 | 4       |
| EW               | 1.38                              | 34.9 | 1.00                | 25.4 | 0.44                   | 11.1 | 3       |
| AW               | 1.72                              | 43.6 | 1.34                | 34.1 | 0.63                   | 15.8 | 3       |
| BW               | 2.13                              | 53.9 | 1.75                | 44.4 | 0.75                   | 19.0 | 3       |
| NW               | 2.63                              | 66.6 | 2.25                | 57.1 | 1.38                   | 34.9 | 3       |
| HW               | 3.50                              | 88.9 | 3.06                | 77.7 | 2.38                   | 60.3 | 3       |

core splitter, rod wicking, pump-out tools or extruders, and hand sieve or strainer.

## 5. Transportation and Storage of Core Containers

5.1 *Core Boxes*, shall be constructed of wood or other durable material for the protection and storage of cores while enroute from the drill site to the laboratory or other processing point. All core boxes shall be provided with longitudinal separators and recovered cores shall be laid out as a book would read, from left to right and top to bottom, within the longitudinal separators. Spacer blocks or plugs shall be marked and inserted into the core column within the separators to indicate the beginning of each coring run. The beginning point of storage in each core box is the upper left-hand corner. The upper left-hand corner of a hinged core box is the left corner when the hinge is on the far side of the box and the box is right-side up. All hinged core boxes must be permanently marked on the outside to indicate the top and the bottom. All other core boxes must be permanently marked on the outside to indicate the top and the bottom and additionally, must be permanently marked internally to indicate the upper-left corner of the bottom with the letters UL or a splotch of red paint not less than 1 in.<sup>2</sup> Lid or cover fitting(s) for core boxes must be of such quality as to ensure against mix up of the core in the event of impact or upsetting of the core box during transportation.

5.2 Transportation of cores from the drill site to the laboratory or other processing point shall be in durable core boxes so padded or suspended as to be isolated from shock or impact transmitted to the transporter by rough terrain or careless operation.

5.3 Storage of cores, after initial testing or inspection at the laboratory or other processing point, may be in cardboard or similar less costly boxes provided all layout and marking requirements as specified in 5.1 are followed. Additional spacer blocks or plugs shall be added if necessary at time of storage to explain missing core. Cores shall be stored for a period of time specified by the engineer but should not normally be discarded prior to completion of the project for which they were taken.

## 6. Procedure

6.1 Use core-drilling procedures when formations are encountered that are too hard to be sampled by soil-sampling methods. A 1-in. (25.4-mm) or less penetration for 50 blows in accordance with Method D 1586 or other criteria established by the geologist or engineer, shall indicate that soil-sampling methods are not applicable.

6.1.1 Seat the casing on bedrock or in a firm formation to prevent raveling of the borehole and to prevent loss of

drilling fluid. Level the surface of the rock or hard formation at the bottom of the casing when necessary, using the appropriate bits. Casing may be omitted if the borehole will stand open without the casing.

6.1.2 Begin the core drilling using an N-size double-tube swivel-type core barrel or other size or type approved by the engineer. Continue core drilling until core blockage occurs or until the net length of the core barrel has been drilled in. Remove the core barrel from the hole and disassemble it as necessary to remove the core. Reassemble the core barrel and return it to the hole. Resume coring.

6.1.3 Place the recovered core in the core box with the upper (surface) end of the core at the upper-left corner of the core box as described in 5.1. Continue boxing core with appropriate markings, spacers, and blocks as described in 5.1. Wrap soft or friable cores or those which change materially upon drying in plastic film or seal in wax, or both, when such treatment is required by the engineer. Use spacer blocks or slugs properly marked to indicate any noticeable gap in recovered core which might indicate a change or void in the formation. Fit fracture, bedded, or jointed pieces of core together as they naturally occurred.

6.1.4 Stop the core drilling when soft materials are encountered that produce less than 50 % recovery. If necessary, secure samples of soft materials in accordance with the procedures described in Method D 1586, Practice D 1587, or Practice D 3550, or by any other method acceptable to the geologist or engineer. Resume diamond core drilling when refusal materials as described in 6.1 are again encountered.

6.2 Subsurface structure, including the dip of strata, the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described. Take special care to obtain and record information about these features. If conditions prevent the continued advance of the core drilling, the hole should be cemented and redrilled, or reamed and cased, or cased and advanced with the next smaller-size core barrel, as required by the geologist or engineer.

6.3 Drilling mud or grouting techniques must be approved by the geologist or engineer prior to their use in the borehole.

### 6.4 Compatibility of Equipment:

6.4.1 Whenever possible, core barrels and drill rods should be selected from the same letter-size designation to ensure maximum efficiency. See Tables 1 and 3.

6.4.2 Never use a combination of pump, drill rod, and core barrel that yields a clear-water up-hole velocity of less than 120 ft/min.

6.4.3 Never use a combination of air compressor, drill rod, and core barrel that yields a clear-air up-hole velocity of less than 3000 ft/min.

## 7. Boring Log

7.1 The boring log shall include the following:

7.1.1 Project identification, boring number, location, date boring began, date boring completed, and driller's name.

7.1.2 Elevation of the ground surface.

7.1.3 Elevation of or depth to ground water and raising or lowering of level including the dates and the times measured.

7.1.4 Elevations or depths at which drilling fluid return was lost.

7.1.5 Size, type, and design of core barrel used. Size, type, and set of core bit and reaming shell used. Size, type, and length of all casing used. Description of any movements of the casing.

7.1.6 Length of each core run and the length or percentage, or both, of the core recovered.

7.1.7 Geologist's or engineer's description of the formation recovered in each run.

7.1.8 Driller's description, if no engineer or geologist is present, of the formation recovered in each run.

7.1.9 Subsurface structure description, including dip of strata and jointing, cavities, fissures, and any other observations made by the geologist or engineer that could yield information regarding the formation.

7.1.10 Depth, thickness, and apparent nature of the filling of each cavity or soft seam encountered, including opinions gained from the feel or appearance of the inside of the inner tube when core is lost. Record opinions as such.

7.1.11 Any change in the character of the drilling fluid or drilling fluid return.

7.1.12 Tidal and current information when the borehole is sufficiently close to a body of water to be affected.

7.1.13 Drilling time in minutes per foot and bit pressure in pound-force per square inch gage when applicable.

7.1.14 Notations of character of drilling, that is, soft, slow, easy, smooth, etc.

## 8. Precision and Bias

8.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

NOTE 2—Inclusion of the following tables and use of letter symbols in the foregoing text is not intended to limit the practice to use of DCDMA tools. The table and text references are included as a convenience to the user since the vast majority of tools in use do meet DCDMA dimensional standards. Similar equipment of approximately equal size on the metric standard system is acceptable unless otherwise stipulated by the engineer or geologist.

*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 B**  
**JUSTIFICATION CRITERIA FOR USE OF PVC WELL CASING**  
**AND SCREEN MATERIAL**

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The following is USEPA Region IV minimum seven point information requirements to justify the use of PVC as an alternate casing material for groundwater monitoring wells. If requested, justification of the use of PVC should be developed by addressing each of the following items:

**1. The DQOs for the groundwater samples to be collected.**

Level IV DQOs will be used for analyses of groundwater samples collected during this project. Analytical parameters have been selected to characterize the presence or absence of contamination and to assess any associated risks to human health or the environment.

**2. The organic compound concerns.**

There are two primary concerns regarding sample bias associated with use of PVC well casing under these conditions. One is that organic contaminants will leach from the PVC well casing. The other is that organic contaminants that may be present in the groundwater would adsorb onto the PVC. Either of these could result in biased analytical results.

**3. The anticipated residence time of the sample in the well and the aquifer's productivity.**

It is important to note that all stagnant water from inside the well casing is purged immediately before sample collection. The time required to do this is expected to be much less than that required for groundwater sampling bias phenomena (adsorbing/leaching) to develop.

Samples collected immediately after purging (i.e., "fresh" from the aquifer).

Aquifer productivity: Subsurface soil samples are mostly fine sand.

The wells should recharge (enough to sample) before any sorbing/leaching of organics can occur.

**4. The reasons for not using other casing materials.**

Costs associated with use of stainless steel and teflon casing materials are prohibitive. PVC strength will be sufficient for this investigation. Existing groundwater quality data indicate that leaching/sorbing of organic materials from/onto the PVC will not be extensive enough to bias future groundwater analysis. PVC is lighter and more flexible than stainless steel.

**5. Literature on the adsorption characteristics of the compounds and elements of interest.**

The following was originally presented in National Water Well Association (NWWA, 1989):

Miller (1982) conducted a study to determine if PVC exhibited any tendency to sorb potential contaminants from solution. Trichloroethene and 1,1,2-trichloroethane did not sorb to PVC. Reynolds and Gillham (1985) found that 1,1,2,2-tetrachloroethane could sorb to PVC. The sorption was slow enough that groundwater sampling bias would not be significant if well development (purging the well of stagnant water) and sampling were to take place in the same day. No data was available for the other organic compounds listed in Item #2.

6. **Whether the wall thickness of the PVC casing would require a larger annular space when compared to other well construction materials.**

It will not. The borehole will be of sufficient diameter for installation of the 2" PVC casing and screen.

7. **The type of PVC to be used and, if available, the manufacturers specifications, and an assurance that the PVC to be used does not leach, mask, react or otherwise interfere with the contaminants being monitored within the limits of the DQOs.**

Baker will request the appropriate manufacturers specifications and assurances regarding this requirement. This material will be supplied to Baker by the drilling subcontractor.

References for Appendix B:

National Water Well Association, 1989, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, Dublin, Ohio, 398 pp.

Miller, G.D., 1982, Uptake of lead, chromium and trace level volatile organics exposed to synthetic well casings. Proceedings of the Second National Symposium on Aquifer Restoration and Ground-Water Monitoring, National Water Well Association, Dublin, Ohio, pp. 236-245.

Reynolds, G.W. and Robert W. Gillham, 1985, Absorption of halogenated organic compounds by polymer materials commonly used in ground-water monitors. Proceedings of the Second Canadian/American Conference on Hydrogeology, National Water Well Association, Dublin, Ohio, pp. 125-132.

**APPENDIX C**  
**GROUNDWATER SAMPLE ACQUISITION**

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**GROUNDWATER SAMPLE ACQUISITION  
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## **GROUNDWATER SAMPLE ACQUISITION**

### **1.0 PURPOSE**

The purpose of this guideline 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 guideline 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 should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

### **3.0 DEFINITIONS**

None.

### **4.0 RESPONSIBILITIES**

**Project Manager** - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

**Field Team Leader** - The Field Team Leader is responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

**Sampling Personnel** - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and the Project Manager. The sampling personnel are responsible for the proper acquisition of groundwater samples.

### **5.0 PROCEDURES**

To be useful and accurate, a groundwater sample must be representative of the particular zone 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 minimize any changes in water quality parameters.

The groundwater sampling program should be developed with reference to ASTM D4448-85A, Standard Guide for Sampling Groundwater Monitoring Wells (Attachment A). This reference is not intended as a monitoring plan or procedure for a specific application, but rather is a review of methods. Specific methods shall be stated in the Sampling and Analysis Plan (SAP).

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 largely isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

1. All monitoring wells shall be pumped or bailed prior to withdrawing a sample. Evacuation of three to five volumes is recommended for a representative sample.
2. Wells that can be pumped or bailed to dryness with the sampling equipment being used, shall be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of at least three well volumes of water is preferred; otherwise, a sample will be taken when enough water is available to fill the sample containers.

Stratification of contaminants may exist in the aquifer formation. This is from concentration gradients due to dispersion and diffusion processes in a homogeneous layer, and from separation of flow streams by physical division (for example, around clay lenses) or by contrasts in permeability (for example, between a layer of silty, fine sand and a layer of medium sand).

Purging rates and volumes for non-production wells during sampling development should be moderate; pumping rates for production wells should be maintained at the rate normal for that well. 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, thus result in the collection of a non-representative sample. Water produced during purging shall be collected, stored or treated and discharged as allowed. Disposition of purge water is usually site-specific and must be addressed in the Sampling and Analysis Plan.

### **5.1 Sampling, Monitoring, and Evacuation Equipment**

Sample containers shall conform with EPA regulations for the appropriate contaminants and to the specific Quality Assurance Project Plan.

The following list is an example of the type of equipment that generally must be on hand when sampling groundwater wells:

1. Sample packaging and shipping equipment: Coolers for sample shipping and cooling, chemical preservatives, and appropriate packing cartons and filler, labels and chain-of-custody documents.
2. Field tools and instrumentation: PID; Thermometer; pH meter; specific conductivity meter; appropriate keys (for locked wells) or bolt-cutter; tape measure; plastic sheeting; water-level indicator; calibrated buckets and, where applicable, flow meter.
3. Pumps
  - a. Shallow-well pumps: Centrifugal, Packer Pumps, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing), as applicable.
  - b. Deep-well pumps: Submersible pump and electrical power generating unit, bladder pump with compressed air source, or air-lift apparatus, as applicable.
4. Tubing: Sample tubing such as teflon, polyethylene, polypropylene, or PVC. Tubing type shall be selected based on specific site requirements and must be chemically inert to the groundwater being sampled.
5. Other Sampling Equipment: Bailers, Packer Pumps, teflon-coated wire, stainless steel single strand wire, and polypropylene monofilament line (not acceptable in EPA Region I) with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.
6. Pails: Plastic, graduated.
7. Decontamination equipment and materials: discussed in SOP F501 and F502.

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

## 5.2 Calculations of Well Volume for Purging

The volume of the cylinder of water in a well is given by:

Where:  $V$  = volume of standing water in well (in cubic feet)

r=well radius (in feet)  
h=standing water in well (in feet)

To insure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well pipe or casing. The volume can be easily calculated by the following method. Calculations shall be entered in the field logbook:

1. Obtain all available information on well construction (location, casing, screens, etc.).
2. Determine well or casing diameter (D).
3. Measure and record static water level (DW-depth to water below ground level or top of casing reference point), using one of the methods described in Section 5.1 of SOP F202.
4. Determine the depth of the well (TD) to the nearest 0.01-foot by sounding using a clean, decontaminated weighted tape measure, referenced to the top of PVC casing or ground surface.
5. Calculate number of linear feet of static water (total well depth minus the depth to static water level).
6. Calculate the volume of water in the casing:

$$V_{gal} = V_w \times 7.48 \text{ gallons/ft}^3$$

$$V_{purge} = V_{gal} (\# \text{ Well Vol})$$

Where:

$V_w$  = Volume of water standing in well in cubic feet (i.e., one well volume)  
 $\pi$  = pi, 3.14  
 $r$  = Well radius in feet  
 $TD$  = Total depth of well in feet (below ground surface or top of casing)  
 $DW$  = Depth to water in feet (below ground surface or top of casing)  
 $V_{gal}$  = Volume of water in well in gallons  
 $V_{purge}$  = Volume of water to be purged from well in gallons  
 $\# \text{ Well Vol.}$  = Number of well volumes of water to be purged from the well (typically three to five)

7. Determine the minimum number of gallons to be evacuated before sampling. (Note:  $V_{\text{purge}}$  should be rounded to the next highest whole gallon. For example, 7.2 gallons should be rounded to 8 gallons.)

Table 5-1 lists gallons and cubic feet of water per standing foot of water for a variety of well diameters.

**TABLE 5-1  
WELL VOLUMES**

| Diameter of Casing or Hole (in.) | Gallons per Foot of Depth | Cubic Feet per Foot of Depth |
|----------------------------------|---------------------------|------------------------------|
| 1                                | 0.041                     | 0.0055                       |
| 2                                | 0.163                     | 0.0218                       |
| 4                                | 0.653                     | 0.0873                       |
| 6                                | 1.469                     | 0.1963                       |
| 8                                | 2.611                     | 0.3491                       |
| 10                               | 4.080                     | 0.5454                       |

### **5.3 Evacuation of Static Water (Purging)**

The amount of purging a well should 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.

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 a wide area. Generally, three to five well volumes are considered effective for purging a well.

An alternative method of purging a well, and one accepted in EPA Regions I and IV, is to purge a well continuously (usually using a low volume, low flow pump) while monitoring specific conductance, pH, and water temperature until the values stabilize. The well is considered properly purged when the values have stabilized.

If a well is dewatered before the required volume is purged, the sample should be collected from the well once as a sufficient volume of water has entered the well. In order to avoid stagnation, the well should not be allowed to fully recharge before the sample is collected. The field parameters (pH, conductance, and temperature) should be recorded when the well was dewatered.

The Project Manager shall define the objectives of the groundwater sampling program in the Sampling and Analysis Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

### 5.3.1 Evacuation Devices

The following discussion is limited to those devices which are commonly used at hazardous waste sites. Note that all of these techniques involve equipment which is portable and readily available.

Bailers - Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line (e.g., Teflon-coated) 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.
- Inexpensive.
- Minimal outgassing of volatile organics while the sample is in the bailer.
- Relatively easy to decontaminate and use.

Limitations on the use of bailers include the following:

- Limited volume of sample.
- Time consuming to remove stagnant water using a bailer.
- Collection and transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.
- Unable to collect depth-discrete sample.

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 (generally 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 10 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps will cause significant loss of dissolved gases, including volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

Gas-Lift Samples - 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 pumps 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. An inert gas such as nitrogen is generally used as a gas source.

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 air 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 two-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- Potentially 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.

#### 5.4 Sampling

The sampling approach consisting of the following, should be developed as part of the Sampling and Analysis Plan prior to the field work:

1. Background and objectives of sampling.
2. Brief description of area and waste characterization.
3. Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
4. Sampling equipment to be used.
5. 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 should be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

6. Sample preservation requirements.
7. Schedule.
8. List of team members.
9. Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

#### **5.4.1 Sampling Methods**

The collection of a groundwater sample includes the following steps:

1. 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. This task is usually performed by the Field Team Leader, Health and Safety Officer, or other designee.
2. When proper respiratory protection has been donned, measure the total depth and water level (with decontaminated equipment) and record these data in the field logbook. Calculate the fluid volume in the well according to Section 5.2 of this SOP.
3. Lower purging equipment or intake into the well to a distance just below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (e.g., DOT-approved 55-gallon drum).
4. Measure the rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters. Record the method of discharge measurement.
5. Observe peristaltic pump intake for degassing "bubbles" and all pump discharge lines. If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. The preferred method for collecting volatile organic samples and the accepted method by EPA Regions I through IV is with a bailer.
6. Purge a minimum of three to five well volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recharge as necessary, but preferably to 70 percent of the static water level, and then sample.

7. Record measurements of specific conductance, temperature, and pH during purging to ensure that the groundwater level has stabilized. Generally, these measurements are made after the removal of three, four, and five well volumes.
8. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling (this requires use of other than a "bucket-type" bailer). Purged water should be collected in a designated container and disposed of in an acceptable manner.
9. (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 should always be tested in a casing section above ground to determine proper inflation pressures for good sealing.
10. In the event that groundwater recovery time is very slow (e.g., 24 hours), sample collection can be delayed until the following day. However, it is preferred that such a well be bailed early in the morning so that sufficient volume of 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.
11. Add preservative if required (see SOP F301). Label, tag, and number the sample bottle(s).
12. Volatile organics septum vials (40 ml) should be completely filled to prevent volatilization and extreme caution should be exercised when filling a vial to avoid turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure. If the second attempt still produces air bubbles, note on Chain-of-Custody form and in field notebook and submit sample to the laboratory.  
  
Fill the remaining sample containers in order of decreasing volatility (semi-volatiles next, then pesticides, PCBs, inorganics, etc.).
13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.



14. Pack the samples for shipping (see SOP F301). Attach custody seals to the shipping container. Make sure that Chain-of-Custody forms and Sample Analysis Request forms are properly filled out and enclosed or attached (see SOP F302).
15. Decontaminate all equipment.

#### **5.4.2 Sample Containers**

For most samples and analytical parameters, either glass or plastic containers are satisfactory. SOP F301 describes the required sampling containers for various analytes at various concentrations. Container requirements shall follow those given in NEESA 20.2 047B.

#### **5.4.3 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. SOP F301 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Sample volume and preservation requirements shall follow those given in NEESA 20.2-047B.

#### **5.4.4 Field Filtration**

In general, preparation and preservation of water samples for dissolved inorganics involve some form of filtration. All filtration must occur in the field immediately upon collection. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) utilizing the pressure provided by the upstream pumping device for its operation.

In Region I, all inorganics are to be collected and preserved in the filtered form, including metals. In Region II, metals samples are to be analyzed as "total metals" and preserved unfiltered. In Regions III and IV, samples collected for metals analysis are also to be unfiltered. However, if metals analysis of groundwater is required, then both an unfiltered and filtered sample are to be collected, regardless of regulatory requirements. Filtration and preservation are to occur immediately in the field with the sample aliquot passing through a 0.45 micron filter. Samples for organic analyses shall never be filtered. Filters must be prerinsed with organic-free, deionized water.

#### **5.4.5 Handling and Transporting Samples**

After collection, samples should 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 should be double-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 should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be

secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SOP F301.

#### 5.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in NEESA 20.2-047B.

### 6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the Field Logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method; volume of water purged prior to sampling; number of well volumes purged).
- Sample disposition (preservatives added; lab sent to; date and time).
- Additional remarks, as appropriate.

Proper chain-of-custody procedures play a crucial role in data gathering. SOP F302 describes the requirements for correctly completing a chain-of-custody form. Chain-of-custody forms (and sample analysis request forms) are considered quality assurance records.

### 7.0 REFERENCES

American Society of Testing and Materials. 1987. Standard Guide for Sampling Groundwater Monitoring Wells. Method D4448-85A, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

**ATTACHMENT A**

**ASTM D4448-85A**

**STANDARD GUIDE FOR SAMPLING GROUNDWATER MONITORING WELLS**



## Standard Guide for Sampling Groundwater Monitoring Wells<sup>1</sup>

This standard is issued under the fixed designation D 4448; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This guide covers procedures for obtaining valid, representative samples from groundwater monitoring wells. The scope is limited to sampling and "in the field" preservation and does not include well location, depth, well development, design and construction, screening, or analytical procedures.

1.2 This guide is only intended to provide a review of many of the most commonly used methods for sampling groundwater quality monitoring wells and is not intended to serve as a groundwater monitoring plan for any specific application. Because of the large and ever increasing number of options available, no single guide can be viewed as comprehensive. The practitioner must make every effort to ensure that the methods used, whether or not they are addressed in this guide, are adequate to satisfy the monitoring objectives at each site.

1.3 *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.*

### 2. Summary of Guide

2.1 The equipment and procedures used for sampling a monitoring well depend on many factors. These include, but are not limited to, the design and construction of the well, rate of groundwater flow, and the chemical species of interest. Sampling procedures will be different if analyzing for trace organics, volatiles, oxidizable species, or trace metals is needed. This guide considers all of these factors by discussing equipment and procedure options at each stage of the sampling sequence. For ease of organization, the sampling process can be divided into three steps: well flushing, sample withdrawal, and field preparation of samples.

2.2 Monitoring wells must be flushed prior to sampling so that the groundwater is sampled, not the stagnant water in the well casing. If the well casing can be emptied, this may be done although it may be necessary to avoid oxygen contact with the groundwater. If the well cannot be emptied, procedures must be established to demonstrate that the sample represents groundwater. Monitoring an indicative parameter such as pH during flushing is desirable if such a parameter can be identified.

2.3 The types of species that are to be monitored as well as the concentration levels are prime factors for selecting sampling devices (1, 2).<sup>2</sup> The sampling device and all materials and devices the water contacts must be constructed of materials that will not introduce contaminants or alter the analyte chemically in any way.

2.4 The method of sample withdrawal can vary with the parameters of interest. The ideal sampling scheme would employ a completely inert material, would not subject the sample to negative pressure and only moderate positive pressure, would not expose the sample to the atmosphere, or preferably, any other gaseous atmosphere before conveying it to the sample container or flow cell for on-site analysis.

2.5 The degree and type of effort and care that goes into a sampling program is always dependent on the chemical species of interest and the concentration levels of interest. As the concentration level of the chemical species of analytical interest decreases, the work and precautions necessary for sampling are increased. Therefore, the sampling objective must clearly be defined ahead of time. For example, to prepare equipment for sampling for mg/L (ppm) levels of Total Organic Carbon (TOC) in water is about an order of magnitude easier than preparing to sample for  $\mu\text{g/L}$  (ppb) levels of a trace organic like benzene. The specific precautions to be taken in preparing to sample for trace organics are different from those to be taken in sampling for trace metals. No final Environmental Protection Agency (EPA) protocol is available for sampling of trace organics. A short guidance manual, (3) and an EPA document (4) concerning monitoring well sampling, including considerations for trace organics are available.

2.6 Care must be taken not to cross contaminate samples or monitoring wells with sampling or pumping devices or materials. All samples, sampling devices, and containers must be protected from the environment when not in use. Water level measurements should be made before the well is flushed. Oxidation-reduction potential, pH, dissolved oxygen, and temperature measurements and filtration should all be performed on the sample in the field, if possible. All but temperature measurement must be done prior to any significant atmospheric exposure, if possible.

2.7 The sampling procedures must be well planned and all sample containers must be prepared and labeled prior to going to the field.

### 3. Significance and Use

3.1 The quality of groundwater has become an issue of national concern. Groundwater monitoring wells are one of

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee D-34 on Waste Disposal and is the direct responsibility of Subcommittee D34.01 on Sampling and Monitoring.

Current edition approved Aug. 23 and Oct. 25, 1985. Published May 1986.

<sup>2</sup> The boldface numbers in parentheses refer to a list of references at the end of this guide.

TABLE 1 Typical Container and Preservation Requirements for a Ground-Water Monitoring Program

| Sample and Measurement                                 | Volume Required (mL) | Container P—Polyethylene<br>G—Glass         | Preservative                                                                           | Maximum Holding Time                |
|--------------------------------------------------------|----------------------|---------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------|
| Metals As/Ba/Cd/Cr/Fc Pb/Sc/<br>Ag/Mn/Na               | 1000–2000            | P/G (special acid cleaning)                 | high purity nitric acid to pH <2                                                       | 6 months                            |
| Mercury                                                | 200–300              | P/G (special acid cleaning)                 | high purity nitric acid to pH <2 +0.05 % K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> | 28 days                             |
| Radioactivity alpha/beta/radium                        | 4000                 | P/G (special acid cleaning)                 | high purity nitric acid to pH <2                                                       | 6 months                            |
| Phenolics                                              | 500–1000             | G                                           | cool, 4°C H <sub>2</sub> SO <sub>4</sub> to pH <2                                      | 28 days                             |
| Miscellaneous                                          | 1000–2000            | P                                           | cool, 4°C                                                                              | 28 days                             |
| Fluoride                                               | 300–500              | P                                           |                                                                                        | 28 days                             |
| Chloride                                               | 50–200               | P/G                                         |                                                                                        | 28 days                             |
| Sulfate                                                | 100–500              | P/G                                         |                                                                                        | 48 hours                            |
| Nitrate                                                | 100–250              | P/G                                         |                                                                                        | 6 h                                 |
| Coliform                                               | 100                  | P/G                                         |                                                                                        | on site/24 h                        |
| Conductivity                                           | 100                  | P/G                                         |                                                                                        | on site/6 h                         |
| pH                                                     | 100                  | P/G                                         |                                                                                        | 48 h                                |
| Turbidity                                              | 100                  | P/G                                         |                                                                                        |                                     |
| Total organic carbon (TOC)                             | 25–100               | P/G                                         | cool, 4°C or cool, 4°C HCl or H <sub>2</sub> SO <sub>4</sub> to pH <2                  | 24 h<br>28 days                     |
| Pesticides, herbicides and total organic halogen (TOX) | 1000–4000            | G/TFE-fluorocarbon lined cap solvent rinsed | cool, 4°C                                                                              | 7 days/extraction +30 days/analysis |
| Extractable organics                                   | 1000–2000            | G/TFE-fluorocarbon-lined cap solvent rinsed | cool, 4°C                                                                              | 7 days/extraction +30 days/analysis |
| Organic purgeables acrolein/acrylonitrile              | 25–120               | G/vial TFE-fluorocarbon-lined septum        | cool, 4°C                                                                              | 14 days<br>3 days                   |

the more important tools for evaluating the quality of groundwater, delineating contamination plumes, and establishing the integrity of hazardous material management facilities.

3.2 The goal in sampling groundwater monitoring wells is to obtain samples that are truly representative of the aquifer or groundwater in question. This guide discusses the advantages and disadvantages of various well flushing, sample withdrawal, and sample preservation techniques. It reviews the parameters that need to be considered in developing a valid sampling plan.

4. Well Flushing (Purging)

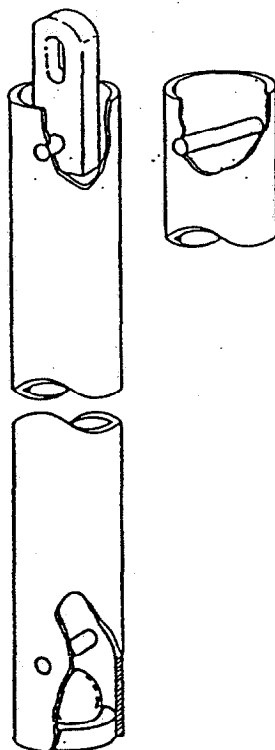
4.1 Water that stands within a monitoring well for a long period of time may become unrepresentative of formation water because chemical or biochemical change may cause water quality alterations and even if it is unchanged from the time it entered the well, the stored water may not be representative of formation water at the time of sampling, or both. Because the representativeness of stored water is questionable, it should be excluded from samples collected from a monitoring well.

4.2 The surest way of accomplishing this objective is to remove all stored water from the casing prior to sampling. Research with a tracer in a full scale model 2 in. PVC well (5) indicates that pumping 5 to 10 times the volume of the well via an inlet near the free water surface is sufficient to remove all the stored water in the casing. The volume of the well may

be calculated to include the well screen and any gravel pack if natural flow through these is deemed insufficient to keep them flushed out.

4.3 In deep or large diameter wells having a volume of water so large as to make removal of all the water impractical, it may be feasible to lower a pump or pump inlet to some point well below the water surface, purge only the volume below that point then withdraw the sample from a deeper level. Research indicates this approach should avoid most contamination associated with stored water (5, 6, 7). Sealing the casing above the purge point with a packer may make this approach more dependable by preventing migration of stored water from above. But the packer must be above the top of the screened zone, or stagnant water from above the packer will flow into the purged zone through the well's gravel/sand pack.

4.4 In low yielding wells, the only practical way to remove all standing water may be to empty the casing. Since it is not always possible to remove all water, it may be advisable to let the well recover (refill) and empty it again at least once. If introduction of oxygen into the aquifer may be of concern, it would be best not to uncover the screen when performing the above procedures. The main disadvantage of methods designed to remove all the stored water is that large volumes may need to be pumped in certain instances. The main advantage is that the potential for contamination of samples with stored water is minimized.



NOTE—Taken from Ref (15).

FIG. 1 Single Check Valve Bailer

4.5 Another approach to well flushing is to monitor one or more indicator parameters such as pH, temperature, or conductivity and consider the well to be flushed when the indicator(s) no longer change. The advantage of this method is that pumping can be done from any location within the casing and the volume of stored water present has no direct bearing on the volume of water that must be pumped. Obviously, in a low yielding well, the well may be emptied before the parameters stabilize. A disadvantage of this approach is that there is no assurance in all situations that the stabilized parameters represent formation water. If significant drawdown has occurred, water from some distance away may be pulled into the screen causing a steady parameter reading but not a representative reading. Also, a suitable indicator parameter and means of continuously measuring it in the field must be available.

4.6 Gibb (4, 8) has described a time-drawdown approach using a knowledge of the well hydraulics to predict the percentage of stored water entering a pump inlet near the top of the screen at any time after flushing begins. Samples are taken when the percentage is acceptably low. As before, the advantage is that well volume has no direct effect in the duration of pumping. A current knowledge of the well's hydraulic characteristics is necessary to employ this approach. Downward migration of stored water due to effects other than drawdown (for example density differences) is not accounted for in this approach.

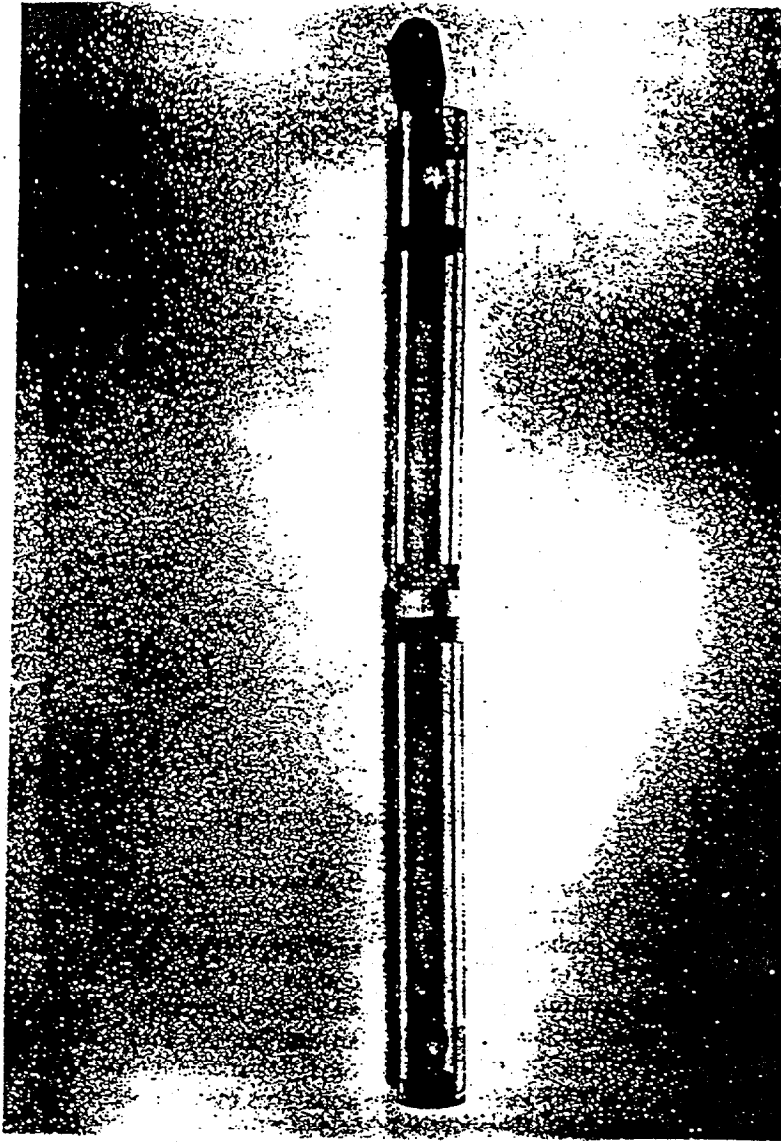
4.7 In any flushing approach, a withdrawal rate that minimizes drawdown while satisfying time constraints should be used. Excessive drawdown distorts the natural flow patterns around a well and can cause contaminants that were not present originally to be drawn into the well.

## 5. Materials and Manufacture

5.1 The choice of materials used in the construction of sampling devices should be based upon a knowledge of what compounds may be present in the sampling environment and how the sample materials may interact via leaching, adsorption, or catalysis. In some situations, PVC or some other plastic may be sufficient. In others, an all glass apparatus may be necessary.

5.2 Most analytical protocols suggest that the devices used in sampling and storing samples for trace organics analysis ( $\mu\text{g/L}$  levels) must be constructed of glass or TFE-fluorocarbon resin, or both. One suggestion advanced by the EPA is that the monitoring well be constructed so that only TFE-fluorocarbon tubing be used in that portion of the sampling well that extends from a few feet above the water table to the bottom of the borehole. (3, 5) Although this type of well casing is now commercially available, PVC well casings are currently the most popular. If adhesives are avoided, PVC well casings are acceptable in many cases although their use may still lead to some problems if trace organics are of concern. At present, the type of background presented by PVC and interactions occurring between PVC and groundwater are not well understood. Tin, in the form of an organotin stabilizer added to PVC, may enter samples taken from PVC casing. (9)

5.3 Since the most significant problem encountered in trace organics sampling, results from the use of PVC adhesives in monitoring well construction, threaded joints might avoid the problem (3, 5). Milligram per litre (parts per million) levels of compounds such as tetrahydrofuran, methyl-ethyl-ketone, and toluene are found to leach into



NOTE—Taken from Ref (17).

FIG. 2 Acrylic Point Source Baller

groundwater samples from monitoring well casings sealed with PVC solvent cement. Pollutant phthalate esters (8, 10) are often found in water samples at ppb levels; the EPA has found them on occasion at ppm levels in their samples. The ubiquitous presence of these phthalate esters is unexplained, except to say that they may be leached from plastic pipes, sampling devices, and containers.

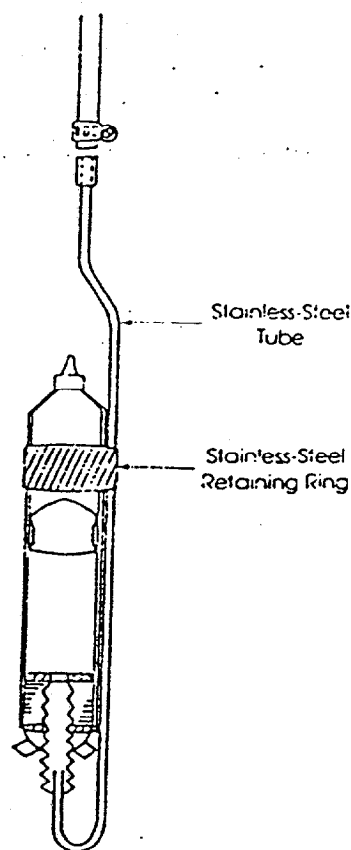
5.4 TFE-fluorocarbon resins are highly inert and have sufficient mechanical strength to permit fabrication of sampling devices and well casings. Molded parts are exposed to high temperature during fabrication which destroys any organic contaminants. The evolution of fluorinated compounds can occur during fabrication, will cease rapidly, and does not occur afterwards unless the resin is heated to its melting point.

5.5 Extruded tubing of TFE-fluorocarbon for sampling may contain surface traces of an organic solvent extrusion aid. This can be removed easily by the fabricator and, once

removed by flushing, should not affect the sample. TFE-fluorocarbon FEP and TFE-fluorocarbon PFA resins do not require this extrusion aid and may be suitable for sample tubing as well. Unsintered thread-sealant tape of TFE-fluorocarbon is available in an "oxygen service" grade and contains no extrusion aid and lubricant.

5.6 Louneman, et al. (11) alludes to problems caused by a lubricating oil used during TFE-fluorocarbon tubing extrusion. This reference also presents evidence that a fluorinated ethylene-propylene copolymer adsorbed acetone to a degree that later caused contamination of a gas sample.

5.7 Glass and stainless steel are two other materials generally considered inert in aqueous environments. Glass is probably among the best choices though it is not inconceivable it could adsorb some constituents as well as release other contaminants (for example, Na, silicate, and Fe). Of course glass sampling equipment must be handled carefully in the field. Stainless steel is strongly and easily machined to



NOTE—Taken from Ref (21).

FIG. 3 Schematic of the Inverted Syringe Sampler

fabricate equipment. Unfortunately, it is not totally immune to corrosion that could release metallic contaminants. Stainless steel contains various alloying metals, some of these (for example Ni) are commonly used as catalysts for various reactions. The alloyed constituents of some stainless steels can be solubilized by the pitting action of nonoxidizing anions such as chloride, fluoride, and in some instances sulfate, over a range of pH conditions. Aluminum, titanium, polyethylene, and other corrosion resistant materials have been proposed by some as acceptable materials, depending on groundwater quality and the constituents of interest.

5.8 Where temporarily installed sampling equipment is used, the sampling device that is chosen should be non-plastic (unless TFE-fluorocarbon), cleanable of trace organics, and must be cleaned between each monitoring well use in order to avoid cross-contamination of wells and samples. The only way to ensure that the device is indeed "clean" and acceptable is to analyze laboratory water blanks and field water blanks that have been soaked in and passed through the sampling device to check for the background levels that may result from the sampling materials or from field conditions. Thus, all samplings for trace materials should be accompanied by samples which represent the field background (if possible), the sampling equipment background, and the laboratory background.

5.9 Additional samples are often taken in the field and spiked (spiked-field samples) in order to verify that the sample handling procedures are valid. The American Chem-

ical Society's committee on environmental improvement has published guidelines for data acquisition and data evaluation which should be useful in such environmental evaluation (10, 12).

## 6. Sampling Equipment

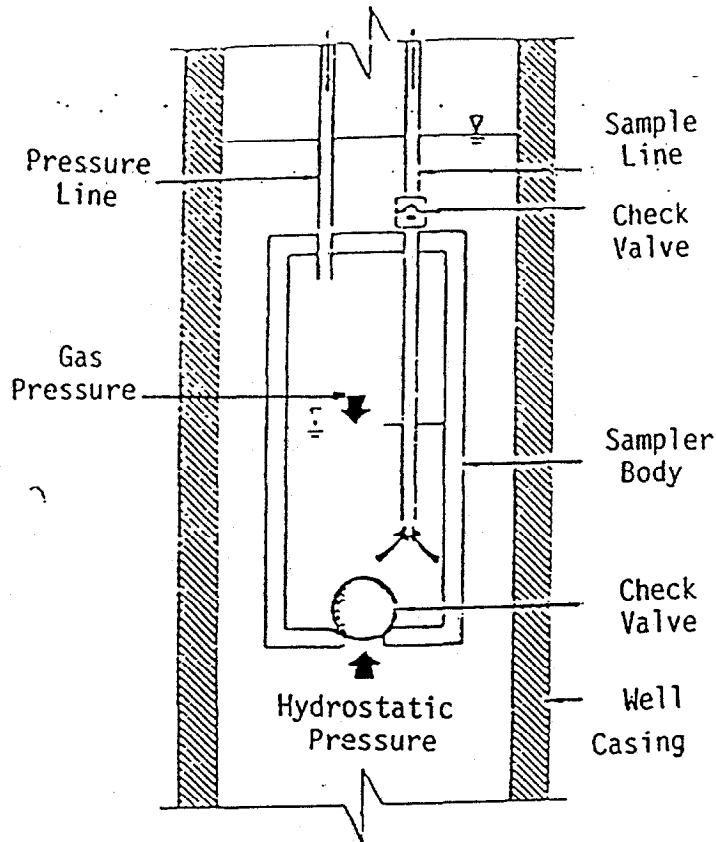
6.1 There is a fairly large choice of equipment present available for groundwater sampling from single screen wells and well clusters. The sampling devices can be categorized into the following eight basic types.

### 6.1.1 Down-Hole Collection Devices:

6.1.1.1 Bailers, messenger bailers, or thief samplers (11, 14) are examples of down-hole devices that probably provide valid samples once the well has been flushed. They are not practical for removal of large volumes of water. The devices can be constructed in various shapes and sizes from a variety of materials. They do not subject the sample to pressure extremes.

6.1.1.2 Bailers do expose part of the sample to the atmosphere during withdrawal. Bailers used for sampling of volatile organic compounds should have a sample cock or draft valve in or near the bottom of the sampler allowing withdrawal of a sample from the well below the exposed surface of the water or the first few inches of the sample should be discarded. Suspension lines for bailers and other samplers should be kept off the ground and free of other contaminating materials that could be carried into the well. Down-hole devices are not very practical for use in deep





NOTE—Taken from Ref (5).

FIG. 4 The Principal of Gas Displacement Pumping

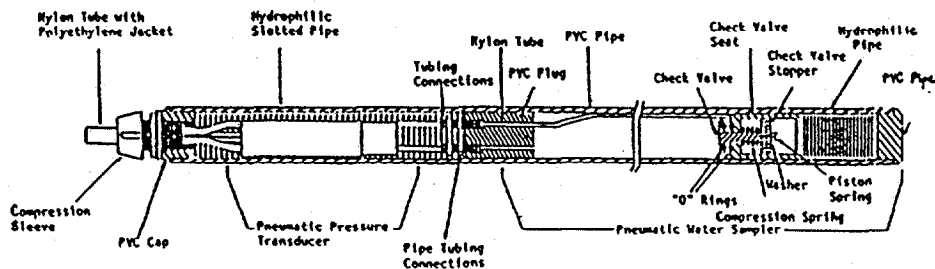
wells. However, potential sample oxidation during transfer of the sample into a collection vessel and time constraints for lowering and retrieval for deep sampling are the primary disadvantages.

6.1.1.3 Three down-hole devices are the single and double check valve bailers and thief samplers. A schematic of a single check valve unit is illustrated in Fig. 1. The bailer may be threaded in the middle so that additional lengths of blank casing may be added to increase the sampling volume. TFE-fluorocarbon or PVC are the most common materials used for construction (15).

6.1.1.4 In operation, the single check valve bailer is lowered into the well, water enters the chamber through the bottom, and the weight of the water column closes the check

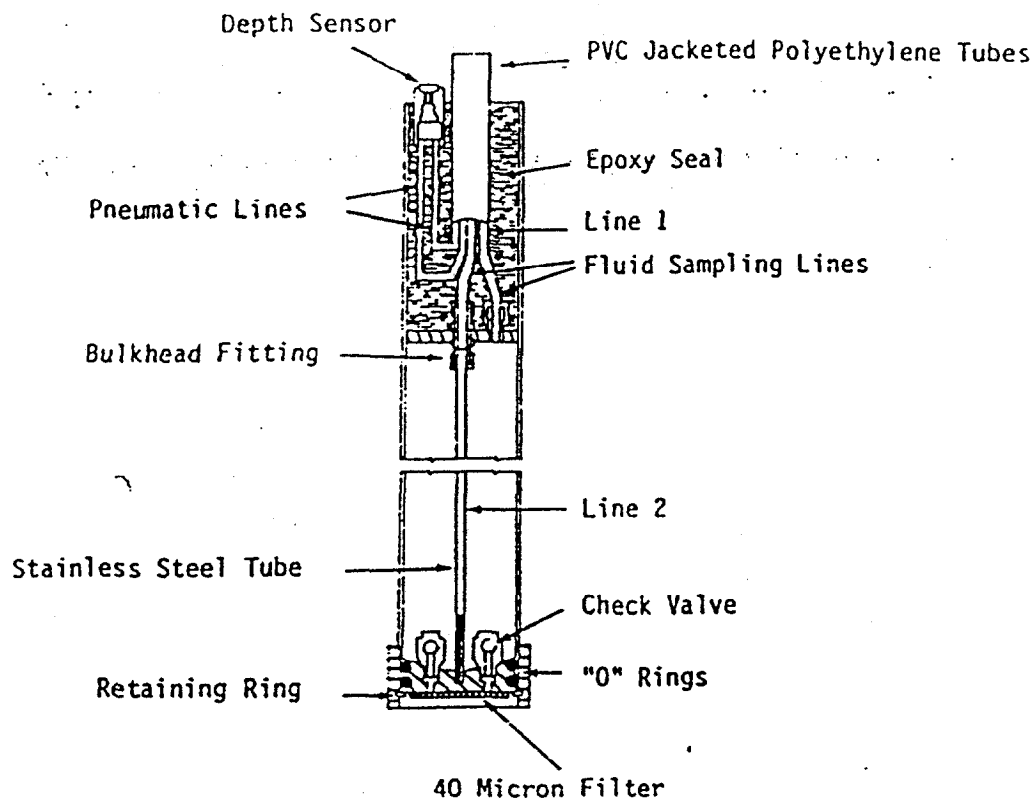
valve upon bailer retrieval. The specific gravity of the ball should be about 1.4 to 2.0 so that the ball almost sits on the check valve seat during chamber filling. Upon bailer withdrawal, the ball will immediately seat without any samples loss through the check valve. A similar technique involves lowering a sealed sample container within a weighted bottle into the well. The stopper is then pulled from the bottle via a line and the entire assembly is retrieved upon filling of the container (14, 16).

6.1.1.5 A double check valve bailer allows point source sampling at a specific depth (15, 17). An example is shown in Fig. 2. In this double check valve design, water flows through the sample chamber as the unit is lowered. A venturi tapered inlet and outlet ensures that water passes freely through the



NOTE—Taken from Ref (41).

FIG. 5 Pneumatic Water Sampler With Internal Transducer



NOTE—Taken from Ref (42).

FIG. 6 Pneumatic Sampler With Externally Mounted Transducer

unit. When a depth where the sample is to be collected is reached, the unit is retrieved. Because the difference between each ball and check valve seat is maintained by a pin that blocks vertical movement of the check ball, both check valves close simultaneously upon retrieval. A drainage pin is placed into the bottom of the bailer to drain the sample directly into a collection vessel to reduce the possibility of air oxidation. The acrylic model in Fig. 2 is threaded at the midsection allowing the addition of threaded casing to increase the sampling volume.

6.1.1.6 Another approach for obtaining point source samples employs a weighted messenger or pneumatic change to "trip" plugs at either end of an open tube (for example, tube water sampler or thief sampler) to close the chamber (18). Foerst, Kemmerer, and Bacon samplers are of this variety (14, 17, 19). A simple and inexpensive pneumatic sampler was recently described by Gillham (20). The device (Fig. 3) consists of a disposable 50 mL plastic syringe modified by sawing off the plunger and the finger grips. The syringe is then attached to a gas-line by means of a rubber stopper assembly. The gas-line extends to the surface, and is used to drive the stem-less plunger, and to raise and lower the syringe into the hole. When the gas-line is pressurized, the rubber plunger is held at the tip of the syringe. The sampler is then lowered into the installation, and when the desired depth is reached, the pressure in the gas-line is reduced to atmospheric (or slightly less) and water enters the syringe. The sampler is then retrieved from the installation and the syringe detached from the gas-line. After the tip is sealed, the syringe is used as a short-term storage container. A number

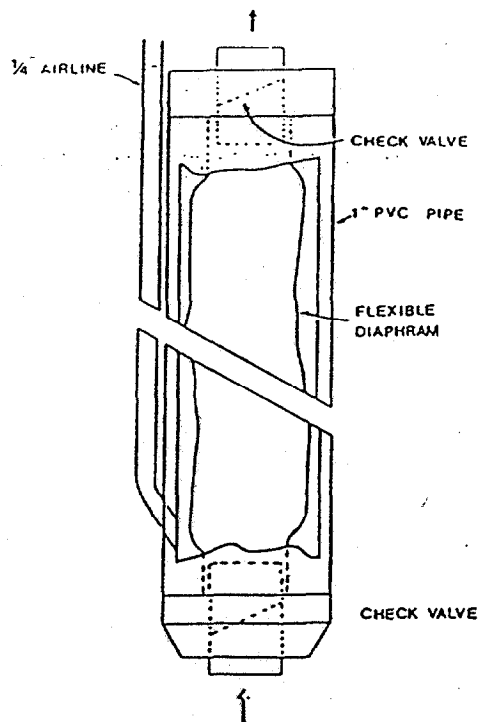
of thief or messenger devices are available in various materials and shapes.

#### 6.1.2 Suction Lift Pumps:

6.1.2.1 Three types of suction lift pumps are the direct line, centrifugal, and peristaltic. A major disadvantage of any suction pump is that it is limited in its ability to raise water by the head available from atmospheric pressure. Thus, if the surface of the water is more than about 25 ft below the pump, water may not be withdrawn. The theoretical suction limit is about 34 ft, but most suction pumps are capable of maintaining a water lift of only 25 ft or less.

6.1.2.2 Many suction pumps draw the water through some sort of volute in which impellers, pistons, or other devices operate to induce a vacuum. Such pumps are probably unacceptable for most sampling purposes because they are usually constructed of common materials such as brass or mild steel and may expose samples to lubricants. They often induce very low pressures around rotating vanes or other such parts such that degassing or even cavitation may occur. They can mix air with the sample via small leaks in the casing, and they are difficult to adequately clean between uses. Such pumps are acceptable for purging of wells, but should not generally be used for sampling.

6.1.2.3 One exception to the above statements is a peristaltic pump. A peristaltic pump is a self-priming, low volume suction pump which consists of a rotor with ball bearing rollers (21). Flexible tubing is inserted around the pump rotor and squeezed by heads as they revolve in a circular pattern around the rotor. One end of the tubing is placed into the well while the other end can be connectec



NOTE—Taken from Ref (4).

FIG. 7 Bladder Pump

directly to a receiving vessel. As the rotor moves, a reduced pressure is created in the well tubing and an increased pressure (<40 psi) on the tube leaving the rotor head. A drive shaft connected to the rotor head can be extended so that multiple rotor heads can be attached to a single drive shaft.

6.1.2.4 The peristaltic pump moves the liquid totally within the sample tube. No part of the pump contacts the liquid. The sample may still be degassed (cavitation is unlikely) but the problems due to contact with the pump mechanism are eliminated. Peristaltic pumps do require a fairly flexible section of tubing within the pumphead itself. A section of silicone tubing is commonly used within the peristaltic pumphead, but other types of tubing can be used particularly for the sections extending into the well or from the pump to the receiving container. The National Council of the Paper Industry for Air and Stream Improvement (22) recommends using medical grade silicone tubing for organic sampling purposes as the standard grade uses an organic vulcanizing agent which has been shown to leach into samples. Medical grade silicone tube is, however, limited to use over a restricted range of ambient temperatures. Various manufacturers offer tubing lined with TFE-fluorocarbon or Viton<sup>3</sup> for use with their pumps. Gibb (1, 8) found little difference between samples withdrawn by a peristaltic pump and those taken by a bailer.

6.1.2.5 A direct method of collecting a sample by suction consists of lowering one end of a length of plastic tubing into the well or piezometer. The opposite end of the tubing is connected to a two way stopper bottle and a hand held or

mechanical vacuum pump is attached to a second tubing leaving the bottle. A check valve is attached between the two lines to maintain a constant vacuum control. A sample can then be drawn directly into the collection vessel without contacting the pump mechanism (5, 23, 24).

6.1.2.6 A centrifugal pump can be attached to a length of plastic tubing that is lowered into the well. A foot valve is usually attached to the end of the well tubing to assist in priming the tube. The maximum lift is about 4.6 m (15 ft) for such an arrangement (23, 25, 26).

6.1.2.7 Suction pump approaches offer a simple sample retrieval method for shallow monitoring. The direct line method is extremely portable though considerable oxidation and mixing may occur during collection. A centrifugal pump will agitate the sample to an even greater degree although pumping rates of 19 to 151 Lpm (5 to 40 gpm) can be attained. A peristaltic pump provides a lower sampling rate with less agitation than the other two pumps. The withdrawal rate of peristaltic pumps can be carefully regulated by adjustment of the rotor head revolution.

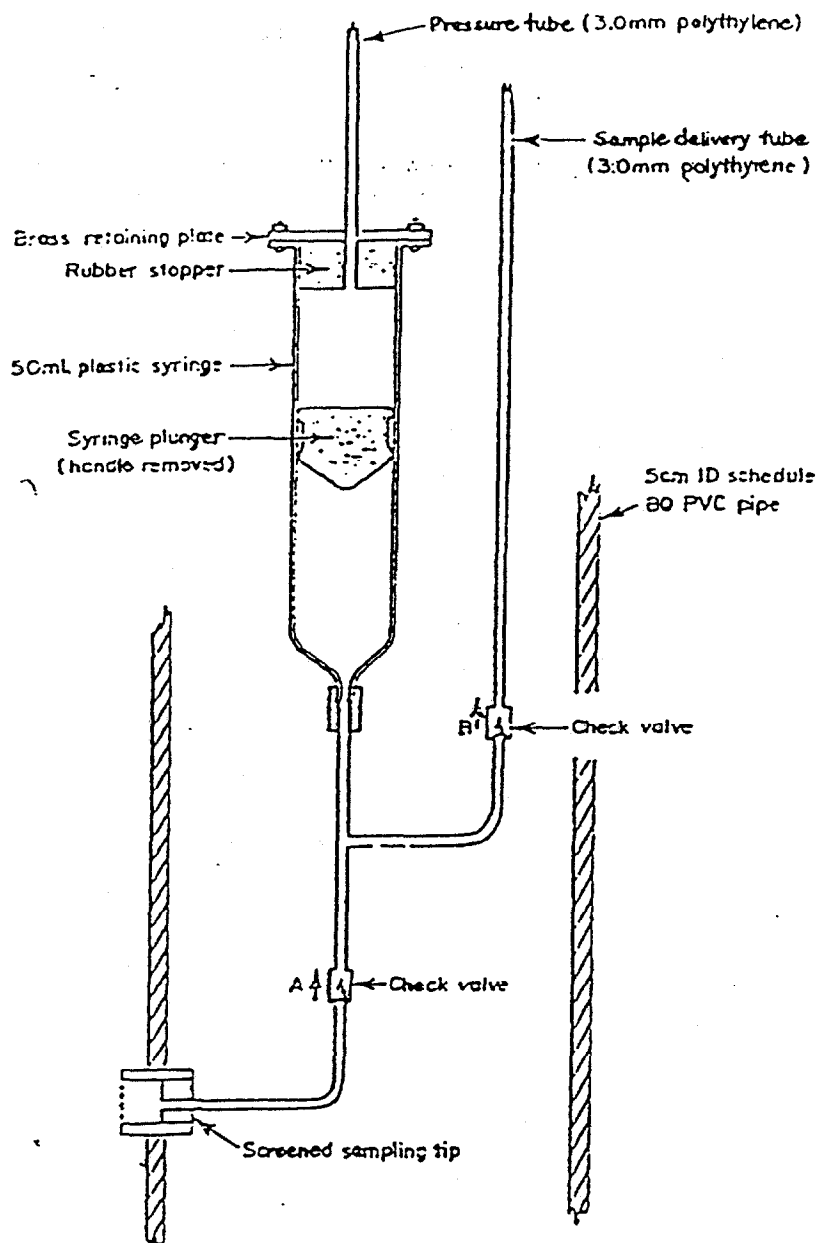
6.1.2.8 All three systems can be specially designed so that the water sample contacts only the TFE fluorocarbon or silicone tubing prior to sample bottle entry. Separate tubing is recommended for each well or piezometer sampled.

### 6.1.3 Electric Submersible Pumps:

6.1.3.1 A submersible pump consists of a sealed electric motor that powers a piston or helical single thread worm at a high rpm. Water is brought to the surface through an access tube. Such pumps have been used in the water well industry for years and many designs exist (5, 26).

6.1.3.2 Submersible pumps provide relatively high discharge rates for water withdrawal at depths beyond suction

<sup>3</sup> Viton is a trademark of E. I. du Pont de Nemours & Co., Wilmington, DE 19898 and has been found suitable for this purpose.



NOTE—Taken from Ref (48).

FIG. 8 Positive Displacement Syringe Pump

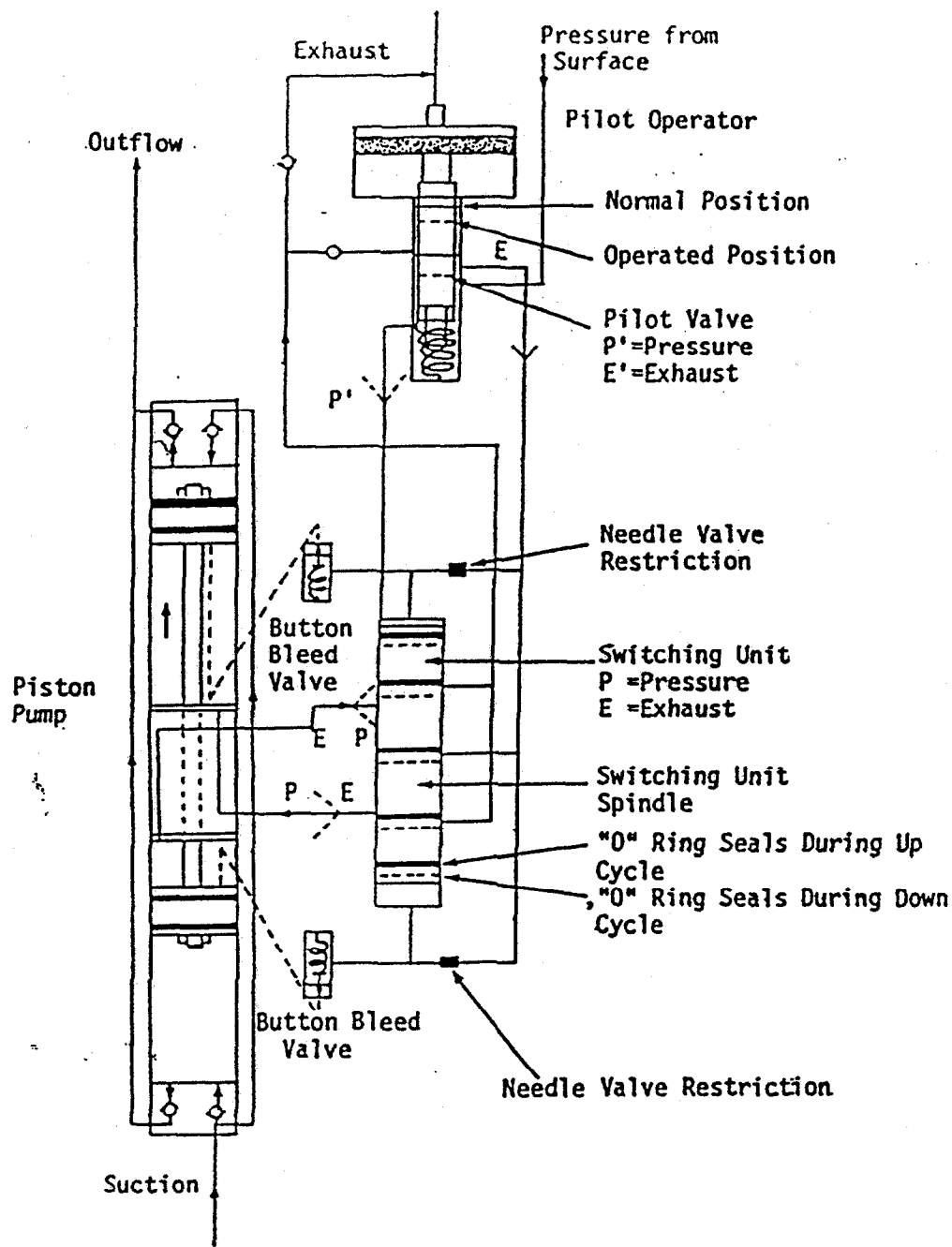
lift capabilities. A battery operated unit 3.6 cm (1.4 in.) in diameter and with a 4.5 Lpm (1.2 gpm) flow rate at 33.5 m (110 ft) has been developed (27). Another submersible pump has an outer diameter of 11.4 cm (4.5 in.) and can pump water from 91 m (300 ft). Pumping rates vary up to 53.0 Lpm (14 gpm) depending upon the depth of the pump (28).

6.1.3.3 A submersible pump provides higher extraction rates than many other methods. Considerable sample agitation results, however, in the well and in the collection tube during transport. The possibility of introducing trace metals into the sample from pump materials also exists. Steam cleaning of the unit followed by rinsing with unchlorinated, deionized water is suggested between sampling when analysis for organics in the parts per million (ppm) or parts per billion (ppb) range is required (29).

#### 6.1.4 Gas-Lift Pumps:

6.1.4.1 Gas-lift pumps use compressed air to bring a water sample to the surface. Water is forced up an eductor pipe that may be the outer casing or a smaller diameter pipe inserted into the well annulus below the water level (30, 31).

6.1.4.2 A similar principle is used for a unit that consists of a small diameter plastic tube perforated in the lower end. This tube is placed within another tube of slightly larger diameter. Compressed air is injected into the inner tube; the air bubbles through the perforations, thereby lifting the water sample via the annulus between the outer and inner tubing (32). In practice, the eductor line should be submerged to a depth equal to 60 % of the total submerged eductor length during pumping (26). A 60 % ratio is considered optimal although a 30 % submergence ratio is adequate.



NOTE—Taken from Ref (49).

FIG. 9 Gas Driven Piston Pump

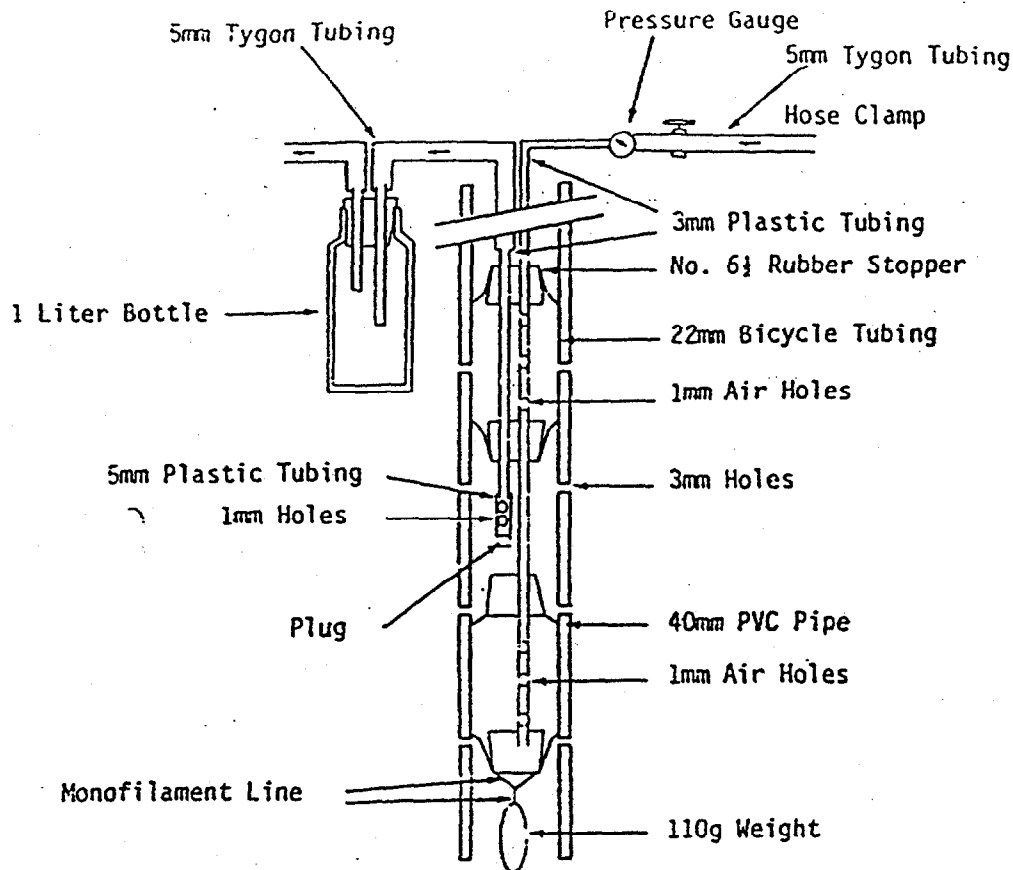
6.1.4.3 The source of compressed gas may be a hand pump for depths generally less than 7.6 m (25 ft). For greater depths, air compressors, pressurized air bottles, and air compressed from an automobile engine have been used.

6.1.4.4 As already mentioned, gas-lift methods result in considerable sample agitation and mixing within the well, and cannot be used for samples which will be tested for volatile organics. The eductor pipe or weighted plastic tubing is a potential source of sample contamination. In addition, Gibb (8) uncovered difficulties in sampling for inorganics. These difficulties were attributed to changes in redox, pH,

and species transformation due to solubility constant changes resulting from stripping, oxidation, and pressure changes.

6.1.5 Gas Displacement Pumps:

6.1.5.1 Gas displacement or gas drive pumps are distinguished from gas-lift pumps by the method of sample transport. Gas displacement pumps force a discrete column of water to the surface via mechanical lift without extensive mixing of the pressurized gas and water as occurs with air-lift equipment. The principle is shown schematically in Fig. Water fills the chamber. A positive pressure is applied to the



NOTE—Taken from Ref (53).

FIG. 10 Packer Pump Arrangement

gas line closing the sampler check valve and forcing water up the sample line. By removing the pressure the cycle can be repeated. Vacuum can also be used in conjunction with the gas (30). The device can be permanently installed in the well (33, 34, 35) or lowered into the well (36, 37).

6.1.5.2 A more complicated two stage design constructed of glass with check valves made of TFE-fluorocarbon has been constructed (38, 39). The unit was designed specifically for sample testing for trace level organics. Continuous flow rates up to 2.3 Lpm (0.6 gpm) are possible with a 5.1 cm (2 in.) diameter unit.

6.1.5.3 Gas displacement pumps have also been developed with multiple functions. The water sampler in Fig. 5 provides piezometric data measurements with an internally mounted transducer (40). A sampler with its transducer exposed externally for piezometric measurements is illustrated in Fig. 6 (41). The sensor can activate the gas source at the predetermined depth. Another design can be used as a water sampler or as a tool for injecting brine or other tracers into a well (42).

6.1.5.4 Gas displacement pumps offer reasonable potential for preserving sample integrity because little of the driving gas comes in contact with the sample as the sample is conveyed to the surface by a positive pressure. There is, however, a potential loss of dissolved gasses or contamination from the driving gas and the housing materials.

### 6.1.6 Bladder Pumps:

6.1.6.1 Bladder pumps, also referred to as gas-operated squeeze pumps, consist of a flexible membrane enclosed by a rigid housing. Water enters the membrane through a check valve in the vessel bottom; compressed gas injected into the cavity between the housing and bladder forces the sample through a check valve at the top of the membrane and into a discharge line (Fig. 7). Water is prevented from re-entering the bladder by the top check valve. The process is repeated to cycle the water to the surface. Samples taken from depths of 30.5 m (100 ft) have been reported.

6.1.6.2 A variety of design modifications and materials are available (43, 44). Bladder materials include neoprene, rubber, ethylene propylene terpolymer (E.P.T.), nitrile, and the fluorocarbon Viton.<sup>3</sup> A bladder made of TFE-fluorocarbon is also under development (45). Automated sampling systems have been developed to control the time between pressurization cycles (46).

6.1.6.3 Bladder pumps provide an adaptable sampling tool due primarily to the number of bladder shapes that are feasible. These devices have a distinct advantage over gas displacement pumps in that there is no contact with the driving gas. Disadvantages include the large gas volumes required, low pumping rates, and potential contamination from many of the bladder materials, the rigid housing, or both.

### 6.1.7 Gas Driven Piston Pumps:

6.1.7.1 A simple and inexpensive example of a gas driven piston pump is a syringe pump (47). The pump (Fig. 8) is constructed from a 50 mL plastic syringe with plunger stem removed. The device is connected to a gas line to the surface and the sample passes through a check valve arrangement to a sampling container at the surface. By successively applying positive and negative pressure to the gas-line, the plunger is activated driving water to the surface.

6.1.7.2 A double piston pump powered by compressed air is illustrated in Fig. 9. Pressurized gas enters the chamber between the pistons; the alternating chamber pressurization activates the piston which allows water entry during the suction stroke of the piston and forces the sample to the surface during the pressure stroke (48). Pumping rates between 9.5 and 30.3 L/hr (2.5 to 8 gal/hr) have been reported from 30.5 m (100 ft). Depths in excess of 457 m (1500 ft) are possible.

6.1.7.3 The gas piston pump provides continuous sample withdrawal at depths greater than is possible with most other approaches. Nevertheless, contribution of trace elements from the stainless steel and brass is a potential problem and the quantity of gas used is significant.

#### 6.1.8 Packer Pump Arrangement:

6.1.8.1 A packer pump arrangement provides a means by which two expandable "packers" isolate a sampling unit between two packers within a well. Since the hydraulic or pneumatic activated packers are wedged against the casing wall or screen, the sampling unit will obtain water samples only from the isolated well portion. The packers are deflated for vertical movement within the well and inflated when the desired depth is attained. Submersible, gas lift, and suction pumps can be used for sampling. The packers are usually constructed from some type of rubber or rubber compound (48, 49, 50, 51). A packer pump unit consisting of a vacuum sampler positioned between two packers is illustrated in Fig. 10 (52).

6.1.8.2 A packer assembly allows the isolation of discrete sampling points within a well. A number of different samplers can be situated between the packers depending upon the analytical specifications for sample testing. Vertical movement of water outside the well casing during sampling is possible with packer pumps but depends upon the pumping rate and subsequent disturbance. Deterioration of the expandable materials will occur with time with the increased possibility of undesirable organic contaminants contributing to the water sample.

## 7. Sample Containers and Preservation

7.1 Complete and unequivocal preservation of samples, whether domestic wastewater, industrial wastes, or natural waters, is practically impossible. At best, preservation techniques only retard the chemical and biological changes that inevitably continue after the sample is removed from the source. Therefore, insuring the timely analysis of a sample should be one of the foremost considerations in the sampling plan schedule. Methods of preservation are somewhat limited and are intended to retard biological action, retard hydrolysis of chemical compounds and complexes, and reduce the volatility of constituents. Preservation methods are generally limited to pH control, chemical addition, refrigeration and freezing. For water samples, immediate

refrigeration just above freezing (4°C in wet ice) is often the best preservation technique available, but it is not the only measure nor is it applicable in all cases. There may be special cases where it might be prudent to include a recording thermometer in the sample shipment to verify the maximum and minimum temperature to which the samples were exposed. Inexpensive devices for this purpose are available.

7.2 All bottles and containers must be specially pre-cleaned, pre-labelled, and organized in ice-chests (isolating samples and sampling equipment from the environment) before one goes into the field. Otherwise, in any comprehensive program utter chaos usually develops in the field or laboratory. The time in the field is very valuable and should be spent on taking field notes, measurements, and in documenting samples, not on labelling and organizing samples. Therefore, the sampling plan should include clear instructions to the sampling personnel concerning the information required in the field data record logbook (notebook), the information needed on container labels for identification, the chain-of-custody protocols, and the methods for preparing field blanks and spiked samples. Example of detailed plans and documentation procedures have been published (14, 53).

7.3 The exact requirements for the volumes of sample needed and the number of containers to use may vary from laboratory to laboratory. This will depend on the specific analyses to be performed, the concentration levels of interest, and the individual laboratory protocols. The manager of the sampling program should make no assumptions about the laboratory analyses. He should discuss the analytical requirements of the sampling program in detail with the laboratory coordinator beforehand. This is especially the case since some analyses and preservation measures must be performed at the laboratory as soon as possible after the samples arrive. Thus, appropriate arrangements must be made.

7.4 There are a number of excellent references available which list the containers and preservation techniques appropriate for water and soils (13, 14, 50, 54, 55, 56). The "Handbook for Sampling and Sample Preservation of Water and Wastewater" is an excellent reference and perhaps the most comprehensive one (14). Some of this information is summarized in Table 1.

7.5 Sample containers for trace organic samples require special cleaning and handling considerations (57). The sample container for purgeable organics consist of a screw-cap vial (25 to 125 mL) fitted with a TFE-fluorocarbon faced silicone septum. The vial is sealed in the laboratory immediately after cleaning and is only opened in the field just prior to pouring sample into it. The water sample then must be sealed into the vial headspace free (no air bubbles) and immediately cooled (4°C) for shipment. Multiple samples (usually about four taken from one large sample container) are taken because leakage of containers may cause losses, may allow air to enter the containers, and may cause erroneous analysis of some constituents. Also, some analyses are best conducted on independent protected samples.

7.6 The purgeable samples must be analyzed by the laboratory within 14 days after collection, unless they are to be analyzed for acrolein or acrylonitrile (in which case they are to be analyzed within 3 days). For samples for solvent extractions (extractable organics-base neutrals, acids and

pesticides), the sample bottles are narrow mouth, screw cap quart bottles or half-gallon bottles that have been pre-cleaned, rinsed with the extracting organic solvent and oven dried at 105°C for at least 1 h. These bottles must be sealed with TFE-fluorocarbon lined caps (Note). Samples for organic extraction must be extracted within 7 days and analyzed within 30 days after extraction. Special pre-cleaned, solvent rinsed and oven-dried stainless steel beakers (one for each monitoring well) may be used for transferring samples from the sampling device to the sample containers.

NOTE—When collecting samples, the bottles should not be overfilled or prerinsed with sample before filling because oil and other materials may remain in the bottle. This can cause erroneously high results.

7.7 For a number of groundwater parameters, the most meaningful measurements are those made in the field at the time of sample collection or at least at an on-site laboratory. These include the water level in the well and parameters that sometimes can change rapidly with storage. A discussion of the various techniques for measuring the water level in the well is contained in a NCASI publication (5) and detailed procedures are outlined in a U.S. Geological Survey publication (58). Although a discussion of these techniques is beyond the scope of this guide, it is important to point out that accurate measurements must be made before a well is flushed or only after it has had sufficient time to recover. Parameters that can change rapidly with storage include specific conductance, pH, turbidity, redox potential, dissolved oxygen, and temperature. For some of the other

parameters, the emphasis in groundwater monitoring is on the concentration of each specific dissolved component, not the total concentration of each. Samples for these types of measurements should be filtered through 0.45 µm membrane filters ideally in the field or possibly at an on-site laboratory as soon as possible. Analyses often requiring filtered samples include all metals, radioactivity parameters, total organic carbon, dissolved orthophosphate (if needed), and total dissolved phosphorous (if needed) (13, 14). If metals are to be analyzed, filter the sample prior to acid preservation. For TOC organics, the filter material should be tested to assure that it does not contribute to the TOC. The type or size of the filter to be used is not well understood. However, if results of metal, TOC or other parameters that could be effected by solids are to be compared, the same filtering procedure must be used in each case. Repeated analytical results should state whether the samples were filtered and how they were filtered.

7.8 Shipment and receipt of samples must be coordinated with the laboratory to minimize time in transit. All samples for organic analysis (and many other parameters), should arrive at the laboratory within one day after it is shipped and be maintained at about 4°C with wet ice. The best way to get them to the laboratory in good condition is to send them in sturdy insulated ice chests (coolers) equipped with bottle dividers. 24-h courier service is recommended, if personal delivery service is not practical.

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**APPENDIX D**  
**SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION**

**SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION  
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## **SURFACE WATER AND SEDIMENT SAMPLE ACQUISITION**

### **1.0 PURPOSE**

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

### **2.0 SCOPE**

The information presented in this SOP is generally applicable to all environmental sampling of surface waters (Section 5.2) and aquatic sediments (Section 5.3), except where the analyte(s) may interact with the sampling equipment.

Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Such innovations shall be documented and presented in the Sampling and Analysis Plan.

### **3.0 DEFINITIONS**

Grab Sample - An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes.

Composite Sample - A sample collected over time that typically consists of a series of discrete samples which are combined or composited.

### **4.0 RESPONSIBILITIES**

**Project Manager** - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation for procedures which deviate from those presented herein.

**Field Team Leader** - The Field Team Leader is responsible for selecting and detailing the specific surface water and/or sediment sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

**Sampling Personnel** - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of surface water and sediment samples.

## **5.0 PROCEDURES**

Collecting a representative sample from surface water or sediments is difficult due to 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 collection methods are important to ensure that a truly representative sample has been collected. Regardless of scrutiny and quality control applied during laboratory analyses, reported data are only as good as the confidence that can be placed on the representativeness of the samples.

### **5.1 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 effect adsorption/desorption). The sampling plan must therefore reflect not only the mixing characteristics of streams and lakes, but also the role of fluvial-sediment transport, deposition, and chemical sorption.

#### **5.1.1 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 within 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 (d) groundwater flow influx to the water body. 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 (when 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 nondetectable concentrations. Such dispersion does not, however, always readily occur throughout the entire body of water; the mixing may be limited to specific flow streams within the water body. For example, obtaining a representative sample of contamination from the center of a channel 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 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 adsorb on particulate matter. Nitrogen, phosphorus, and the heavy metals also may 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.

The first step in selecting sampling locations; therefore, is to review site history, define hydrologic boundaries and features of the site, and identify the sources, pathways and potential distribution of contamination based on these considerations. The numbers, types and general locations of required samples upgradient, on site and downgradient can then be identified.

### **5.1.2 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. Wading or sampling from a stream bank often is sufficient for springs, seeps, and small streams. Bridges or piers are the first choice for locating a sampling station on a larger stream or small river; they provide ready access and also permit the sampling technician to sample any point across the stream or river. 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.

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. Use of boats or wading to collect samples requires the use of U. S. Coast Guard approved personal flotation devices (PFDs).

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.

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

### **5.1.3 Frequency of Sampling**

The sampling frequency and the objectives of the sampling event will be defined by the Sampling and Analysis 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 often is not 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 established and consistent intervals, as specified in the Sampling and Analysis 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.

## **5.2 Surface Water Sample Collection**

This section presents methods for collection of samples from various surface water bodies, as well as a description of types of surface water sampling equipment. The guidance in this section should be used to develop specific sampling procedures based on site conditions and investigation goals. A summary of sampling techniques and procedures is given in Section 5.2.5.

### **5.2.1 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 multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) method.

Samples from different depths or cross-sectional locations, collected 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 collected depend on the river's width, depth, discharge, and amount of suspended sediment. With a greater number of individual points sampled, it is 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 location 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 greater than three feet in depth, two samples at each station shall be taken from just below the surface, and just above the bottom.

### **5.2.2 Lakes, Ponds and Reservoirs**

Lakes, ponds, and reservoirs have a much greater tendency to stratify according to physical or chemical differences than rivers and streams. The relative lack of mixing requires that more samples be obtained.

The number of water sampling locations 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 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 grab samples shall be composited to form a single sample. These vertical samples often are collected 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 sample consists of several vertical samples collected at various depths.

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

Many lake measurements now are made in-situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth,



pH, oxidation-reduction potential (ORP), specific conductance, dissolved oxygen, some cations and anions, and light penetration.

### 5.2.3 Estuaries

Estuarine areas are by definition among those zones where inland freshwaters (both surface and ground) mix with marine waters. Estuaries generally are 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 normally is 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 coupled with vertical dissolved oxygen and temperature profiles.

### 5.2.4 Surface Water Sampling Equipment

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

- Dip sampler
- Weighted bottle
- 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; and dissolved oxygen (optional) as soon as it is recovered. These analyses will provide information on water mixing/stratification and potential contamination.

#### 5.2.4.1 Dip Sampling

Water often is 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. Dip sampling often is the most appropriate sampling method for springs, seeps, ditches, and small streams.

#### 5.2.4.2 Weighted Bottle Sampling

A grab sample also can 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 stoppered 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 as follows:

- 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).

#### 5.2.4.3 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. A "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.

#### 5.2.5 **Surface Water Sampling Techniques**

Most samples taken during site investigations are grab samples. Typically, surface water sampling involves immersing the sample container directly in the body of water. The following suggestions are applicable to sampling springs, seeps, ditches, culverts, small streams and other relatively small bodies of water, and are presented to help ensure that the samples obtained are representative of site conditions:

- The most representative samples will likely be collected from near mid-stream, the center of flow in a culvert, etc.
- Downstream samples shall be collected first, with subsequent samples taken while moving upstream. Care shall be taken to minimize sediment disturbance while collecting surface water samples. If necessary, sediment samples shall be collected after the corresponding surface water sample.
- Samples may be collected either by immersing the approved sample container or a glass or nalgene beaker into the water. Sample bottles (or beakers) which do not contain preservatives shall be rinsed at least once with the water to be sampled prior to sample collection.
- Care shall be taken to avoid excessive agitation of the water which may result in the loss of volatile constituents. Additionally, samples for volatile organic analyses shall be collected first, followed by the samples for other constituents.
- Measurements for temperature, pH, specific conductance, or other field parameters, as appropriate, shall be collected immediately following sample collection for laboratory analyses.
- All samples shall be handled as described in SOP F301.

- The sampling location shall be marked via wooden stake placed at the nearest bank or shore. The sampling location number shall be marked with indelible ink on the stake.
- The following information shall be recorded in the field logbook:
  - ▶ Project location, date and time.
  - ▶ Weather.
  - ▶ Sample location number and sample identification number.
  - ▶ Flow conditions (i.e., high, low, in flood, etc.) and estimate of flow rate.
  - ▶ Visual description of water (i.e., clear, cloudy, muddy, etc.).
  - ▶ On-site water quality measurements.
  - ▶ Sketch of sampling location including boundaries of water body, sample location (and depth), relative position with respect to the site, location of wood identifier stake.
  - ▶ Names of sampling personnel.
  - ▶ Sampling technique, procedure, and equipment used.

General guidelines for collection of samples from larger streams, ponds or other water bodies are as follows:

- The most representative samples are obtained from mid-channel at mid-stream depth in a well-mixed stream.
- 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 may also proceed from zones suspected of low contamination to zones of high contamination.
- It is suggested that sample containers which do not contain preservative be rinsed at least once with the water to be sampled before the sample is taken.
- 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 composite sample, or several grids are selected at random.
- Care should be taken to avoid excessive agitation of the water that would result 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 inward. The bottle can be turned upside down to check for air bubbles after the bottle is filled and capped.

- 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 mouth of the bottle facing upstream.
- Measurements for temperature, pH, specific conductance, or other field parameters, as appropriate shall be collected immediately following sample collection for laboratory analysis.
- All samples shall be handled as described in SOP F301.
- Items to be recorded in the field logbook are the same as those described above for small streams.

### **5.3 Sediment Sampling**

Sediment samples usually are collected at the same locations as surface water samples. If only one sediment sample is to be collected, the sample location shall be approximately at the center of the water body. If, however, multiple samples are required, sediment samples should be collected along a cross-section to characterize the bed material. A common procedure for obtaining multiple samples is to sample at quarter points along the cross-section of flow. As with surface water samples, sediment samples should be collected from downstream to upstream.

#### **5.3.1 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, U. S. Coast Guard approved personal flotation devices 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
- Bucket/hand auger
- Stainless steel spoon or trowel

#### 5.3.1.1 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.

#### 5.3.1.2 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 permits 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 chance of metal contamination from the frame of the device.

#### 5.3.1.3 Bucket (Hand) Auger

Bucket (hand) augering is a viable method for collecting sediment samples in narrow, intermittent streams or tidal flats. Typically, a 4-inch auger bucket with a cutting head is pushed and twisted

into the ground and removed as the bucket is filled. The auger hole is advanced one bucket at a time, to a depth specified in the project plans.

When a specific vertical sampling interval is required, one auger bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a new bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of sediment should be removed from the bucket to minimize the changes of cross-contamination of the sample from fall-in of material from the upper portions of the hole. The bucket auger should be decontaminated between samples as outlined in SOP F502.

#### 5.3.1.4 Stainless Steel Spoon or Trowel

For loosely packed sediments, a stainless steel scoop or trowel can be used to collect a representative sample, in narrow intermittent streams or tidal flats.

Use the scoop or trowel to collect the sample from a desired depth. Remove heavy debris, rocks, and twigs before collecting the sample. Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, chain-of-custody record, and other required forms.

#### 5.3.2 **Sediment Sampling Procedure**

The following general procedure should be used, where applicable, for sampling sediment from springs, seeps, small streams, ditches, or other similar small bodies of water. Procedures sampling larger bodies of water (i.e., rivers, lakes, estuaries, etc.) should be developed on a project-specific basis, as needed.

- Sediment samples shall be collected only after the corresponding surface water sample has been collected, if one is to be collected.
- Sediment samples shall be collected from downstream locations to upstream locations.
- Samples shall be collected by excavating a sufficient amount of bottom material using a scoop, beaker, spoon, trowel, or auger. Samples should be collected with the sampling device facing upstream and the sample collected from downstream to upstream. Care should be taken to minimize the loss of fine-grained materials from the sample.
- The sample shall be transferred to the appropriate sample containers. Sampling personnel shall use judgment in removing large plant fragments to limit bias caused by bio-organic accumulation.

- All samples shall be handled as described in SOP F301.
- The sampling location shall be marked via a wooden stake placed at the nearest bank or shore. The sample location number shall be marked on the stake with indelible ink.
- The following information shall be recorded in the field logbook:
  - ▶ Project location, date and time.
  - ▶ Weather.
  - ▶ Sample location number and sample identification number.
  - ▶ Flow conditions.
  - ▶ Sketch of sampling location including boundaries of water body, sample location, water depth, sample collection depth, relative position with respect to the site, location of wooden identifier stake.
  - ▶ Chemical analyses to be performed.
  - ▶ Description of sediment (refer to SOP F001).

## 6.0 QUALITY ASSURANCE RECORDS

The description of the sampling event in the field logbook shall serve as a quality assurance record. Other records include chain-of-custody and sample analysis request forms as discussed in SOP F302.

## 7.0 REFERENCES

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**APPENDIX E**  
**DECONTAMINATION OF SAMPLING**  
**AND MONITORING EQUIPMENT**

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**DECONTAMINATION OF SAMPLING AND  
MONITORING EQUIPMENT**

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## DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

### 1.0 PURPOSE

The purpose of this SOP is to provide a general methodology and protocol, and to reference information for the proper decontamination of field chemical sampling and analytical equipment.

### 2.0 SCOPE

This procedure applies to all field sampling equipment including, but not limited to, split-barrel soil samplers (split-spoons), bailers, beakers, trowels, filtering apparatus, and pumps. This procedure should be consulted when decontamination procedures are being developed as part of project-specific plans. Additionally, current USEPA regional procedures and decontamination guidance as well as state guidance should be reviewed.

### 3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

### 4.0 RESPONSIBILITIES

**Project Manager** - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

**Field Team Leader** - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring field personnel performing decontamination activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader.

## 5.0 PROCEDURES

In order to ensure that chemical analysis results reflect actual concentrations present at sampling locations, sampling equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sampling locations) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sampling locations and the transfer of contamination off site.

Preferably, sampling equipment should be dedicated to a given sampling location. If this is not possible, equipment must be decontaminated between sampling locations. Sampling personnel also must use disposable gloves and change them between sampling locations.

### 5.1 Sampling Equipment Decontamination Procedures

Soil and sediment sampling equipment including, but not limited to trowels, beakers, dredges, etc., shall be decontaminated using the following USEPA Region procedures.

The following sections summarize decontamination procedures for USEPA Regions I through IV for overall comparison. Each region should be contacted prior to initiation of sampling activities to assure that the most recent, accepted decontamination procedures are used.

#### USEPA Region I

Prior to use, all sampling equipment should be carefully cleaned using the following procedure:

1. A dilute hydrochloric acid rinse
2. Deionized water rinse
3. Methanol or acetone rinse; and,
4. Distilled, organic-free water rinse.

For badly contaminated equipment, a hot water detergent wash may be needed prior to the rinse procedure. Additionally, a hexane rinse also may be needed, prior to the final distilled water rinse, when sampling for low-level organic pollutants.

### USEPA Region II

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Low-phosphate detergent wash (i.e., Alconox or Liquinox)
2. Tap water rinse
3. 10 percent nitric acid solution rinse
4. Tap water rinse
5. Methanol followed by a hexane or an acetone rinse
6. Analyte-free deionized water rinse
7. Air dry
8. Wrap in aluminum foil, shiny side out, for storage or transport

If the samples will not be analyzed for metals, then steps 3 and 4 may be omitted; if samples will not be analyzed for organics, then step 5 may be omitted. All solvents must be pesticide-grade.

### USEPA Region III

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Potable water rinse
2. Alconox or Liquinox detergent wash
3. Scrubbing, as necessary
4. Potable water rinse
5. 10 percent nitric acid rinse
6. Distilled-deionized water rinse
7. Methanol or hexane rinse
8. Distilled-deionized water rinse
9. Air dry

### USEPA Region IV

Prior to use, all sampling equipment will be decontaminated using the following procedures:

1. Clean with tap water and laboratory detergent using a brush if necessary to remove particulate matter and surface films.
  2. Rinse thoroughly with tap water.
  3. Rinse thoroughly with deionized water.
  4. Rinse twice with pesticide grade isopropanol.
  5. Rinse thoroughly with organic-free water and allow to air dry as long as possible.
  6. If organic-free water is not available, allow equipment to air dry as long as possible. Do not rinse with deionized or distilled water.
  7. Wrap with aluminum foil, if appropriate, to prevent contamination if equipment is going to be stored or transported.
- \* Portable power augers (such as the Little Beaver®) or large soil boring/drill rigs should be cleaned before boring or drilling operations.

## **5.2 Field Analytical Equipment Decontamination**

Field analytical equipment which may come in direct contact with the sample or sample media, including, but not limited to water level meters, water/product level meters, pH or specific ion probes, specific conductivity probes, thermometers, and/or borehole geophysical probes must be decontaminated before and after use, according to the procedures outlined in Section 5.1, unless manufacturers instructions indicate otherwise. Probes that contact water samples not used for laboratory analyses may be rinsed with distilled water. Probes which make no direct contact (e.g. HNu or OVA probes) will be wiped clean with clean paper towels or an alcohol-saturated cloth.

## **6.0 QUALITY ASSURANCE RECORDS**

Decontamination procedures are monitored through the collection of equipment rinsate samples and field blanks. Collection of these samples shall be specified in the project-specific Sampling and Analysis and Quality Assurance Plans following the requirements of NEESA 20.2-047B. Documentation recorded in the field logbook also shall serve as a quality assurance record.

## 7.0 REFERENCES

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**APPENDIX F**  
**DECONTAMINATION OF DRILL RIGS AND**  
**MONITORING WELL MATERIALS**

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**DECONTAMINATION OF DRILLING RIGS  
AND MONITORING WELL MATERIALS**

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## DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

### 1.0 PURPOSE

The purpose of this SOP is to provide a general reference regarding the proper decontamination of drilling rigs and monitoring well materials used in the performance of field investigations.

### 2.0 SCOPE

This procedure addresses drilling equipment, test pit equipment (i.e. backhoe) and monitoring well material decontamination and should be consulted during the preparation of project-specific plans. This procedure does not pertain to personnel decontamination, or to chemical sampling or field analytical equipment decontamination.

### 3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

### 4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring the field personnel overseeing decontamination activities, and personnel conducting the activities have been briefed and trained to execute these procedures.

Drilling Inspector (Site Geologist, Rig Geologist etc.) - It is the responsibility of the drilling inspector to ensure that the drilling subcontractor follows these, or other project-specific procedures as directed by the Field Team Leader.

### 5.0 PROCEDURE

The various drilling equipment and materials involved with test boring, test pit excavation, subsurface soil sampling, and monitoring well construction must be properly decontaminated to ensure that chemical analysis results reflect actual concentrations present at sampling locations. These procedures will minimize the potential for cross contamination between sampling locations and the transfer of contamination off site.

### **5.1 Equipment**

All drilling equipment involved in field sampling activities shall be decontaminated prior to drilling, excavation, or sampling activities. Such equipment includes drilling rigs, backhoes, augers, downhole tools, well casings, and screens. Split-spoon soil samplers and other similar soil sampling devices shall be decontaminated according to the procedures given in SOP F502.

### **5.2 Decontamination Procedures**

Prior to drilling, or leaving the site, large equipment not directly utilized for sampling will be decontaminated by steam-cleaning in a designated area. The decontamination procedure consists of steam-cleaning the equipment, using potable water as the steam source, to remove visible signs of soils or wastes, and allowing the equipment to air dry. If necessary, the equipment may be cleaned with a scrub brush and alconox/liquinox-water solution prior to steam cleaning to remove visible signs of contamination.

The steam cleaning area will 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 tank. A shallow, above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

At certain sites, due to the type of contaminants or proximity to residences, concerns may exist about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing one or more of the following practices:

- Locate the steam cleaning area on site to minimize potential impacts.
- Enclose steam cleaning operations. For example, augers and drilling rods can be steam cleaned in drums. Tarpaulins also can be placed around the steam cleaning area to control emissions.

For a given project, the location of the steam cleaning area will be identified in the Sampling and Analysis Plan.

Decontamination wastes will be collected and contained unless otherwise directed by LANTDIV. The eventual disposition of these wastes will be determined on a project-specific basis, but may include on-site treatment and/or transport off site to an approved treatment/disposal facility.

### **6.0 QUALITY ASSURANCE RECORDS**

Rinsate samples may be collected from steam-cleaned equipment as quality assurance records. The frequency of rinsate samples from either drilling tools or well casings/screens shall be specified in the Sampling and Analysis and Quality Assurance Project Plans for a given project, as appropriate.

Documentation in the field logbook also shall serve as a quality assurance record of decontamination activities.

## 7.0 REFERENCES

None.

**APPENDIX G**  
**ON-SITE WATER QUALITY TESTING**

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**ON-SITE WATER QUALITY TESTING  
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## ON-SITE WATER QUALITY TESTING (FIELD PARAMETERS)

### 1.0 PURPOSE

This SOP describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance (Sc)/Salinity
- Temperature (T)
- Dissolved Oxygen Concentration (DO)
- Turbidity (Secchi Disc)

The first three are the usual field parameters; dissolved oxygen may be used in particular applications according to project requirements.

### 2.0 SCOPE

These procedures are applicable for use in an on-site water quality monitoring program to be conducted during a Remedial Investigation or Site Investigation at a hazardous or nonhazardous 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.

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 DEFINITIONS

Conductance - A measurement of water's capacity for conveying electrical current and is directly related to the concentrations of ionized substances in the water. The units of measurement for conductance (mhos) are the inverse of ohms, the unit commonly used to express resistance. Conductivity and specific conductance are used synonymously.

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.

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.

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration. The range of pH is 0 to 14 standard units.

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 (in units of volts), I is the current (in units of Amperes), and R is the resistance (in units of ohms).

Secchi disc - A metal disc having four quadrants, two opposing ones painted black and the other two either white or unpainted. The Secchi disc is used to measure turbidity based on the depth of light penetration.

Turbidity - An optical property of water that causes light to be scattered or absorbed in the water, resulting in decrease in water transparency. It is a function of at least three variables: 1) dissolved chemicals, such as tannins, acids, or salts; 2) suspended particles, such as silt, clay, and organic matter; and, 3) density of microbial and planktonic life.

Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants.

#### 4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for determining which on-site water quality measurements shall be made, the data quality objectives (DQOs) for these measurements, and for ensuring that these measurements are made in accordance with project-specific plans.

Field Team Leader - The Field Team Leader is responsible for determining that these water quality measurement procedures are implemented in the field in accordance with this SOP, or in accordance with project-specific plans, and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures for collecting on-site water quality measurements including instrument calibration, quality control and recording of results, as well as care and maintenance of the instruments in the field.



## 5.0 PROCEDURES

The following sections provide general procedures for collecting pH, specific conductance/salinity, temperature, dissolved oxygen concentration and turbidity measurements.

### 5.1 Measurement of pH

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 also can 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; specific measurement techniques for solids are not described here.

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; the pH meter is used 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 most cases, use of a pH meter will be required.

#### 5.1.1 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity 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 the establishment of a potential difference across a glass or other type of 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.

#### 5.1.2 Equipment

The following equipment and reagents are needed for taking pH measurements:

- Portable pH meter, or pH indicator paper, such as Mydrion or Alkacid, to cover the pH range 2 through 12.
- Laboratory-prepared buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

### 5.1.3 Measurement Techniques for Field Determination of pH

#### A. pH Meter

Standardization, calibration, and operation and maintenance shall be performed according to the manufacturers instructions. The following procedure is used for measuring pH with a pH meter:

1. The batteries and instrument shall be checked and calibrated prior to initiation of the field effort.
2. 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.
3. 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.
4. 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).
5. Immerse the electrode(s) in a pH-7 buffer solution.
6. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). It is best to maintain the buffer solution at or near expected sample temperature before calibration, if possible.
7. Adjust the pH meter to read 7.0.
8. Remove the electrode(s) from the buffer and rinse well with distilled-deionized 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.

9. 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.
10. After adjusting the temperature compensator to the sample temperature, read and record the pH of the solution. The pH value shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature. All measurements shall be recorded in the Field Logbook.
11. Upon completion of measurement and removal of the electrode from the sample, the electrode shall be thoroughly rinsed with deionized water.
12. The electrode(s) shall remain 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 within the electrode, 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 in the Field Logbook.

**B. 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, or 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/Salinity**

Conductance provides a measure of dissolved ionic species in water and can be used to suggest the direction and extent of migration of contaminants in groundwater or surface water. Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants. One basic measure of salinity is the ability of water to conduct electric current, and, therefore, a measurement of specific conductance provides a measurement of salinity and the same instrument can be used. Salinity measurements are important in ecological field investigations because flora and fauna can be limited in their distribution based on the salinity of the sampled waters.

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 and salinity measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

### **5.2.1 Principles of Equipment Operation**

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions (cations) migrate toward the negative electrode (cathode), while the negatively charged ions (anions) migrate toward the positive electrode (anode). 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 also may 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.

### **5.2.2 Equipment**

A portable conductivity meter, probe and thermometer are needed for taking specific conductance and salinity measurements. A variety of conductivity meters are available which also may be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirements of the sampling program.

### **5.2.3 Measurement Techniques for Specific Conductance/Salinity**

Standardization, calibration, and operation and maintenance shall be performed according to manufacturers instructions. The steps involved in taking specific conductance and salinity measurements are listed below.

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Calibration information shall be recorded in the field logbook.

3. Rinse the cell with one or more portions of the sample to be tested or with deionized water.
4. Immerse the electrode in the sample and measure the conductivity and salinity. If specified, adjust the temperature setting to the sample temperature.
5. Read and record the results on the Calibration Form (in the absence of the Calibration Form, the Field Logbook will be used).
6. If the meter does not compensate for temperature variations, the corrections given in Attachment A shall be applied.
7. On some meters, specific conductivity and salinity measurements may need to be reported with the associated temperature measurement. If the conductivity and salinity has been corrected, the measurements shall be reported as "corrected to 25°C." (See Attachment A)
  - a. Do not take readings if the sample temperature is less than 10° C, because the calibration curve no longer follows a straight line below this temperature. If necessary, heat the sample in your vehicle to at least 10° C.
  - b. Measure the sample temperature to the nearest 0.1° C to comply with SW-846.
  - c. Only report results to the nearest two significant digits for the most circumstances, because of the inherent inaccuracy in the test and conversion procedure.

examples:

- a calculated reading of 2353 umhos/cm @ 25° C should be reported as 2400 umhos/cm @ 25° C
- a calculated reading of 2325 should be reported as 2300
- a calculated reading of 337 should be reported as 340
- etc.

### 5.3 Measurement of Temperature

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 prior to sample collection. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

### 5.3.1 Equipment

Temperature measurements may be taken with Thermistor, alcohol-toluene, mercury or bimetal 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 can be performed.

### 5.3.2 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 to the nearest 0.5 or 0.1°C, depending on the measurement device used.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to the manufacturer's recommendations with an approved thermometer.

## 5.4 Measurement of Dissolved Oxygen Concentration

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 discussed here 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. DO meters also are free from interference caused by color, turbidity, colloidal material or suspended matter.

### 5.4.1 Principles of Equipment Operation

Dissolved oxygen probes normally are electrochemical cells that have two solid metal electrodes of different potential immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of higher 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 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 gaseous interference is suspected, it shall be noted in the Field Logbook and checked if possible. Temperature variations also can cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation normally is provided by the manufacturer. Attachment B presents variations of DO in water as a function of temperature and salinity.

#### **5.4.2 Equipment**

The following, similar or equivalent, equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor (or equivalent).
- Dissolved oxygen/temperature probe.
- Sufficient cable to allow the probe to contact the sample.

#### **5.4.3 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.

1. Calibrate equipment and check batteries in the laboratory before going to the field.
2. The probe shall be conditioned in a water sample for as long 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.
3. 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).

4. 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 which are placed in wells should be moved up and down.
5. Record the dissolved oxygen content and temperature of the sample in a Field Logbook.
6. Recalibrate the probe when the membrane is replaced, or following similar maintenance, 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 whether a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen dissolution and positive test interferences.

#### **5.5 Measurement of Turbidity Using a Secchi Disc**

In combination with other parameters, turbidity can be a useful indicator of the likelihood of biological action in a water body. It can be used to determine the depth of light penetration of surface water and the distribution and intensity of photosynthesis in the body of water. Turbidity measurements shall be taken in-situ with a Secchi disc.

##### **5.5.1 Equipment**

Turbidity measurements may be taken with a Secchi disc. In addition, turbidity may be measured using a colimeter or a spectrophotometer. These are ex-situ measurements conducted in a laboratory environment.

##### **5.5.2 Measurement Techniques for Turbidity**

Observations must be made through a shaded area of water surface.

- Standard conditions for the use of the Secchi disc are: 1) clear sky; (2) sun directly overhead; 3) shaded, protected side of boat or under a sun shade; 4) minimal waves or ripples; and, 5) any departure from these conditions should be specifically stated on field sheets.
- Rope accurately graduated in meters with 0.1 meter graduations for the first meter and 0.5 meters thereafter.
- Observer's eye should be 1 meter above the surface of the water.



- Observations should be made during the middle of the day.
- Lower the disc into the water, noting the depth at which it disappears, then lift the disc and note the depth at which it reappears. The average of the two readings is considered to be the limit of visibility and is recorded in a Field Logbook to the nearest 0.1 meter (first meter) or 0.5 meter, depending on the depth of visibility.

## 6.0 QUALITY ASSURANCE RECORDS

Quality assurance records for on-site water quality management consists principally of observations and measurements recorded in the Field Logbook. Records of instrument calibration, malfunction, repair, etc., shall be maintained in an Equipment Logbook as described in the Navy CLEAN Contractor Quality Control Plan.

## 7.0 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.

**ATTACHMENT A**

**SPECIFIC CONDUCTANCE CONVERSION TABLE**

**ATTACHMENT A**  
**SPECIFIC CONDUCTANCE CONVERSION TABLE**

| Temperature<br>Degrees C | Calculated<br>Multiplier | Temperature<br>Degrées C | Calculated<br>Multiplier | Temperature<br>Degrees C | Calculated<br>Multiplier | Temperature<br>Degrees C | Calculated<br>Multiplier | Temperature<br>Degrees C | Calculated<br>Multiplier |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 10                       | 1.402                    | 12                       | 1.330                    | 14                       | 1.266                    | 16                       | 1.208                    | 20                       | 1.106                    |
| 10.1                     | 1.398                    | 12.1                     | 1.327                    | 14.1                     | 1.263                    | 16.1                     | 1.205                    | 20.1                     | 1.103                    |
| 10.2                     | 1.394                    | 12.2                     | 1.324                    | 14.2                     | 1.260                    | 16.2                     | 1.202                    | 20.2                     | 1.101                    |
| 10.3                     | 1.390                    | 12.3                     | 1.320                    | 14.3                     | 1.257                    | 16.3                     | 1.199                    | 20.3                     | 1.099                    |
| 10.4                     | 1.387                    | 12.4                     | 1.317                    | 14.4                     | 1.254                    | 16.4                     | 1.197                    | 20.4                     | 1.096                    |
| 10.5                     | 1.383                    | 12.5                     | 1.314                    | 14.5                     | 1.251                    | 16.5                     | 1.194                    | 20.5                     | 1.094                    |
| 10.6                     | 1.379                    | 12.6                     | 1.310                    | 14.6                     | 1.248                    | 16.6                     | 1.191                    | 20.6                     | 1.092                    |
| 10.7                     | 1.376                    | 12.7                     | 1.307                    | 14.7                     | 1.245                    | 16.7                     | 1.188                    | 20.7                     | 1.089                    |
| 10.8                     | 1.372                    | 12.8                     | 1.304                    | 14.8                     | 1.242                    | 16.8                     | 1.186                    | 20.8                     | 1.087                    |
| 10.9                     | 1.369                    | 12.9                     | 1.301                    | 14.9                     | 1.239                    | 16.9                     | 1.183                    | 20.9                     | 1.085                    |
| 11                       | 1.365                    | 13                       | 1.297                    | 15                       | 1.236                    | 17                       | 1.180                    | 21                       | 1.083                    |
| 11.1                     | 1.361                    | 13.1                     | 1.294                    | 15.1                     | 1.233                    | 17.1                     | 1.178                    | 21.1                     | 1.080                    |
| 11.2                     | 1.358                    | 13.2                     | 1.291                    | 15.2                     | 1.230                    | 17.2                     | 1.175                    | 21.2                     | 1.078                    |
| 11.3                     | 1.354                    | 13.3                     | 1.288                    | 15.3                     | 1.227                    | 17.3                     | 1.172                    | 21.3                     | 1.076                    |
| 11.4                     | 1.351                    | 13.4                     | 1.285                    | 15.4                     | 1.225                    | 17.4                     | 1.170                    | 21.4                     | 1.074                    |
| 11.5                     | 1.347                    | 13.5                     | 1.281                    | 15.5                     | 1.222                    | 17.5                     | 1.167                    | 21.5                     | 1.072                    |
| 11.6                     | 1.344                    | 13.6                     | 1.278                    | 15.6                     | 1.219                    | 17.6                     | 1.165                    | 21.6                     | 1.069                    |
| 11.7                     | 1.341                    | 13.7                     | 1.275                    | 15.7                     | 1.216                    | 17.7                     | 1.162                    | 21.7                     | 1.067                    |
| 11.8                     | 1.337                    | 13.8                     | 1.272                    | 15.8                     | 1.213                    | 17.8                     | 1.159                    | 21.8                     | 1.065                    |
| 11.9                     | 1.334                    | 13.9                     | 1.269                    | 15.9                     | 1.210                    | 17.9                     | 1.157                    | 21.9                     | 1.063                    |
| 22                       | 1.061                    | 24                       | 1.019                    | 26                       | 0.981                    | 28                       | 0.946                    | 30                       | 0.913                    |
| 22.1                     | 1.059                    | 24.1                     | 1.017                    | 26.1                     | 0.979                    | 28.1                     | 0.944                    | 30.1                     | 0.911                    |
| 22.2                     | 1.057                    | 24.2                     | 1.016                    | 26.2                     | 0.978                    | 28.2                     | 0.942                    | 30.2                     | 0.910                    |
| 22.3                     | 1.054                    | 24.3                     | 1.014                    | 26.3                     | 0.976                    | 28.3                     | 0.941                    | 30.3                     | 0.908                    |
| 22.4                     | 1.052                    | 24.4                     | 1.012                    | 26.4                     | 0.974                    | 28.4                     | 0.939                    | 30.4                     | 0.907                    |
| 22.5                     | 1.050                    | 24.5                     | 1.010                    | 26.5                     | 0.972                    | 28.5                     | 0.937                    | 30.5                     | 0.905                    |
| 22.6                     | 1.048                    | 24.6                     | 1.008                    | 26.6                     | 0.970                    | 28.6                     | 0.936                    | 30.6                     | 0.903                    |
| 22.7                     | 1.046                    | 24.7                     | 1.006                    | 26.7                     | 0.969                    | 28.7                     | 0.934                    | 30.7                     | 0.902                    |
| 22.8                     | 1.044                    | 24.8                     | 1.004                    | 26.8                     | 0.967                    | 28.8                     | 0.932                    | 30.8                     | 0.900                    |

**ATTACHMENT A (Continued)**  
**SPECIFIC CONDUCTANCE CONVERSION TABLE**

| Temperature<br>Degrees C | Calculated<br>Multiplier | Temperature<br>Degrees C | Calculated<br>Multiplier | Temperature<br>Degrees C | Calculated<br>Multiplier | Temperature<br>Degrees C | Calculated<br>Multiplier | Temperature<br>Degrees C | Calculated<br>Multiplier |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 22.9                     | 1.042                    | 24.9                     | 1.002                    | 26.9                     | 0.965                    | 28.9                     | 0.931                    | 30.9                     | 0.899                    |
| 23                       | 1.040                    | 25                       | 1.000                    | 27                       | 0.963                    | 29                       | 0.929                    | 31                       | 0.897                    |
| 23.1                     | 1.038                    | 25.1                     | 0.998                    | 27.1                     | 0.961                    | 29.1                     | 0.927                    | 31.1                     | 0.896                    |
| 23.2                     | 1.036                    | 25.2                     | 0.996                    | 27.2                     | 0.960                    | 29.2                     | 0.926                    | 31.2                     | 0.894                    |
| 23.3                     | 1.034                    | 25.3                     | 0.994                    | 27.3                     | 0.958                    | 29.3                     | 0.924                    | 31.3                     | 0.893                    |
| 23.4                     | 1.032                    | 25.4                     | 0.992                    | 27.4                     | 0.956                    | 29.4                     | 0.922                    | 31.4                     | 0.891                    |
| 23.5                     | 1.029                    | 25.5                     | 0.991                    | 27.5                     | 0.954                    | 29.5                     | 0.921                    | 31.5                     | 0.890                    |
| 23.6                     | 1.027                    | 25.6                     | 0.989                    | 27.6                     | 0.953                    | 29.6                     | 0.919                    | 31.6                     | 0.888                    |
| 23.7                     | 1.025                    | 25.7                     | 0.987                    | 27.7                     | 0.951                    | 29.7                     | 0.918                    | 31.7                     | 0.887                    |
| 23.8                     | 1.023                    | 25.8                     | 0.985                    | 27.8                     | 0.949                    | 29.8                     | 0.916                    | 31.8                     | 0.885                    |
| 23.9                     | 1.021                    | 25.9                     | 0.983                    | 27.9                     | 0.948                    | 29.9                     | 0.914                    | 31.9                     | 0.884                    |

Notes:

- Do not make specific conductance measurements at temperatures below 10° C.
- Measure temperature to the nearest 0.1° C.
- Report all conductivities at 25° C, to two significant digits.
- This conversion table is based on a temperature coefficient of 0.0191 (as per SW-846) and a cell constant of 1, where the ratio of conductivity at 25 C to the conductivity at temperature t° C equals  $1/(1+0.0191[t-25])$ .
- The temperature coefficient and cell constants are only approximate, actual values may differ.
- The more the temperature deviates from 25° C, the greater the uncertainty in applying the temperature correction.

**ATTACHMENT B**

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

ATTACHMENT B

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

| Temperature<br>°C | Dissolved Oxygen mg/l           |       |        |        |        |                                |
|-------------------|---------------------------------|-------|--------|--------|--------|--------------------------------|
|                   | Chloride Concentration in Water |       |        |        |        | Difference/<br>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   | 0.106                          |
| 2                 | 13.8                            | 13.1  | 12.3   | 11.5   | 10.8   | 0.015                          |
| 3                 | 13.5                            | 12.7  | 12.0   | 11.2   | 10.5   | 0.015                          |
| 4                 | 13.1                            | 12.4  | 11.7   | 11.0   | 10.3   | 0.014                          |
| 5                 | 12.8                            | 12.1  | 11.4   | 10.7   | 10.0   | 0.014                          |
| 6                 | 12.5                            | 11.8  | 11.1   | 10.5   | 9.8    | 0.014                          |
| 7                 | 12.2                            | 11.5  | 10.9   | 10.2   | 9.6    | 0.013                          |
| 8                 | 11.9                            | 11.2  | 10.6   | 10.0   | 9.4    | 0.013                          |
| 9                 | 11.6                            | 11.0  | 10.4   | 9.8    | 9.2    | 0.012                          |
| 10                | 11.3                            | 10.7  | 10.1   | 9.6    | 9.0    | 0.012                          |
| 11                | 11.1                            | 10.5  | 9.9    | 9.4    | 8.8    | 0.011                          |
| 12                | 10.8                            | 10.3  | 9.7    | 9.2    | 8.6    | 0.011                          |
| 13                | 10.6                            | 10.1  | 9.5    | 9.0    | 8.5    | 0.011                          |
| 14                | 10.4                            | 9.9   | 9.3    | 8.8    | 8.3    | 0.010                          |
| 15                | 10.2                            | 9.7   | 9.1    | 8.6    | 8.1    | 0.010                          |
| 16                | 10.0                            | 9.5   | 9.0    | 8.5    | 8.0    | 0.010                          |
| 17                | 9.7                             | 9.3   | 8.8    | 8.3    | 7.8    | 0.010                          |
| 18                | 9.5                             | 9.1   | 8.6    | 8.2    | 7.7    | 0.009                          |
| 19                | 9.4                             | 8.9   | 8.5    | 8.0    | 7.6    | 0.009                          |
| 20                | 9.2                             | 8.7   | 8.3    | 7.9    | 7.4    | 0.009                          |
| 21                | 9.0                             | 8.6   | 8.1    | 7.7    | 7.3    | 0.009                          |
| 22                | 8.8                             | 8.4   | 8.0    | 7.6    | 7.1    | 0.008                          |
| 23                | 8.7                             | 8.3   | 7.9    | 7.4    | 7.0    | 0.008                          |
| 24                | 8.5                             | 8.1   | 7.7    | 7.3    | 6.9    | 0.008                          |
| 25                | 8.4                             | 8.0   | 7.6    | 7.2    | 6.7    | 0.008                          |

**ATTACHMENT B**  
**(Continued)**  
**VARIATION OF DISSOLVED OXYGEN CONCENTRATION**  
**IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY**

| Temperature<br>°C | Dissolved Oxygen mg/l           |       |        |        |        |                                |
|-------------------|---------------------------------|-------|--------|--------|--------|--------------------------------|
|                   | Chloride Concentration in Water |       |        |        |        | Difference/<br>100 mg chloride |
|                   | 0                               | 5,000 | 10,000 | 15,000 | 20,000 |                                |
| 26                | 8.2                             | 7.8   | 7.4    | 7.0    | 6.6    | 0.008                          |
| 27                | 8.1                             | 7.7   | 7.3    | 6.9    | 6.5    | 0.008                          |
| 28                | 7.9                             | 7.5   | 7.1    | 6.8    | 6.4    | 0.008                          |
| 29                | 7.8                             | 7.4   | 7.0    | 6.6    | 6.3    | 0.008                          |
| 30                | 7.6                             | 7.3   | 6.9    | 6.5    | 6.1    | 0.008                          |

**Note:** In a chloride solution, conductivity can be roughly related to chloride concentration (and therefore used to correct measured D.O. concentration) using Attachment A.

**APPENDIX H**  
**WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS**  
**AND WELL DEPTH MEASUREMENTS**

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**WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND  
WELL DEPTH MEASUREMENTS  
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  - 5.1 Water Level Measurement
  - 5.2 Groundwater-Product Interface Level Measurement
  - 5.3 Well Depth Measurements
  - 5.4 Decontamination of Measuring Devices
- 6.0 QUALITY ASSURANCE RECORDS**

## **WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS**

### **1.0 PURPOSE**

The purpose of this procedure is to describe the method of determining various down-hole measurements: groundwater levels and product (or non-aqueous phase liquid, NAPL) levels, if present, and total depth of groundwater monitoring wells and piezometers.

### **2.0 SCOPE**

The methods described in this SOP generally are applicable to the measurement of groundwater levels, product or NAPL levels, and well depths in monitoring wells and piezometers.

### **3.0 DEFINITIONS**

None.

### **4.0 RESPONSIBILITIES**

**Project Manager** - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed.

**Field Team Leader** - The Field Team Leader is responsible for ensuring that these procedures are implemented in the field, and for ensuring that personnel performing these activities have been briefed and trained to execute these procedures.

**Sampling Personnel** - It is the responsibility of the sampling personnel to follow these procedures or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of down-hole measurements.

### **5.0 PROCEDURES**

Calculations of groundwater elevations and product or NAPL interface level measurements collected from a monitoring well give an indication of:

- The horizontal hydraulic gradient and the direction of groundwater flow.
- The vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane).

- Floating or sinking product thicknesses which are also known as Light Non-Aqueous Phase Liquids (LNAPLS) and Dense Non-Aqueous Phase Liquids (DNAPLS), respectively.

This information, when combined with other site specific information such as hydraulic conductivity or transmissivity, extent of contamination, and product density, may be used to estimate the rate of contaminant movement or source areas, etc.

Well depth is one of the factors used to determine the zone that a well monitors. Well depth also is used in the calculation of purge volumes as discussed in SOP F104, Groundwater Sample Acquisition.

The following sections briefly discuss the procedures for measuring groundwater levels, product or NAPL levels, and well depth. For all of the procedures discussed, it is assumed that the measurement will be taken from the top of the PVC or stainless steel casing (though other measuring points can be used), and that horizontal and vertical control is available for each well through a site survey, such that measurements may be converted to elevations above Mean Sea Level (MSL) or some other consistent datum. A permanent notch, placed on the inner PVC or stainless steel casing by the surveyor will facilitate consistent water level measurements.

The manufacturer's instructions for all equipment referenced herein should be read by the equipment operator(s) and accompany the equipment to the field.

### **5.1 Water Level Measurement**

Water levels in groundwater monitoring wells shall be measured from the permanent point indicated at the top of the inner casing (the surveyed elevation point, as marked by the surveyor), unless otherwise specified in the project plans, using an electronic water level measuring device (water level indicator). The point of measurement will be documented in the field logbook if different from the top of the inner casing. The reason for deviating from the measurement point should also be noted.

Water levels are measured by lowering the probe into the well until the device indicates that water has been encountered, usually with either a constant buzz, or a light, or both. The water level is recorded to the nearest foot (0.01) using the graduated markings on the water level indicator cord. This measurement, when subtracted from the measuring point elevation, yields the groundwater elevation.

Groundwater levels shall always be measured to the nearest 0.01 foot. However, reporting of water level elevations depends on the accuracy of the vertical control (typically either 0.1 or 0.01 foot).

## 5.2 Product or NAPL Level Measurements

The procedure for product or NAPL level measurement is nearly identical to that for groundwater elevation measurements. The only differences are the use of an interface probe that detects both NAPLs and water, and the indication signal given by the measurement device. Typically, encountering NAPLs in a monitoring well is indicated by a constant sound. When water is encountered, the signal becomes an alternating on/off beeping sound. This allows for the collection of measurements for both the top of the NAPL layer in a well and the water/NAPL interface.

The apparent water table elevation below the product level will be determined by subtracting the "depth to water" from the measuring point elevation. The corrected water table elevation will then be calculated using the following equation:

$$WTE_c = WTE_a + (\text{Free Product Thickness} \times 0.80)$$

Where:

|         |   |                                                                                                           |
|---------|---|-----------------------------------------------------------------------------------------------------------|
| $WTE_c$ | = | Corrected water table elevation                                                                           |
| $WTE_a$ | = | Apparent water table elevation                                                                            |
| 0.80    | = | Average value for the density of petroleum hydrocarbons. Site-specific data will be used where available. |

## 5.3 Well Depth Measurements

Well depths typically are measured using a weighted measuring tape. A water level meter may also be used. The tape is lowered down the well until resistance is no longer felt, indicating that the weight has touched the bottom of the well. The weight should be moved in an up and down motion a few times so that obstructions, if present, may be bypassed. The slack in the tape then is collected until the tape is taut. The well depth measurement is read directly off of the measuring tape, at the top of the PVC or stainless steel casing, to the nearest 0.01-foot and recorded in the Field Logbook. If a water level indicator is used, add the distance from the bottom of the probe to the point where water levels are measured.

## 5.4 Decontamination of Measuring Devices

Water level indicators, interface probes and weighted measuring tapes that come in contact with groundwater must be decontaminated using the following steps after use in each well:

- Rinse with potable water
- Rinse with deionized water
- Rinse with Methanol or Isopropanol

- Rinse with deionized water

Portions of the water level indicators or other similar equipment that do not come into contact with groundwater, but may encounter incidental contact during use, need only undergo potable water and deionized water rinses.

## **6.0 QUALITY ASSURANCE RECORDS**

The Field Logbook shall serve as the quality assurance record for water, product level or well depth measurements.

**APPENDIX I**  
**PHOTOIONIZATION DETECTOR (PID)**  
**HNU MODELS PI 101 AND DL 101**

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**PHOTOIONIZATION DETECTOR (PID)  
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**PHOTOIONIZATION DETECTOR (PID)  
HNu MODELS PI 101 and DL 101**

**1.0 PURPOSE**

The purpose of this SOP is to provide general reference information for using the HNu Model PI 101 or DL 101 photoionization detector (PID), or an equivalent or similar instrument, in the field. Calibration and operation, along with field maintenance will be included in this SOP.

**2.0 SCOPE**

This procedure provides information on the field operation and general maintenance of the HNu (PID). Application of the information contained herein will ensure that this type of field monitoring equipment will be used properly. Review of the manufacturer's instruction manual is necessary for more complete information.

These procedures refer only to monitoring for health and safety. The methods are not directly applicable to surveillance of air quality for analytical purposes.

**3.0 DEFINITIONS**

Ionization Potential - In this case, a numeric equivalent that expresses the amount of energy needed to replace an electron with a photon. This energy is further defined in terms of electron volts (eV).

PID - Photoionization Detector

ppm - parts per million: parts of vapor or gas per million parts of air (directly proportional to calibration gas).

**4.0 RESPONSIBILITIES**

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.



Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in both the Field Logbook and the daily Realtime Air Monitoring Log during each field investigation.

## 5.0 PROCEDURES

The HNu utilizes the principle of photoionization whereby contaminant molecules enter the ion chamber and electrons are displaced by ultraviolet photons producing positive ions. These displaced positive ions are in turn collected on a special electrode. As the positive ions collect on the electrode, they create an electrical current which is amplified and displayed on the meter as a concentration in parts per million (ppm).

The HNu is only effective for contaminants that have ionization potentials (IP) of less than or equal to the electron volt (eV) capacity of the lamp (i.e., methane, having an IP of 12.98 eV, will not be detected at a lamp potential of 11.7 eV). The standard lamp is 10.2 eV with optional lamps of 9.5 eV and 11.7 eV, respectively. For the PI 101 the span settings should be as follows: 1.0 for 9.5 eV lamps; 9.8 for 10.2 eV lamps; and 5.0 for 11.7 eV lamps. During calibration, these span settings will be adjusted as necessary, using the span control knob.

The following subsections will discuss HNu calibration, operation, and maintenance. These sections, however, should not be used as a substitute for the manufacturer's instruction manual.

### 5.1 Calibration

For calibration purposes, the following items will be needed:

- \*Gas cylinder containing 95 to 100 parts per million (ppm) of isobutylene, balance in air.
- A 0.30 liters per minute regulator.
- Connector tubing.
- Screwdriver set.
- Calibration Gas Humidifier (for high humidity environments).
- Photoionization Detector (PID) Calibration Form.

\*Note: Do not rely on accuracy of rated cylinder concentration when content drops to <200 psi.

Prior to each use, make sure that the battery is fully charged, the ultraviolet lamp is working, and that the fan is operating and drawing air into the probe (fan operates at approximately 100-200

cc/minute for the PI 101 and 225 cc/minute for the DL 101). Procedures for completing these preliminary activities are given in the manufacturer's instruction manual.

### **PI 101**

To calibrate the HNu PI 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 3-5 in the manufacturer's instruction manual. The HNu PI 101 should be calibrated on a daily basis.

- Turn the function control switch to the standby position and zero the instrument by turning the zero adjustment knob to align the indicator needle with zero on the readout meter.
- Set the range on the HNu and allow the instrument to warm up a few minutes before calibrating. Choices for range are 0-20, 0-200, and 0-2,000 ppm, respectively. Range choice must take into account the concentration of the calibration gas. For example, if you are using a concentration of 100 ppm isobutylene as the calibration gas, your range should be set on the 0-200 scale. If you have to zero the instrument in the desired range, record background if present.
- Attach tubing to the regulator (use the Calibration Gas Humidifier in high humidity environments).
- Attach the free end of the tubing to the probe and turn on the calibration gas.
- Calibrate the PID to benzene equivalents. Using the 10.2 eV (lamp) probe and 100 ppm isobutylene, the meter should read 56 units. Using the 11.7 eV (lamp) probe and 100 ppm isobutylene, the meter should read 65 units. If the reading on the meter is not  $\pm 5$  percent of the concentration of the calibration gas, adjust the span setting knob until the meter reads accordingly. If after adjusting the span setting knob the readout meter is still not responding, refer to the manufacturer's instruction manual. Also, when the HNu is calibrated it should respond to a minimum of 90 percent of the concentration of the calibration gas within three seconds after introduction of that gas. If proper calibration cannot be obtained, internal calibration may be required. Note, only qualified personnel should perform internal calibrations.
- Record the calibration on the "Photoionization Detector (PID) Calibration Form".

### **DL 101**

To calibrate the HNu DL 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 4.4 in the manufacturer's instruction manual.

- Press and release the POWER button on the keypad and wait for the screen to stabilize then press the CALIBRATE key until "Calibrate?" appears. At this point press the ENTER key until "Elec\_Zero? Yes" appears on the screen in which case you will press the ENTER key, again, to confirm the electronic zero.
- The display will now read "CE/ENT/EXIT Conc = \_\_\_\_ ppm" which requires the concentration of the calibration gas (noted on the side of the calibration gas bottle) to be entered on the keypad. The display will prompt you to "Attach gas to probe and /ENTER/" so attach tubing to probe (use the calibration gas humidifier in high humidity environments), open valve, and press ENTER key. Press ENTER again when "Press ENTER when Ready: xxx ppm" appears on screen. This will cause "Calibrating...Please Wait" to appear on screen.

Note: This calibration is effective when the instrument is in the Survey Mode, which is the default mode. For calibrations other the one described, or if proper calibration cannot be obtained, refer to the manufacturer's instruction manual.

- For calibrations using an alternate gas or span values, refer to Section 4.5 of the manufacturer's instruction manual.
- Record the calibration on the "Photoionization Detector (PID) Calibration Form" which accompanies each HNu.

## 5.2 Operation

### PI 101

Note: IMPORTANT - The HNu should be "zeroed" in a fresh air environment if at all possible. If there is a background concentration, it must be documented and then zeroed out.

- Prior to each use of the HNu, check that the battery is fully charged by turning the dial to BATT and making sure that it is within range. Also make sure that the ultraviolet lamp and the fan are working properly.
- Select your desired range. HNu ranges consists of a 0-20, 0-200, and 0-2,000 ppm, respectively. Consult with the Field Team Leader for more information when choosing the appropriate range, however, in most instances the range will be set initially at 0-20.
- When HNu is used intermittently, turn knob to STANDBY to help in extending the life of the UV lamp when operating in a low humidity environment. Otherwise, leave the knob set to the range desired so that the UV lamp will "burn off" any accumulated moisture.

Note: When using the PI 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

### **DL 101**

The DL 101 is designed to default to the survey mode when initially powered up, therefore once the calibration has been completed, the instrument is ready to go. Within the survey mode several options are available, briefly these options include:

#### 1. The Site Function

The Site function assigns a number to a site that is being analyzed. Press the Site Key on the keypad to enter a specific site number, or press the gray button on the rear of the probe to increment a site number.

#### 2. Logging Data

The Log function stores data in memory. To log data, press the Log key on the keypad or the Log button on the back of the probe. "Log" will appear in the upper right corner of the display when activated and disappears when not activated. To turn logging off, press either the Log key on the keypad or the red Log button on the rear of the probe.

- The DL 101 allows for the interchanging of different voltage lamps, however, refer to the manufacturer's instructions before attempting to change the lamp.
- The DL 101 also offers three other modes of operation, the Hazardous Waste Mode, the Industrial Hygiene Mode, and the Leak Detection Mode. Each of these modes increases the range of capabilities for this instrument which is covered in detail in the manufacturer's instruction manual.

Note: When using the DL 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

### **5.3 Interferences and Potential Problems**

A number of factors can affect the response of the PI 101 HNu and DL 101 HNu.

- High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high, or when monitoring a soil gas well that is accessible to groundwater.
- High concentrations of methane can cause a downscale deflection of the meter.

- High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpenes in wooded areas, will also affect instrument response.

#### 5.4 Maintenance

The best way to keep an HNu operating properly is to keep it as clean as possible. HNu's should be decontaminated or wiped down daily or after each use, as appropriate.

##### **Corrective Maintenance**

- The ultraviolet lamp should be periodically cleaned using a special compound supplied by HNu Systems, Inc. for the 10.2 eV lamp, and a chlorinated solvent such as 1,1,1-trichloroethane for the 11.7eV lamp. Consult the manufacturer's instruction manual for specific cleaning instructions.
- The ionization chamber can be periodically cleaned with methyl alcohol and a swab.

Note: UV lamp and ion chamber cleaning is accomplished by following the procedures outlined in Section 5.2, however, this should only be performed by trained personnel.

- Documenting the HNu's observed symptoms and then referring to the manufacturer's instruction manual section on troubleshooting (Section 6.0) also can be employed. If this does not work, the Field Team Leader should be consulted for an appropriate course of action.

Repair and Warranty Repair - HNu's have different warranties for different parts, so documenting the problem and sending it into the manufacturer assists in expediting repair time and obtaining appropriate warranty service.

#### 5.5 Shipping and Handling

Following is information regarding the transport of the HNu meter and calibration gas.

- If HNu is to be carried on in aircraft, the calibration gas must be removed from the carrying case as cylinders of compressed gas are not permitted on passenger aircraft. The calibration gas should either be shipped to the site of its intended use, or purchased locally.
- Shipping of the calibration gas requires the completion of a form (specified by the shipping company) that identifies the package as a compressed gas. Compressed gas stickers must be affixed to the package.

## 6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc.) serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., the HNu meter had wide range fluctuations during air monitoring activities).

## 7.0 REFERENCES

HNu Systems, Inc. Instruction Manual. Model PI 101, 1986.  
HNu Systems, Inc. Operator's Manual. Model DL 101, 1991.

**APPENDIX J**  
**BACHARACH OXYGEN/ COMBUSTIBLE GAS METER**  
**AND PERSONAL GAS MONITOR**

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**BACHARACH COMBUSTIBLE GAS/  
OXYGEN METER PERSONAL GAS MONITOR  
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## BACHARACH COMBUSTIBLE GAS/ OXYGEN METER AND PERSONAL GAS MONITOR

### 1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the Bacharach Sentinel 4 and Bacharach Sniffer® 503-A meters in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

### 2.0 SCOPE

This procedure provides information into the field operation and general maintenance of the Sentinel 4 Sniffer and 503-A. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

### 3.0 DEFINITIONS

Carbon Monoxide Sensor - Expresses the Carbon Monoxide concentration in parts per million (ppm).

Combustible Gas - Combustible gas is expressed as a percent of the lower explosive limit (LEL).

Hydrogen Sulfide Sensor - Expresses the Hydrogen Sulfide concentration in parts per million (ppm).

Oxygen Sensor - Expresses the Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

Sentinel 4 - Combustible Gas/Oxygen/Hydrogen Sulfide/Carbon Monoxide meter.

Sniffer 503-A - portable Combustible Gas and Oxygen Alarm instrument.

### 4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project -specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in the Field Logbook during each field investigation.

## **5.0 PROCEDURES**

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A utilize the principle of detecting sensors. The following four paragraphs discuss theory of operation as it applies to each functional sensor.

The combustible gas sensor uses two elements that are wound with a platinum wire. One of the elements is impregnated with a catalyst to oxidize combustible gases. The other element is impregnated with material that will also oxidize combustible gases, but will respond to temperature and humidity conditions. When the meter is turned on, an electrical current is passed through the elements and wires. As a combustible gas enters the chamber the elements will oxidize the combustible gas, thus increasing the heat and resistance of the element. This change in resistance causes a system imbalance, which produces a measurable signal proportional to the combustible gas concentration.

The percent oxygen is measured utilizing an electrochemical sensor. As atmospheric oxygen enters the meter it diffuses into the sensor which converts the amount of oxygen in the sensor to a voltage signal. This voltage is directly proportional to percent oxygen in the atmosphere.

The concentration of hydrogen sulfide is measured utilizing an electrochemical sensor. As atmospheric hydrogen sulfide enters the meter it diffuses into the sensor which converts the amount of hydrogen sulfide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric hydrogen sulfide concentration.

The concentration of carbon monoxide as measured utilizing an electrochemical sensor. As atmospheric carbon monoxide enters the meter it diffuses into the sensor which converts the amount of carbon monoxide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric carbon monoxide concentration.

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A are intrinsically safe for use in Class I, Division 1, Groups A, B, C and D hazard areas. One fact that needs to be expressed is that this type of monitoring equipment utilizes internal oxidation of combustibles, if the meter is placed in an oxygen deficient atmosphere, the combustible reading may be affected. Review of each of the instruction manuals will aid in determining the percentage of oxygen that affects the combustible gas readings.

The following subsections will discuss Sentinel 4 and Sniffer 503-A calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

## **5.1 Calibration**

### **Sentinel 4**

Due to the numerous steps involved in calibration, it is recommended that you follow the calibration procedures (on a daily basis) as outlined in the instruction manual from pages 5-12 to 5-20.

NOTE: A calibration kit will be provided for each Sentinel 4. This kit contains a cylinder for the combustible gas sensor, one cylinder for the hydrogen sulfide sensor, and one cylinder for the carbon monoxide sensor. The oxygen sensor can be calibrated with (uncontaminated/fresh air environment) atmospheric air and does not need cylinder gas.

Note: When a single sensor doesn't zero, none of the sensors are zeroed.

### **Sniffer® 503-A**

#### **Oxygen Detector**

1. Check battery charge by turning function switch to "BATTERY TEST," if battery is in recharge zone instrument will need to be charged.
2. To zero the oxygen detector, turn function switch to "BATTERY TEST" position and press "TEST" switch and observe the O<sub>2</sub> meter indication. If indicator is zero, no further adjustment is necessary. If not, follow procedures in Section 5.4.1 of the Operations Manual.
3. To calibrate the oxygen detector, turn function switch to "BATTERY TEST" position. Unlock the "OXYGEN CALIB" knob and adjust it for an O<sub>2</sub> meter indication of 21 or at the CAL mark. Relock "OXYGEN CALIB" knob. If using zero calibration gas, follow procedures in Section 5.4.2 of the Operator's Manual.
4. Record on Calibration Sheet.

### % LEL Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if batter is in recharge zone, instrument will need to be charged. Allow 5 minutes for the instrument to warm up.
2. Turn function switch to the % LEL position.

Note: To eliminate the annoyance of the audible alarm, cover the alarm with a hand or duct tape during calibration. The tape must be removed, prior to operation!!

3. Connect calibration gas (typically 30% of the LEL) and allow gas to flow for 1 minute.

Note: If calibration gas has a concentration value, not a % LEL value, the % LEL can be calculated as follows:

$$\% \text{ calibration gas (i.e., methane)} \times 20\% \text{ LEL (meter alarm setting)} = \% \text{ LEL calibration setting}$$

If meter indication is within  $\pm 5\%$  of LEL calibration gas, no further adjustment is required. If not, follow procedures in Section 5.5.4 of Operator's Manual.

### Sniffer® 503-A

1. Connect sample probe and tubing to the instrument's sample inlet (refer to Sections 8.4 and 8.5 for the Operator's Manual for available hoses and probes.
2. Check that battery is in Operational Range.
3. Turn instrument to % LEL range and allow to warm up for 1 minute.
4. Check in a fresh air environment that % LEL reads 0% and that O<sub>2</sub> indicator reads 21% (calibration mark).
5. Sample air/gas from area to be tested, allow 30 seconds for readings to stabilize. When finished, allow at least 10 seconds (longer if extension line is used) to purge sample line.
6. If instrument is operating erratically, refer to "TROUBLESHOOTING" Section (Table 5-2) in Operator's Manual.

## 5.2 Operation

### Sentinel 4

Due to the Sentinel 4 having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 6-1 to 6-34.

NOTE: Since the Sentinel 4 is capable of measuring four different parameters, an understanding of the alarm, error, and fault messages must be obtained. This can be done by reviewing the troubleshooting table found on pages 9-2 to 9-9.

## 5.3 Site Maintenance

After each use, the meters should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

## 5.4 Scheduled Maintenance

| <u>Function</u>                          | <u>Frequency</u>                               |
|------------------------------------------|------------------------------------------------|
| Check alarm and settings                 | Monthly/before each use                        |
| Clean screens and gaskets around sensors | Monthly                                        |
| Replace sensors                          | Biannually or when calibration is unsuccessful |

## 6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., the Sentinel 4 or Sniffer 503-A had wide range fluctuations during air monitoring activities.)

NOTE: The "Toxic Gas Meter Calibration Form" will be completed daily, prior to performing any air monitoring.

## 7.0 REFERENCES

Bacharach Installation, Operation, Maintenance Manual, Sentinel 4 Personal Gas Monitor, 1990.  
Bacharach Installation, Operation, Maintenance Manual, Sniffer® 503-A, Rev. 3 - October, 1990.

**APPENDIX K**  
**DRUM SAMPLING**

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**DRUM SAMPLING  
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## DRUM SAMPLING

### 1.0 PURPOSE

The purpose of this SOP is intended to provide general information for the sampling of drums by qualified individuals in the field. Due to widely varied (and potentially hazardous) conditions posed by drum sampling, specific SOPs must be determined on a case-by-case basis. This SOP provides information to assist in ensuring that safe procedures are followed as applicable to the inspection, opening, and sampling of drums in the field.

### 2.0 SCOPE AND APPLICATION

This SOP provides technical guidance on safe and cost-effective response actions at sites containing both known and unknown drum contents. Container contents are sampled and characterized for disposal, bulking, recycling, grouping and/or classification purposes.

### 3.0 DEFINITIONS

Bung - a threaded metal or plastic plug usually positioned at the top or side of a drum.

Over Pack - a metal or plastic drum-like container that is larger than the container(s) stored therein.

Lab Pack - a drum holding multiple individual containers of laboratory materials normally surrounded by cushioning absorbent material.

### 4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the drum sampling activities.

Project Health and Safety Officer (PHSO) - The PHSO is responsible for developing a site-specific Health and Safety Plan (HASP) for drum sampling activities which include personal protection levels, air monitoring requirements, and safe drum sampling procedures.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the proper respiratory and personal protective equipment for each member of the sampling team is selected in compliance with the HASP, and coordinating these efforts with the Field Team Leader.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the drum sampling techniques and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the Field Investigation



personnel performing drum sampling activities have been briefed and trained to execute these procedures.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader and Project Manager. The Field Investigation Personnel are responsible for documenting all sampling data on the appropriate Drum Sample Characterization Sheet presented as Attachment A and in the Field Logbook.

## 5.0 METHOD SUMMARY

Prior to sampling, drums should be inventoried and properly staged in a secure area. An inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization and sometimes consolidation of drums which have similar wastes or characteristics.

## 6.0 INTERFERENCES

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used if the drums are visually overpressurized (bulging) or if shock-sensitive materials are suspected. Drums that have been overpressurized, to the extent that the head is swollen several inches above the chime (beveled edge of drumtop), should not be moved. A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid hooking device attached to the tube goes over the chime and holds the spear securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum and the gas vents along the grooves. The device can be inexpensively and easily designed and constructed where needed. Once the pressure has been relieved, the bung can be removed and the drum contents sampled.

## 7.0 EQUIPMENT APPARATUS

The following are standard materials and equipment required for drum sampling:

- Health and Safety Plan
- Air monitoring equipment
- Fire extinguishing equipment
- Personnel protective equipment
- Wide mouth glass jars with teflon cap liner, approximately 500 ml volume
- Uniquely numbered sample identification labels with corresponding data sheets
- One-gallon covered (paint) cans half-filled with absorbent (i.e. kitty litter or vermiculite)
- Chain-of-Custody forms
- Decontamination plan and materials

- Glass thieving tubes or Composite Liquid Waste Sampler (COLIWASA)
- Drum opening devices

### 7.1 Bung Wrench

A common method for opening drums manually is using a universal bung wrench (see Figure 1, Attachment B). These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast-iron, brass or a bronze-beryllium, nonsparking alloy formulated to reduce the likelihood of sparks. The use of a "NONSPARKING" wrench does not completely eliminate the possibility of a spark being produced, therefore extreme caution should be exercised.

### 7.2 Drum Deheader

One means by which a drum can be opened manually (when a bung is not removable with a bung wrench) is by using a drum deheader (see Figure 2, Attachment B). This tool is designed to cut the lid of a drum off (or part way off) by means of a scissors-like cutting action. This device is limited in that it can be attached only to closed head drums. Drums with removable heads must be opened by other means.

### 7.3 Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket (see Figure 3 and 4, Attachment B). In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure to the potentially hazardous nature of the drum's contents.

### 7.4 Hydraulic Drum Opener

Another remote drum opening procedure is the utilization of remotely operated hydraulic devices. One such device uses hydraulic pressure to pierce through the wall of a drum (see Figure 5, Attachment B). The device consists of a manually operated pump which pressurizes oil through a length of hydraulic line.

### 7.5 Pneumatic Devices

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed (see Figure 6, Attachment B). It should be noted that this bung removal method does not permit the slow venting of the container, and therefore appropriate precautions must be taken to reduce personnel exposure to pressurized, potentially hazardous drum contents. It also requires the container to be upright and relatively level. Bungs that are rusted shut or are in very poor condition cannot be removed with this device.

## 8.0 PROCEDURES

It is anticipated that the procedures for drum sampling may include a limited degree of drum handling. Therefore, it will be necessary to inspect the drum(s) for certain conditions prior to sampling.

### 8.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies will be needed.
2. Obtain necessary sampling and monitoring equipment.
3. Decontaminate or preclean equipment, and ensure that the equipment is in good working order.
4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
5. Perform a general site survey prior to site entry in accordance with the site-specific Health and Safety Plan.
6. Use marking devices to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

### 8.2 Inspection

Prior to sampling, drums will be visually inspected to gain as much information as possible about their contents. Items to consider during inspection include:

- Symbols, wording, labels, or other marks indicating that drum contents are hazardous, e.g., radioactive, explosive, corrosive, toxic, or flammable.
- Symbols, wording, labels, or other marks indicating that the drum contains discarded laboratory chemicals, reagents, or other potentially dangerous materials in small-volume individual containers.
- Signs of deterioration such as corrosion, rust, and leaks.
- Signs of the chemical nature of the contents, such as residue, crystal buildup, etc. at bung opening.
- Signs that the drum is under pressure such as swelling and bulging.

- Special drum types (refer to Table 1).
- Configuration of the drumhead (ringtop or bung).
- Orientation such as whether the drum is standing upright, tilted, or lying on its side.
- Accessibility of the drum.

Monitoring will be conducted around the drums using instruments such as a gamma radiation survey instrument, organic vapor monitor (OVA or HNu), colorimetric tubes (Dräger tubes), and/or a combustible gas meter. The results can be used to classify the drums into categories such as radioactive, leaking/deteriorating, bulging, explosive/shock-sensitive, or laboratory packs.

**Personnel will not handle, move, open, sample or in anyway disturb a drum containing radioactive waste, explosive or shock-sensitive waste, laboratory packs, or biohazardous waste until specific direction and safe procedures are received from the Project Manager, PHSO and the Field Team Leader.**

When drums exhibit the characteristics of the aforementioned categories, the following procedures will be followed:

- Radioactive Wastes - If the drum exhibits radiation levels above background, normally 0.01-0.02 mrem/hr (milliroentgen equivalent in man per hour), that are less than or equal to 2 mrem/hr, there is a possible radiation source present. Continue the investigation with caution, and inform the SHSO. If the radiation levels are greater than 2 mrem/hr there is a potential radiation hazard. Work will stop, and the Field Team Leader and Project Manager will be notified so that new procedures can be developed and implemented.
- Explosive or Shock-Sensitive Waste - If handling is necessary, exercise extreme caution, have nonessential personnel move to a safe distance, and use a grappler unit for initial handling which is constructed for explosive containment. Use nonsparking equipment and/or remote control devices.
- Bulging Drums - Do not move drums under internal pressure unless proper equipment is used, such as a grappler unit constructed for explosive containment.
- Packaged Laboratory Wastes (Lab Packs) - Lab Packs can be an ignition source for fires and sometimes contain shock-sensitive materials. Once a lab pack has been opened, a chemist or other qualified individual should inspect, classify and segregate the bottles (without opening), according to the hazards of the wastes. The objective of such a classification system is to ensure safe segregation of the lab packs' contents (refer to Table 2 for an example of a lab pack classification). If crystalline material is noted at the neck of any bottle, handle it as a shock-sensitive

waste (due to the potential presence of picric acid, potassium permanganate or explosive mixtures resulting when the aqueous solution crystallizes), or other inimical (harmful) materials, and obtain advice from qualified personnel prior to handling.

Until drum contents are characterized, sampling personnel will assume that unlabeled drums contain hazardous materials. Personnel also should be aware that drums are frequently mislabeled and may not contain the material identified.

### **8.3 Drum Opening**

Drums are to be opened and sampled in place. For opening drums manually, equipment such as a nonsparking metal (brass, bronze/manganese, aluminum, molybdenum) bung/plug wrench and a drum deheading device will be used for waste contents that are known to be nonreactive and nonexplosive, within a structurally sound drum. The drums will be grounded prior to opening either the bung or the lid

While opening drums manually with a bung wrench, the following procedures will be used:

- Drums will be positioned bung up, or, for drums with bungs on the side, laid on their sides with the bung plug up. Note that care should be taken when moving a drum into position for opening.
- Use a wrenching motion that is a slow and steady pull across the drum, using a "cheater bar" if the leverage for unscrewing the bung is poor.
- If there is evidence of incompatible chemical reactions, a sudden pressure buildup, or a release of potentially toxic fumes while the bung is being loosened, field personnel will immediately leave the area and arrange for remote drum opening equipment to be used.
- If the drum cannot be opened successfully using a nonsparking hand wrench, then other methods of drum opening (deheading or puncturing) must be considered. If deheading or puncturing a drum, it will be necessary to overpack the drum to minimize the potential for spilling the drum's contents.
- If the drum shows signs of swelling or bulging, perform all steps slowly. From a remote location, relieve excess pressure prior to drum opening using the devices listed below, if possible. If performing drum opening activities manually, place a barrier such as an explosion-resistant plastic shield between the worker and bung to deflect any gas, liquid, or solids which may be expelled as the bung is loosened.

Whenever possible, use the following remote-controlled devices for opening drums:

- A pneumatically operated impact wrench to remove drum bungs.
- A hydraulically or pneumatically operated drum piercer.
- A backhoe equipped with bronze spikes for penetrating drum tops (typical in large-scale operations).

Additional general procedures for drum opening are as follows:

- If a supplied-air respiratory protection system is used, the bank of air cylinders must be maintained outside of the work area.
- If personnel must be located near the drums being opened, place explosion-resistant plastic shields between them and the drums, in case of detonation. Locate controls for drum opening equipment, monitoring equipment, and fire suppression equipment behind the explosion-resistant plastic shield. Nonessential personnel must be positioned upwind from the drum opening and sampling operations.
- When feasible, monitor air quality continuously during drum opening, and as close as possible to the potential source of contaminants, (i.e., placing probes as close as practical without hindering drum opening operations), and hang or balance the drum opening equipment to minimize exertion.
- Do not use picks, chisels, etc. to open drums manually.
- Open exotic metal drums and polyethylene or polyvinylchloride-lined (PVC-lined) drums by removing or manually drilling the bung, while exercising extreme caution.
- Do not open or sample individual containers within laboratory packs.
- Reseal open bungs and/or drill openings as soon as possible, with new bungs or plugs to avoid explosions and/or vapor generation. If an open drum cannot be resealed, place the drum into an overpack.
- Plug any openings in pressurized drums with pressure venting caps set to a 5-psi release to allow venting of vapor pressure.
- Decontaminate and/or properly dispose of sampling equipment after each use to avoid mixing incompatible wastes and contaminating subsequent samples.

#### 8.4 Drum Sampling

When sampling a previously sealed vessel, check for the presence of bottom sludge. Since some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel.

The most widely used instrument for sampling is a glass tube commonly referred to as a glass thief (Figure 7, Attachment B). This tool is simple, cost effective, quick and collects a sample without having to decontaminate. Glass thieves are typically 6 mm to 16 mm I.D. and 48 inches long.

Drum sampling can be a very hazardous activity because it often involves direct contact with unidentified wastes. Prior to collecting any sample, field team personnel will become familiar with the procedures identified in the Sampling Plan and in this SOP.

Certain information can be construed from the drumhead configuration prior to sampling, such as:

- Removable "Whole" Lid = designed to contain solid material
- Bung opening = designed to contain liquids
- Drum Liner = may contain a highly corrosive or otherwise hazardous material

When manually sampling from a drum, use the following techniques:

- Keep sampling personnel at a safe distance while drums are being opened. Sample only after opening procedures are complete.
- Do not lean over or between other drums to reach the drum being sampled.
- Cover drum tops with plastic sheeting or other suitable uncontaminated materials to avoid excessive contact with the drum tops.
- Never stand on drums. Use mobile steps or another platform to achieve the height necessary to safely sample from the drums.
- After the drum has been opened, monitor headspace gases with no less than an explosimeter and an organic vapor analyzer. In most cases it is impossible to observe the contents of these sealed or partially sealed vessels.
- Obtain samples with either glass rods (thiefs) or with a vacuum pump and tubing. Do not use contaminated items such as discarded rags during sampling. Glass rods will be removed prior to pumping to minimize damage to pumps.
- Identify each drum with a sample number. Record the number on the Drum Waste Characterization Sheet and permanently on the drum (mark lid and side) using

either a label, permanent marker, or spray paint. Cover drums with plastic sheeting and secure to minimize degradation of labeling from variable weather conditions.

**8.4.1 Procedures for using a glass thief are as follows:**

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the drum or until a solid layer is encountered. About one foot of tubing should extend above the drum.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with stopper.
5. Carefully remove the capped tube from the drum and insert the uncapped end in the sample container.
6. Release stopper and allow the glass thief to drain until the container is approximately 2/3 full.
7. Remove tube from the sample container.
8. Cap the sample container tightly and place pre-labeled sample container in a carrier.
9. Replace bung or lid securely on drum.
10. Break the thief into pieces inside a drum which has been designated for solid hazardous waste disposal. Previously, drum thieves were broken and disposed inside the drum being sampled. However, this activity hinders the future disposal of liquid drum contents by introducing solid material.
11. Log all samples in the site logbook and on field data sheets.
12. Package samples and complete necessary paperwork.
13. Transport sample to decontamination zone in preparation for transport to analytical laboratory.

**8.4.2 COLIWASA Sampler**

The Composite Liquid Waste Sampler (COLIWASA) is designed to collect a sample from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. The COLIWASA (Figure 8, Attachment B) is a much cited sampler designed to permit representative



sampling of multiphase wastes from drums and other containerized materials. One configuration consists of a 152 cm x 4 cm inside diameter (I.D.) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

## 9.0 QUALITY ASSURANCES/QUALITY CONTROL

The following quality assurance procedures apply:

- Document all data on standard chain of custody forms, field data sheets and/or within site logbooks.
- Operate all instrumentation in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the Work Plan and Sampling Plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and must be documented in the field logbook.

Quality assurance records shall consist of completed Drum Waste Characterization Sheets and data entered into the Field Logbook. A sample Drum Waste Characterization Sheet is presented as Attachment A. Attachment B contains example figures of drum sampling equipment.

## 10.0 REFERENCES

NIOSH/OSHA/USCG/EPA, 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. Publication No. 85-115.

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NIOSH, 1990. NIOSH Pocket Guide to Chemical Hazards. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio. Publication No. 90-117.

U.S. EPA, 1991 Compendium of ERT Waste Sampling Procedures. OSWER Directive 9360.4-07. EPA/540/P-91/008

**ATTACHMENT A**

**DRUM WASTE CHARACTERIZATION SHEET**



Drum/Sample No. \_\_\_\_\_

**DRUM WASTE CHARACTERIZATION SHEET**

Project Location \_\_\_\_\_ Project No. \_\_\_\_\_  
 Project Manager \_\_\_\_\_ Telephone \_\_\_\_\_  
 Logger \_\_\_\_\_ Sampler \_\_\_\_\_  
 Weather \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

Drum Type:  Fiber  Steel  Poly  Stainless Steel  Nickel  
 Poly-Lined  Ring Top  Closed Top  Overpacked

Drum Size: 85  55  42  30  16  10  5  Other \_\_\_\_\_

Drum Contents: Amount Full  3/4  1/2  1/4  <1/4  MT

Drum Condition: Good  Fair  Poor

|        | Physical State |       |     |        | Color<br>Use Std. Colors | Clarity |        |        | Layer Thickness (inches) |
|--------|----------------|-------|-----|--------|--------------------------|---------|--------|--------|--------------------------|
|        | Liquid         | Solid | Gel | Sludge |                          | Clear   | Cloudy | Opaque |                          |
| Top    |                |       |     |        |                          |         |        |        |                          |
| Middle |                |       |     |        |                          |         |        |        |                          |
| Bottom |                |       |     |        |                          |         |        |        |                          |

pH \_\_\_\_\_ PID \_\_\_\_\_ ppm  
 Rad Meter \_\_\_\_\_ mr/hr  
 Other \_\_\_\_\_  
 \_\_\_\_\_  
 MFG Name \_\_\_\_\_  
 Chemical Name \_\_\_\_\_

Additional Information: \_\_\_\_\_

**LABORATORY COMPATIBILITY ANALYSES**

|        | Physical State |       |     |        | Color<br>Use Std. Colors | Clarity |        |        | Water Sol.<br>Sol. S or I Density | React.<br>A- Air<br>W - Water | pH<br>Std. Unit | Hex. Sol.<br>S or I | Per.<br>+ or - | Oxid.<br>+ or - | CN<br>+ or - | Sul.<br>+ or - | Biel-Stein<br>+ or - | Flash Point<br>°C or °F |
|--------|----------------|-------|-----|--------|--------------------------|---------|--------|--------|-----------------------------------|-------------------------------|-----------------|---------------------|----------------|-----------------|--------------|----------------|----------------------|-------------------------|
|        | Liquid         | Solid | Gel | Sludge |                          | Clear   | Cloudy | Opaque |                                   |                               |                 |                     |                |                 |              |                |                      |                         |
| Top    |                |       |     |        |                          |         |        |        |                                   |                               |                 |                     |                |                 |              |                |                      |                         |
| Middle |                |       |     |        |                          |         |        |        |                                   |                               |                 |                     |                |                 |              |                |                      |                         |
| Bottom |                |       |     |        |                          |         |        |        |                                   |                               |                 |                     |                |                 |              |                |                      |                         |

Comments: \_\_\_\_\_

PCB Conc. \_\_\_\_\_ ppm Flash Point \_\_\_\_\_ °C

Data Reviewer \_\_\_\_\_ Compatibility Comp. Bulk No. \_\_\_\_\_

Field Reviewer \_\_\_\_\_

**ATTACHMENT B**

**LIST OF FIGURES**

Figure 1: Universal Bung Wrench

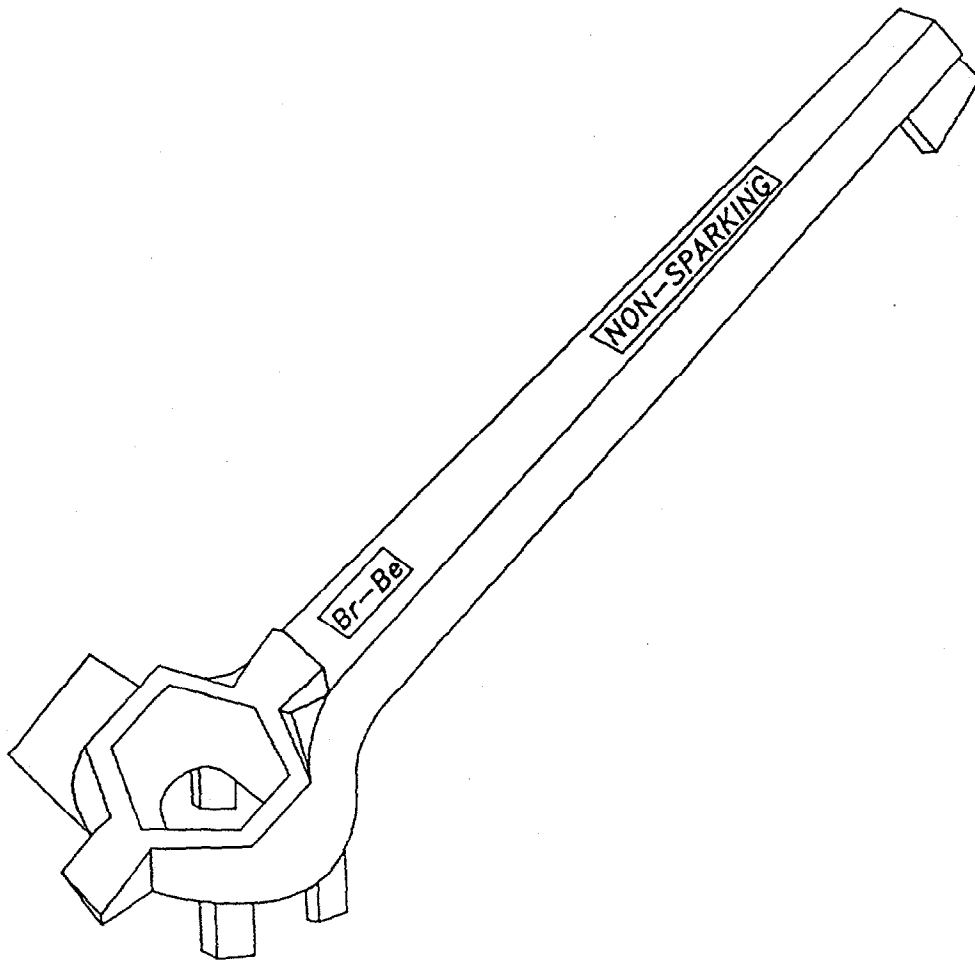


Figure 2: Drum Deheader

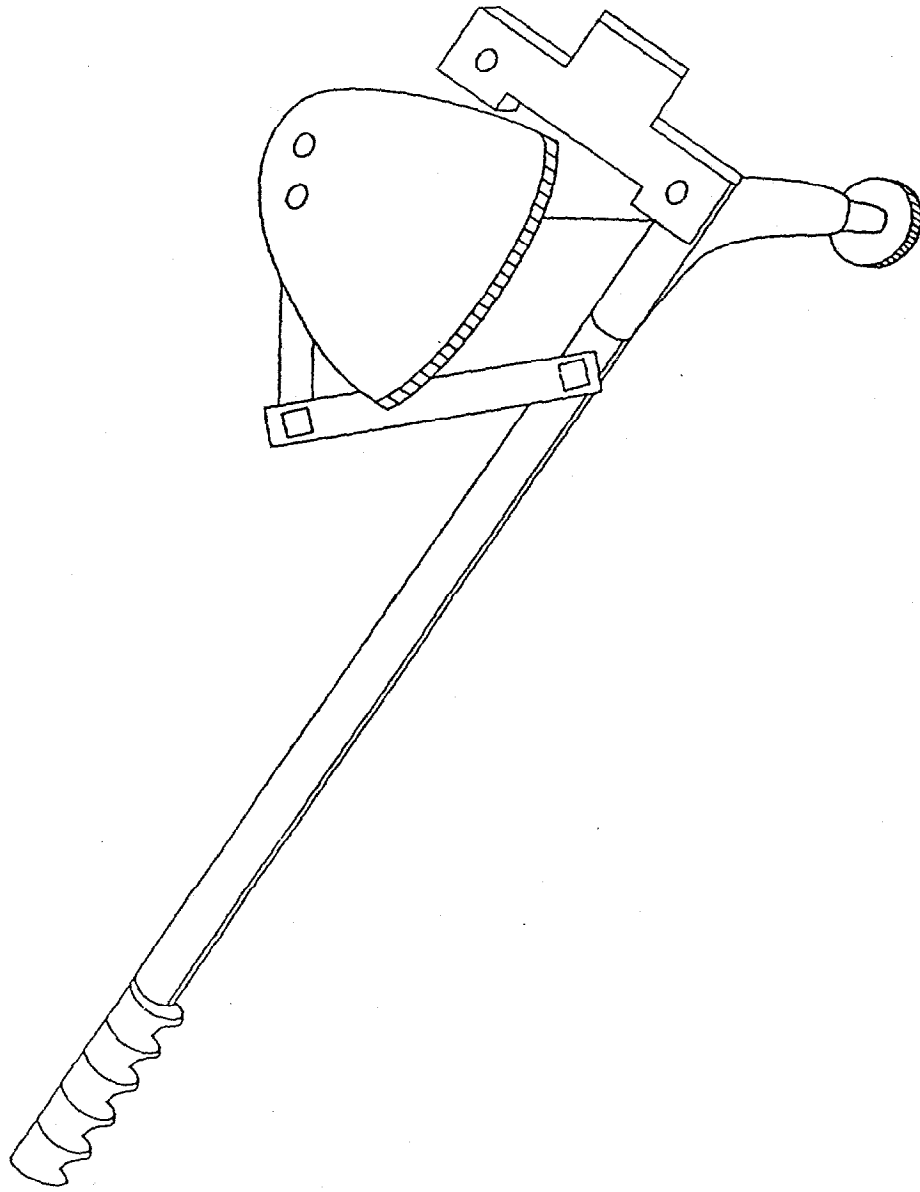
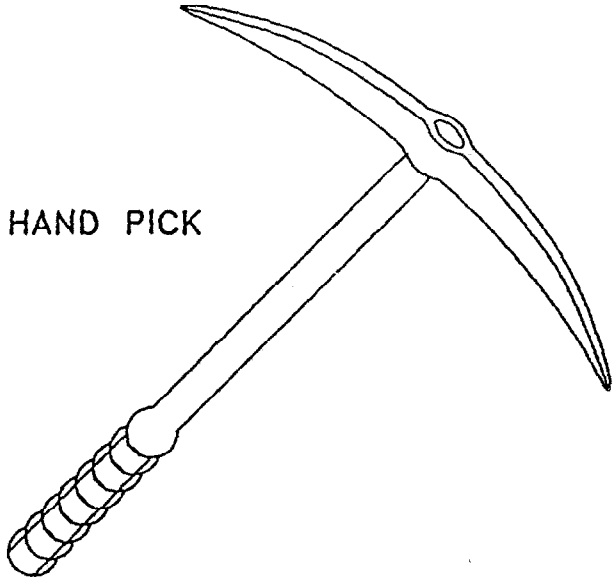
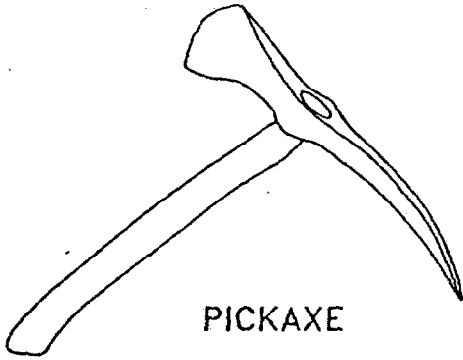


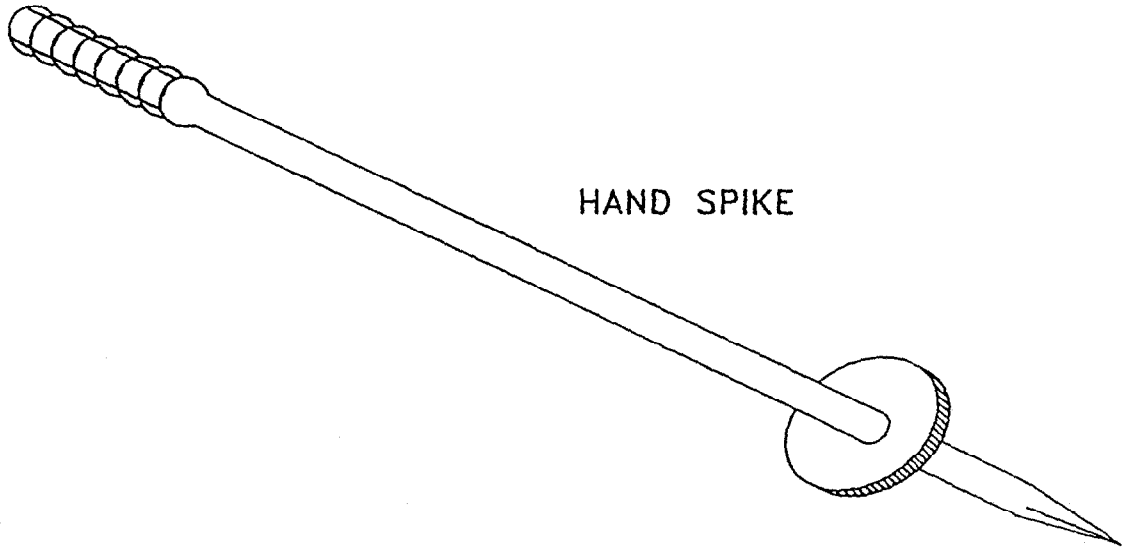
Figure 3: Hand Pick, Pickaxe, and Hand Spike



HAND PICK



PICKAXE



HAND SPIKE

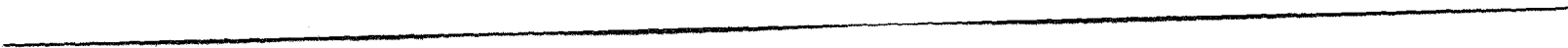


Figure 4: Backhoe Spike

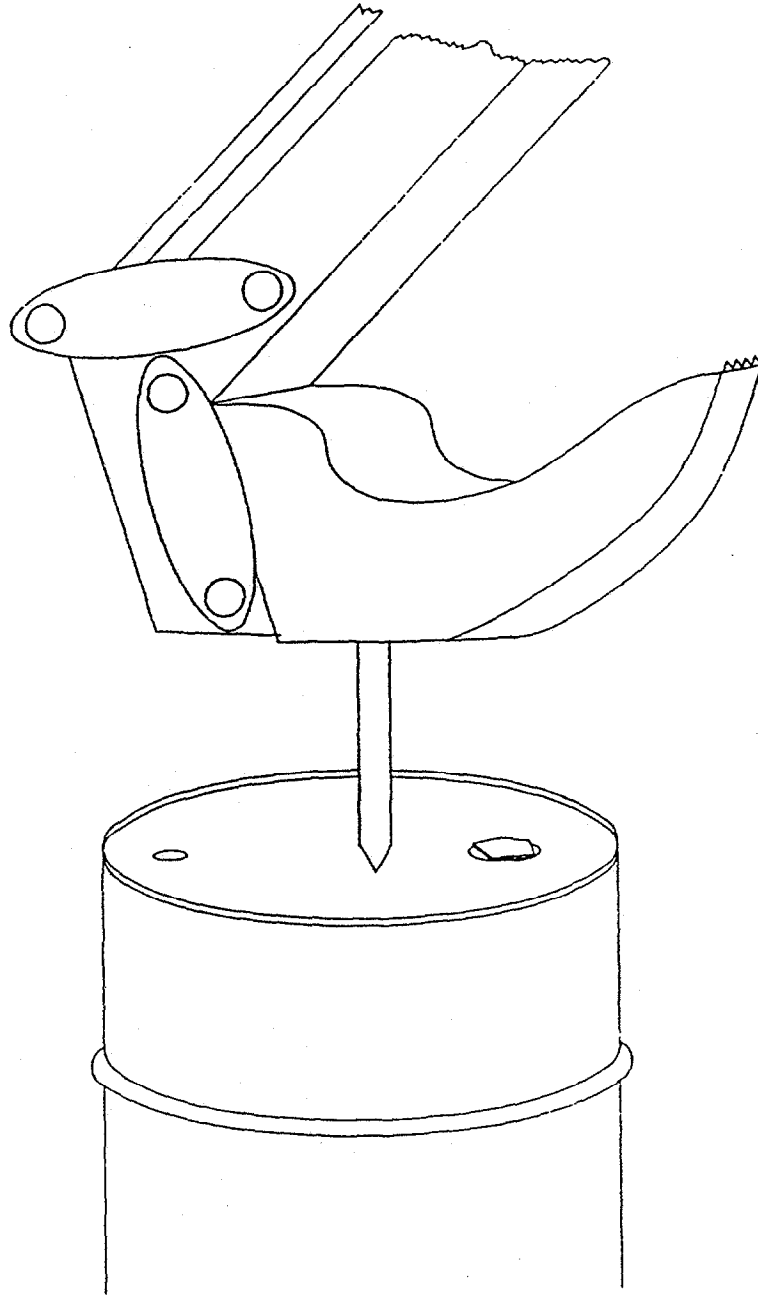




Figure 5: Hydraulic Drum Opener

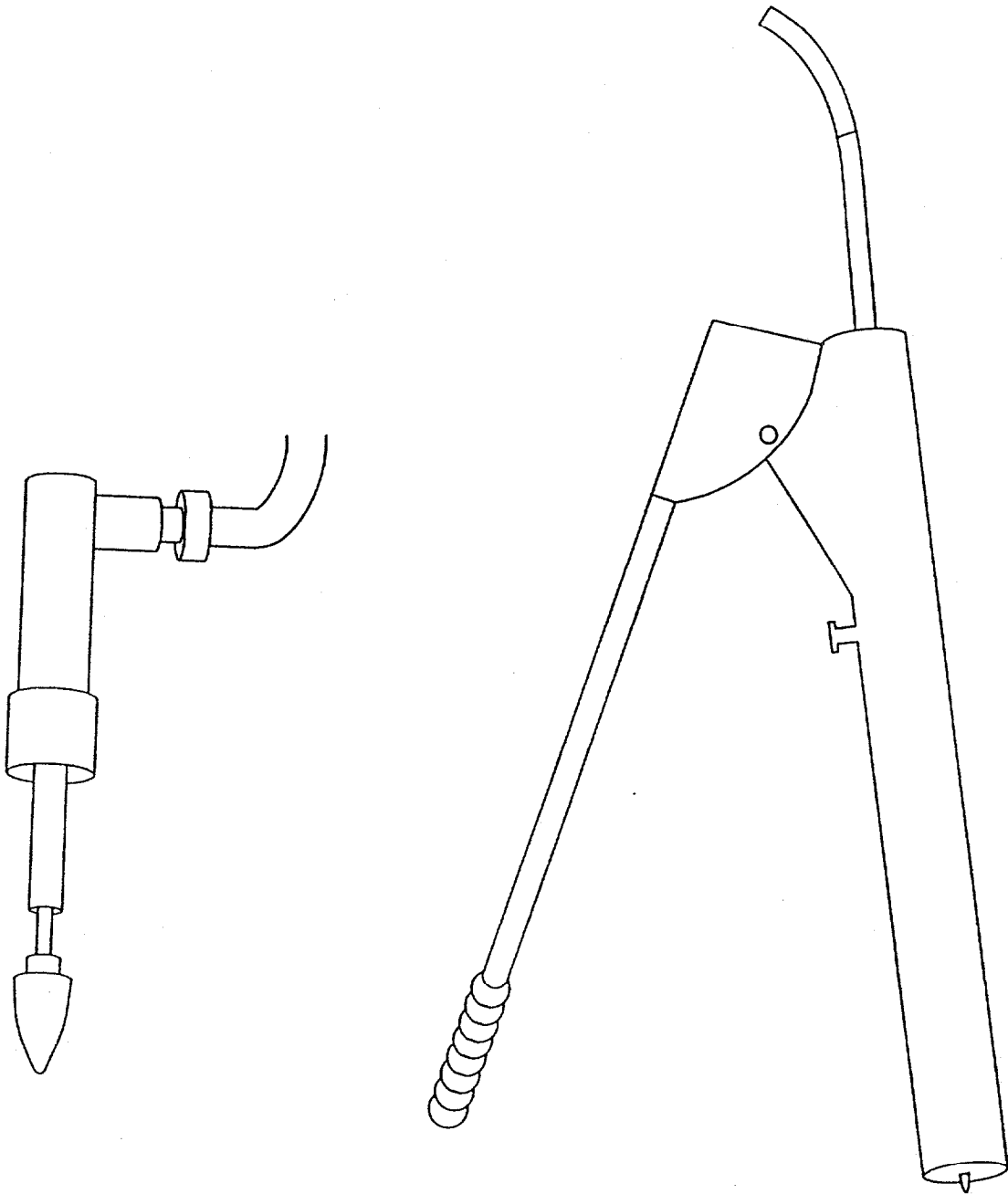


Figure 6: Pneumatic Bung Remover

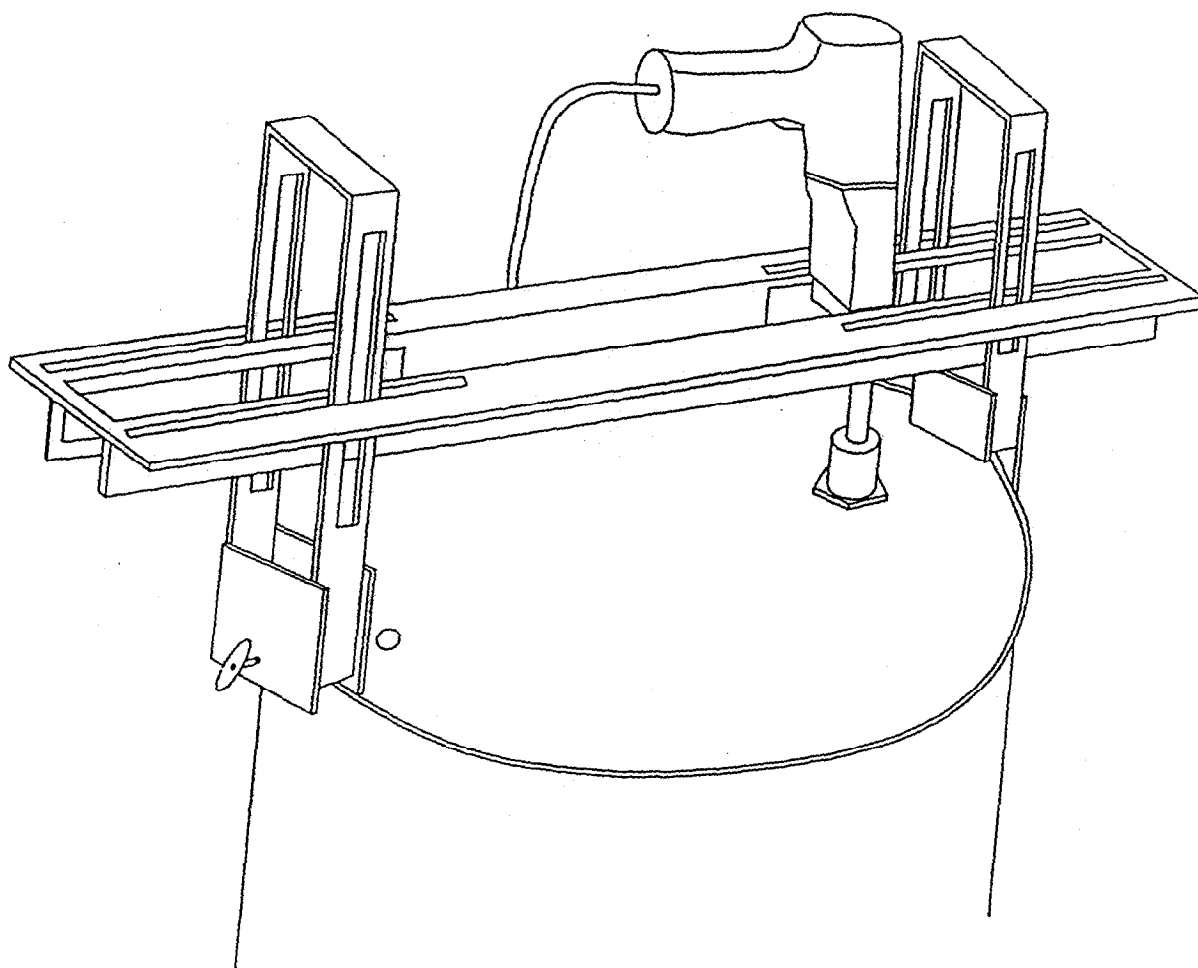
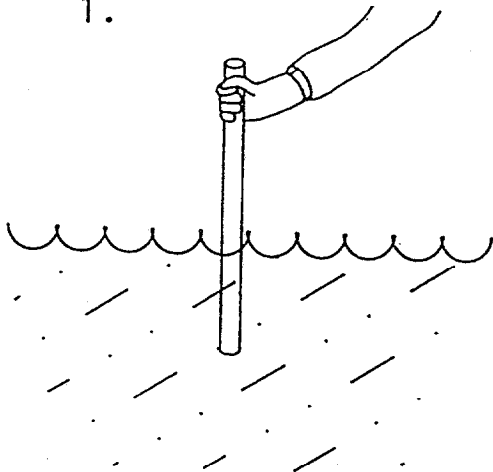


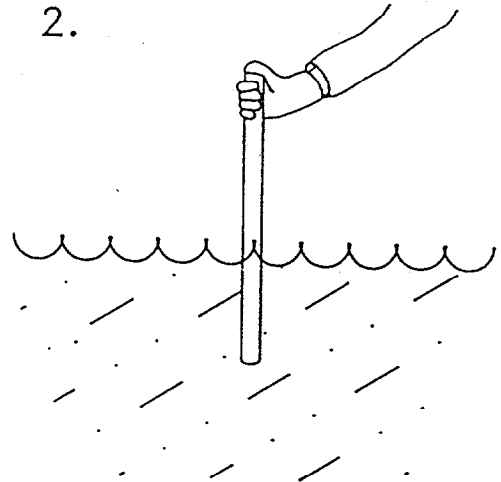
Figure 7: Glass Thief

1.



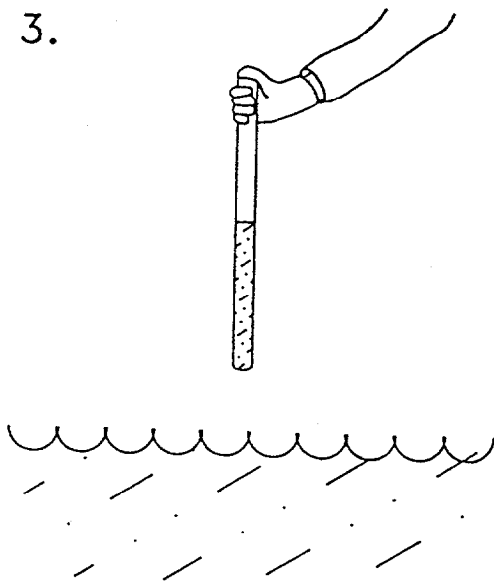
Insert open tube (thief) sampler in containerized liquid.

2.



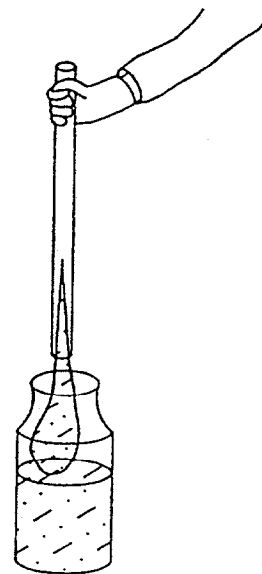
Cover top of sampler with gloved thumb.

3.



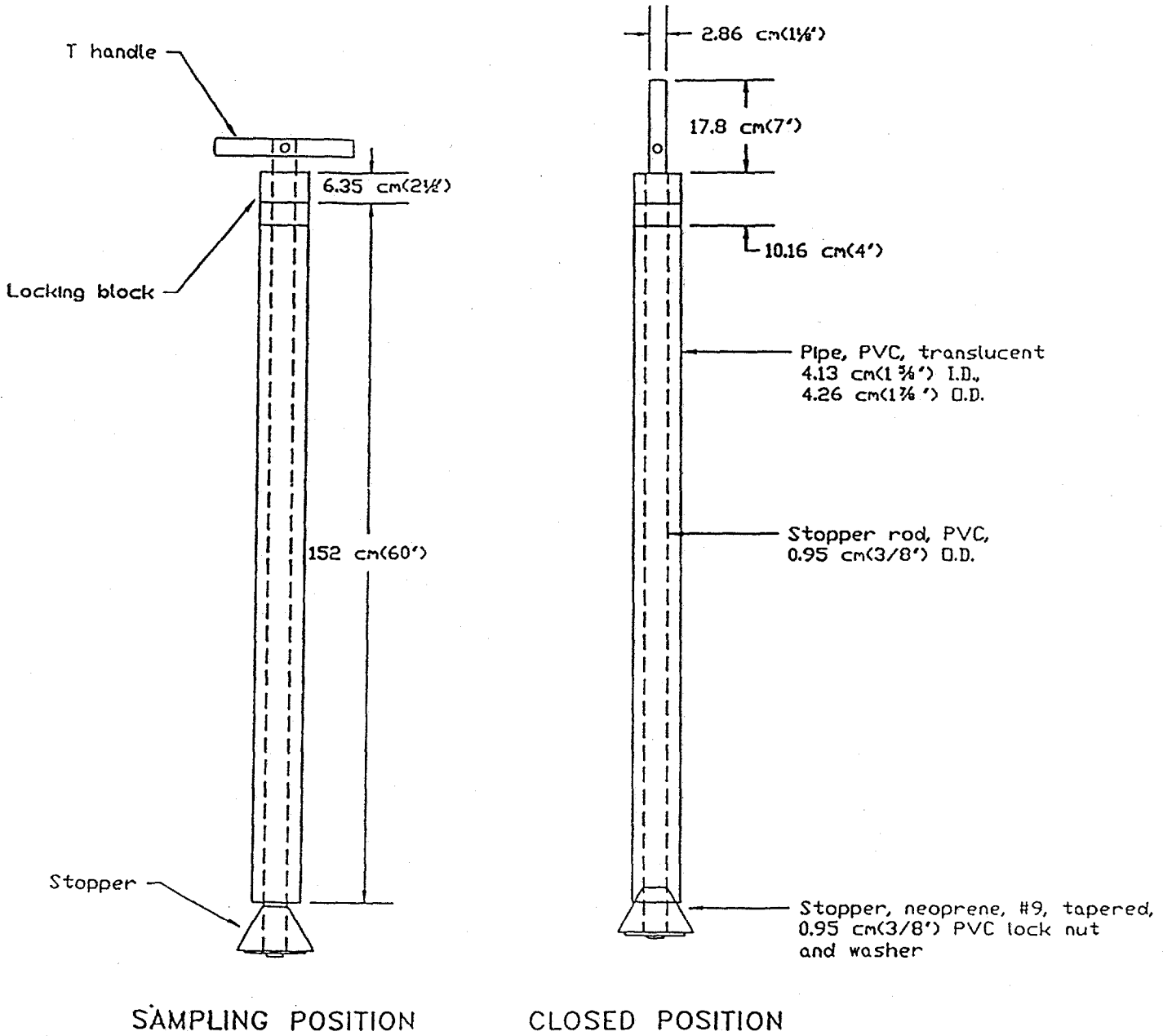
Remove open tube (thief) sampler from containerized liquid.

4.



Place open tube sampler over appropriate sample bottle and remove gloved thumb.

Figure 8: COLIWASA



**APPENDIX L**  
**WASTEWATER SAMPLE ACQUISITION**

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**WASTEWATER SAMPLE ACQUISITION  
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  - 5.2 Off-Shore
- 6.0 QUALITY ASSURANCE RECORDS**
- 7.0 REFERENCES**

## WASTEWATER SAMPLE ACQUISITION

### 1.0 PURPOSE

The purpose of this SOP is to provide general reference information for collecting wastewater samples.

### 2.0 SCOPE

This procedure provides information for the acquisition of waste water samples. Review of the information contained herein will ensure that sample acquisition is properly conducted.

### 3.0 DEFINITIONS

Sampling Plan - A "plan of action" that guides the implementation of methods that will lead to achieving the plans objective(s).

Grab Sample - An entire sample which is collected at one specific sample location at a specific point in time.

Composite Sample - A sample which is collected at several different locations and/or at different points in time.

Environmental Sample - Samples of naturally occurring materials; soil, sediment, air, water.

Waste Sample - Samples which are comprised of process wastes or other manmade waste material(s).

### 4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project specific plans are in accordance with procedures where applicable, or that other approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the waste water sample acquisition techniques and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the Field Investigation personnel performing the sample acquisition activities have been briefed and trained to execute these procedures.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project specific procedures as outlined in the Work Plan and as directed by the Field Team Leader and Project Manager. The Field Investigation Personnel

are responsible for documenting all wastewater sampling activities and ambient air monitoring results in the field log book.

## 5.0 PROCEDURES

This protocol outlines procedures and equipment for the collection of representative liquid samples and sediment/sludge samples from standing lakes, ponds and lagoons, and flowing streams, rivers, channels, sewers and leachate seeps.

The collection of samples from these sources presents a unique challenge. Often sampling can be quite easy and routine (e.g., collecting a surface water sample from a two foot deep stream). Other times, the nature of site specific conditions may dictate that: 1) special equipment is needed to access the sample, 2) appropriate health and safety measures are critical, 3) proper timing is essential due to waste release times or tidal fluctuations, and/or 4) wastewater flow rate is a factor for consideration.

Prior to sample collection, impoundment characteristics (size, depth, flow) should be recorded in the field log book. Sampling should proceed from downstream locations to upstream locations so that sediment disturbance (turbidity) caused by sampling does not affect sample quality. Additionally, if a sediment sample will be collected at the same location as a liquid sample, the liquid sample must be collected first to minimize sample turbidity.

If the Sampling Plan requires that samples are to be collected from the shore of an impoundment, specific health and safety considerations must be addressed. The person collecting the sample should be fitted with a safety harness and rope secured to a sturdy, immobile object on shore. Backup personnel should be available to assist in sample collection and should be prepared and able to pull the sampler to safety if unstable banks are encountered.

To more adequately characterize the content and/or quality of an impoundment, samples may be collected away from the shoreline, often at various depths. If the content of the impoundment is suspected to be highly hazardous, the risk to sampling personnel must be weighed against the need to collect the sample. If a barge or boat is used, each person on the vessel must be equipped with a life preserver and/or lifeline.

The sampling of liquids in lakes, ponds, lagoons, streams, rivers, channels, sewers and leachate seeps is generally accomplished through the use of one of the following samplers:

- Laboratory cleaned sample bottle
- Pond sampler
- Weighted bottle sampler
- Wheaton dip sampler
- Kemmerer Depth Sampler
- Bacon Bomb Sampler



The factors that will contribute to the selection of a sampler include the width, depth and flow of the location being sampled, and whether the sample will be collected from the shore or a vessel.

For flowing liquids, tidal influence on the collected sample is an additional concern and should be addressed in the Sampling Plan. At a minimum, the stage of the tide at the time of sample collection should be recorded. Consideration should be given to sampling at varied tidal stages as well as seasonally. Tidal information can be obtained from local bait shops, newspaper listings and/or local radio or television news reports.

Samplers may encounter situations where rate of flow affects their ability to collect a sample. For fast flowing rivers and streams it may be nearly impossible to collect a mid-channel sample at a specific point. Low flowing streams and leachate seeps present the opposite problem. In these cases the sampler should attempt to locate an area where flow is obstructed and a pool is created. If this is not possible, sediment may be dug with a decontaminated trowel to create a pooled area where sufficient liquid will accumulate for sampling.

#### **5.1 On-Shore**

If the banks are not sloped, sampling personnel may be able to collect the liquid directly into the sample bottle. In some instances where access is limited, a pond sampler, by virtue of its extension capabilities, may be necessary. For a stream, channel or river, collect the sample at mid-depth. For standing liquid, collect the sample from just below the surface or at mid-depth. Once the sample is obtained by sample vessel, transfer it directly into the sample bottle. If volatile organic compounds (VOCs) are to be analyzed, fill the appropriate sample containers for VOCs first, then fill sample containers for other chemical analyses. Decontaminate the sampling device following procedures outlined in the Sampling Plan and/or SOP F502 before obtaining the next sample.

#### **5.2 Off-Shore**

Collect a liquid sample using the sample bottle or decontaminated pond sampler, if necessary. If the liquid has stratified, a sample of each strata should be collected. One of the depth samplers listed above will allow collection of discrete representative liquid samples at various depths. Proper use of the chosen sampling device includes slowly lowering and careful retrieval of the sample, immediate transfer of the liquid into the appropriate sampling container, and logbook notation of the depth at which the sample was collected. After collection, the sampling device must be decontaminated prior to obtaining the next sample.

### **6.0 QUALITY ASSURANCE RECORDS**

Quality assurance records shall consist of recording sample date and acquisition time(s), sample number, sample location(s), sample depth(s), name of the Field Investigation Personnel collecting the sample(s), and Service Order Number in the field logbook. The type of container used to hold the sample and preservative agent, if needed, also will be documented, as will the method of

sampling equipment decontamination. In addition, if photographs are taken of the sample site, the photograph number and direction of view shall be recorded as well.

## 7.0 REFERENCES

Field Sampling Procedures Manual. Chapter 8. New Jersey Department of Environmental Protection, Trenton, New Jersey. February 1988.

Sampling and Analysis Methods. Compilation of EPA's Sampling and Analysis Methods, USEPA, Washington, D.C. 1991.

Characterization of Hazardous Waste Sites. USEPA, Washington, D. C. 1990.

**APPENDIX M**  
**SAMPLE PRESERVATION AND HANDLING**

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- 5.0 PROCEDURES**
  - 5.1 Sample Containers
  - 5.2 Preservation Techniques
  - 5.3 Sample Holding Times
- 6.0 SAMPLE HANDLING AND TRANSPORTATION**
- 7.0 REFERENCES**

## **SAMPLE PRESERVATION AND HANDLING**

### **1.0 PURPOSE**

This SOP describes the appropriate containers for samples of particular matrices, and the steps necessary to preserve those samples when shipped off site for chemical analysis. It also identifies the qualifications for individuals responsible for the transportation of hazardous materials and samples and the regulations set forth by the Department of Transportation regarding the same.

### **2.0 SCOPE**

Some chemicals react with sample containers made of certain 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 integrity of the sample prior to analysis.

Many water and soil samples are unstable and may change in chemical character during shipment. Therefore, preservation of the sample may be necessary 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). While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that may occur after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/freezing. Their purposes are to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

Typical sample container and preservation requirements for the CLEAN Program are referenced in NEESA 20.2-047B and are provided in Attachment A of this SOP. Note that sample container requirements (i.e., volumes) may vary by laboratory.

The Department of Transportation, Code of Federal Regulations (CFR) Title 49 establishes regulations for all materials offered for transportation. The transportation of environmental samples for analysis is regulated by Code of Federal Regulations Title 40 (Protection of the Environment), along with 49 CFR Part 172 Subpart H. The transportation of chemicals used as preservatives and samples identified as hazardous (as defined by 49 CFR Part 171.8) are regulated by 49 CFR Part 172.

### 3.0 DEFINITIONS

HCl - Hydrochloric Acid  
H<sub>2</sub>SO<sub>4</sub> - Sulfuric Acid  
HNO<sub>3</sub> - Nitric Acid  
NaOH - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalents per liter, where an equivalent is the amount of a substance containing one mole of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one mole of H, is "one-normal," while a one molar solution of H<sub>2</sub>SO<sub>4</sub> containing two moles of H, is "two-normal."

### 4.0 RESPONSIBILITIES

**Project Manager** - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is also responsible for proper certification of individuals responsible for transportation of samples of hazardous substances.

**Field Team Leader** - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures. The Field Team Leader is responsible to ensure all samples and/or hazardous substances are properly identified, labeled, and packaged prior to transportation.

Sampling Personnel – It is the responsibility of the field sampling personnel to initiate sample preservation and handling. It is also the responsibility of the field sampling personnel to understand and adhere to the requirements for proper transportation of samples and/or hazardous substances.

## 5.0 PROCEDURES

The following procedures discuss sample containerization and preservation techniques that are to be followed when collecting environmental samples for laboratory analysis.

### 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 measured is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then glass or plastic containers may be used. Containers shall be kept out of direct sunlight (to minimize biological or photo-oxidation/photolysis of constituents) until they reach the analytical laboratory. The sample container shall have approximately five to ten percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (one liter of water at 4°C expands by 15 milliliters if heated to 130°F/55°C); however, head space for volatile organic analyses shall be omitted.

The analytical laboratory shall provide sample containers that have been certified clean according to USEPA procedures. Shipping containers for samples, consisting of sturdy ice chests, are to be provided by the laboratory.

Once opened, the sample 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 liners (if required for the container) shall be discarded.

General sample container, preservative, and holding time requirements are listed in Attachment A.

## **5.2 Preservation Techniques**

The preservation techniques to be used for various analytes are listed in Attachment A. 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 using laboratory supplied preservatives. Some of the more commonly used sample preservation techniques include storage of sample at a temperature of 4°C, acidification of water samples, and storage of samples in dark (i.e. amber) containers to prevent the samples from being exposed to light.

All samples shall be stored at a temperature of 4°C. Additional preservation techniques shall be applied to water samples as follows:

- Water samples to be analyzed for volatile organics shall be acidified.
- Water samples to be analyzed for semivolatile organics shall be stored in dark containers.
- Water samples to be analyzed for pesticides/PCBs shall be stored in dark containers.
- Water samples to be analyzed for inorganic compounds shall be acidified.

These preservation techniques generally apply to samples of low-level contamination. The preservation techniques utilized for samples may vary. However, unless documented otherwise in the project plans, all samples shall be considered low concentration. All samples preserved with chemicals shall be clearly identified by indicating on the sample label that the sample is preserved.

## **5.3 Sample Holding Times**

The elapsed time between sample collection and initiation of laboratory analyses is considered the holding time and must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for routine sample collection are provided in Attachment A.



## 6.0 SAMPLE HANDLING AND TRANSPORTATION

After collection, the outside of all sample containers will be wiped clean with a damp paper towel; however sample handling should be minimized. Personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination and loss of sample labels. Sealable plastic bags, (zipper-type bags), should be used when glass sample containers are placed in ice chests to prevent cross-contamination, if breakage should occur.

Samples may be hand delivered to the laboratory or they may be shipped by common carrier. Relevant regulations for the storage and shipping of samples are contained in 40 CFR 261.4(d). Parallel state regulations may also be relevant. Shipment of dangerous goods by air cargo is also regulated by the United Nations/International Civil Aviation Organization (UN/ICAO). The Dangerous Goods Regulations promulgated by the International Air Transport Association (IATA) meet or exceed DOT and UN/ICAO requirements and should be used for shipment of dangerous goods via air cargo. Standard procedure for shipping environmental samples are given in Attachment B.

## 7.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

USEPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

USEPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. USEPA EMSL, Cincinnati, Ohio.

USEPA, Region IV, 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.

Protection of the Environment, Code of Federal Regulation, Title 40, Parts 260 to 299.

Transportation, Code of Federal Regulation, Title 49, Parts 100 to 177.

**ATTACHMENT A**

**REQUIRED CONTAINER, PRESERVATION TECHNIQUES  
AND HOLDING TIMES**

ATTACHMENT A

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES

| Parameter                             | Bottle Requirements     | Preservation Requirements                              | Holding Time <sup>(1)</sup>                 | Analytical Method  | Bottle Volume |
|---------------------------------------|-------------------------|--------------------------------------------------------|---------------------------------------------|--------------------|---------------|
| Volatile Organic Compounds (VOA)      | glass teflon lined cap  | Cool to 4°C<br>1:1 HCl pH <2                           | 10 days                                     | CLP                | 2 x 40 ml     |
| Semivolatile Organic Compounds (SVOA) | glass teflon lined cap  | Cool to 4°C<br>Dark                                    | Extraction within 5 days<br>Analyze 40 days | CLP                | 2 x 1 liter   |
| PCB/Pesticides                        | glass teflon lined cap  | Cool to 4°C<br>Dark                                    | Extraction within 5 days<br>Analyze 40 days | CLP                | 2 x 1 liter   |
| Cyanide                               | plastic/glass           | NaOH to pH>12<br>Cool to 4°C                           | 14 days                                     | CLP<br>EPA 335.2   | 1 x 1 liter   |
| Metals (TAL)                          | plastic/glass           | HNO <sub>3</sub> to pH <2                              | 180 days except Mercury is<br>26 days       | CLP                | 1 x 1 liter   |
| Total Organic Carbon                  | glass, teflon lined cap | Cool to 4°C<br>H <sub>2</sub> SO <sub>4</sub> to pH <2 | 28 days                                     | EPA 415.1          | 2 x 40 ml     |
| Total Organic Halogen                 | plastic/glass           | Cool to 4°C<br>H <sub>2</sub> SO <sub>4</sub> to pH <2 | 28 days                                     | EPA 450.1          | 250 ml        |
| Chloride                              | plastic/glass           | none required                                          | 28 days                                     | EPA<br>325.2/325.3 | 250 ml        |
| Sulfate                               | plastic/glass           | Cool to 4°C                                            | 28 days                                     | EPA 375.4          | 250 ml        |
| Alkalinity                            | plastic/glass           | Cool to 4°C                                            | 14 days                                     | EPA<br>310.1/310.2 | 250 ml        |
| Gross alpha/gross beta                | plastic/glass           | HNO <sub>3</sub> to pH <2                              | 6 months                                    | 9310               | 1 gallon      |
| Chlorinated herbicides                | glass, teflon lined cap | Cool to 4°C                                            | 14/28 days                                  | EPA 515.1          | 1000 ml       |
| Hardness                              | plastic/glass           | HNO <sub>3</sub> to pH <2                              | 6 months                                    | EPA 130.2          | 150 ml        |

<sup>(1)</sup> Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991.  
Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT A (Continued)

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOIL SAMPLES

| Parameter                             | Bottle Requirements    | Preservation Requirements | Holding Time <sup>(1)</sup>                  | Analytical Method | Bottle Volume |
|---------------------------------------|------------------------|---------------------------|----------------------------------------------|-------------------|---------------|
| Volatile Organic Compounds (VOA)      | glass teflon lined cap | Cool to 4°C               | 10 days                                      | CLP               | 1 x 50 gm     |
| Semivolatile Organic Compounds (SVOA) | glass teflon lined cap | Cool to 4°C               | Extraction within 10 days<br>Analyze 40 days | CLP               | 1 x 250 gm    |
| PCB/Pesticides                        | glass teflon lined cap | Cool to 4°C               | Extraction within 10 days<br>Analyze 40 days | CLP               | 1 x 50 gm     |
| Metals (TAL)                          | plastic/glass          | Cool to 4°C               | Mercury is 26 days<br>180 days               | CLP               | 1 x 50 gm     |
| Cyanide                               | plastic/glass          | Cool to 4°C               | 14 days                                      | CLP<br>EPA 335.2M | 1 x 50 gm     |

<sup>(1)</sup> Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991.  
Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

**ATTACHMENT B**

**SAMPLE SHIPPING PROCEDURES**

**ATTACHMENT B**  
**SAMPLE SHIPPING PROCEDURES**

**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 substances. The guidance for complying with U.S. 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."

Pertinent regulations for the shipping of environmental samples is given in 40 CFR 261.4(d). Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods/hazardous substance. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by the United Nations International Civil Aviation Organization (UN/ICAO), which is equivalent to IATA.

Individuals responsible for transportation of environmental samples or dangerous goods/hazardous substances must be tested and certified by their employer. This is required by 49 CFR Part 172 Subpart H Docket HM-126 to assure the required qualifications for individuals offering materials for transportation.

Environmental samples shall be packed prior to shipment by commercial air carrier using the following procedures:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug (inside and outside) with fiber or duct tape. Line the cooler with a large heavy duty plastic bag. This practice keeps the inside of the cooler clean and minimizes cleanup at the laboratory after samples are removed.
2. Allow sufficient headspace (ullage) in all bottles (except VOAs) 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). In many regions custody seals are also applied to sample container lids. The reason for this practice is two-fold: to maintain integrity of samples and keep lid on the container should the lid loosen during shipment. Check with the appropriate regional procedures prior to field work. In many cases, the laboratory manager of the analytical lot to be used on a particular project can also provide this information.
4. It is good practice to wrap all glass containers in bubblewrap or other suitable packing material prior to placing in plastic bags.
5. Place all bottles in separate and appropriately sized polyethylene bags and seal the bags with tape (preferably plastic electrical tape, unless the bag is a zipper-type bag). Up to three VOA bottles, separately wrapped in bubblewrap, may be packed in one plastic bag.
6. Optionally, place three to six VOA vials in a quart metal can and then fill the can with vermiculite.
7. Place two to four inches of vermiculite (ground corn cob, or other inert packing material) 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.
8. Put frozen "blue ice" (or ice that has been placed in properly sealed, double-bagged, heavy duty polyethylene bags) on top of and between the samples. Fill all remaining space between the bottles or cans with packing material. Fold and securely fasten the top of the large heavy duty plastic bag with tape (preferably electrical or duct).
9. Place the Chain-of-Custody Record and the Request for Analysis Form (if applicable) into a plastic bag, tape the bag to the inner side of the cooler lid, and then close the cooler and securely tape (preferably with fiber tape) the top of the cooler unit. Wrap the tape three to four times around each side of the cooler unit. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.
10. Each cooler (if multiple coolers) should have its own Chain-of-Custody Record reflecting the samples shipped in that cooler.
11. Label according to 40 CFR 261.4(d). The shipping containers should 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 and laboratory shall be placed on the outside of the container. It is good practice to secure this label with clear plastic tape to prevent removal during shipment by blurring of important information should the label become wet. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill, which is secured to the top of the shipping container. Please note several coolers/shipping containers may be shipped under one airbill. However, each cooler must be labeled as "Cooler 1 of 3, Cooler 2 of 3, etc.", prior to shipping. Additionally it is good practice to label each COC form to correspond to each cooler (i.e., 1 of 3, 2 of 3, etc.).

**APPENDIX N**  
**CHAIN-OF-CUSTODY**

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## CHAIN-OF-CUSTODY

### 1.0 PURPOSE

The purpose of this SOP is to provide information on chain-of-custody procedures to be used to document sample handling.

### 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 samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters, SOP F101). 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. 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 DEFINITIONS

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. One copy of the form must be retained in the project file.

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 one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she 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

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures

which deviate from those presented herein. The Project Manager is responsible for ensuring that chain-of-custody procedures are implemented. The Project Manager also is responsible for determining that custody procedures have been met by the analytical laboratory.

Field Team Leader - The Field Team Leader is responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate chain-of-custody procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

## **5.0 PROCEDURES**

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed 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.

### **5.1 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.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s)
- CTO Number
- Project Sample Number
- Sample location or sampling station number
- Date and time of sample collection and/or measurement
- Field observations
- Equipment used to collect samples and measurements
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

### 5.1.1 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 and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project or Contract Task Order (CTO) Number.
- Station Location - The unique sample number identifying this sample.
- 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 am., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only 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 the 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 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.

### 5.2.1 Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the 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; photographs will be stored in the project files. It is good practice to identify sample locations in photographs by including an easily read sign with the appropriate sample/location number.
- 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 if the pen would not function in freezing weather.

### 5.2.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individual(s) 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 given below.

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method, grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample shipping package. Retain the 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 C 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 shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening so that it would be broken if the container was to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using 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 shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

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.

## 6.0 QUALITY ASSURANCE RECORDS

Once samples have been packaged and shipped, the COC copy and airbill receipt becomes part of the Quality Assurance Record.

## 7.0 REFERENCES

1. USEPA. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

**ATTACHMENT A**  
**EXAMPLE SAMPLE LABEL**

ATTACHMENT A

EXAMPLE SAMPLE LABEL

|                                        |                                                                                                               |
|----------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <b>Baker</b>                           | <b>Baker Environmental Inc.<br/>Airport Office Park, Bldg. 3<br/>420 Rouser Road<br/>Coraopolis, PA 15108</b> |
| Project: <u>19026-SRN</u>              | CTO No.: <u>0026</u>                                                                                          |
| Sample Description: <u>Groundwater</u> |                                                                                                               |
| Date: <u>09/17/92</u>                  | Sampler: <u>ABC</u>                                                                                           |
| Time: <u>0944</u>                      |                                                                                                               |
| Analysis: <u>TAL Metals (CAP)</u>      | Preservation: <u>HNO<sub>3</sub></u>                                                                          |
| Project Sample No.: <u>CAX-GW-04</u>   |                                                                                                               |

Note: Typically, sample labels are provided by the analytical laboratory and may be used instead of the above. However, samplers should make sure all pertinent information can be affixed to the label used.



**ATTACHMENT B**

**EXAMPLE CHAIN-OF-CUSTODY RECORD**



**ATTACHMENT C**  
**EXAMPLE CUSTODY SEAL**

**ATTACHMENT C**

**EXAMPLE CUSTODY SEAL**

|              |                        |              |                        |
|--------------|------------------------|--------------|------------------------|
| <b>Baker</b> | ____/____/____<br>Date | <b>Baker</b> | ____/____/____<br>Date |
|              | _____<br>Signature     |              | _____<br>Signature     |
|              | <b>CUSTODY SEAL</b>    |              | <b>CUSTODY SEAL</b>    |

**APPENDIX O**  
**FIELD LOGBOOK**

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**FIELD LOGBOOK  
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- 4.0 RESPONSIBILITIES**
- 5.0 PROCEDURES**
  - 5.1 Cover
  - 5.2 Daily Entries
  - 5.3 Photographs
- 6.0 QUALITY ASSURANCE RECORDS**
- 7.0 REFERENCES**

## FIELD LOGBOOK

### 1.0 PURPOSE

This SOP describes the process for maintaining a field logbook.

### 2.0 SCOPE

The field logbook is a document which records all major on-site activities conducted during a field investigation. At a minimum, the following activities/events shall be recorded in the field logbook by each member of the field crew.

- Arrival/departure of site workers and visitors
- Arrival/departure of equipment
- Sample pickup (sample numbers, carrier, time)
- Sampling activities
- Start or completion of boreholes, monitoring wells, or sampling activities
- Health and safety issues

The field logbook is initiated upon arrival at the site for the start of the first on-site activity. Entries are made every day that on-site activities take place. At least one field logbook shall be maintained per site.

The field logbook becomes part of the permanent site file. Because information contained in the field logbook may be admitted as evidence in legal proceedings, it is critical that this document is properly maintained.

### 3.0 DEFINITIONS

Field logbook - The field logbook is a bound notebook with consecutively numbered pages. Upon entry of data, the logbook requires the signature of the responsible data/information recorder.

### 4.0 RESPONSIBILITIES

The Field Team Leader is responsible for maintaining a master field logbook for the duration of on-site activities. Each member of the sampling crew is responsible for maintaining a complete and accurate record of site activities for the duration of the project.

### 5.0 PROCEDURES

The following sections discuss some of the information which must be recorded in the field logbook. In general, a record of all events and activities, as well as other potentially important information shall be recorded by each member of the field team.

### 5.1 Cover

The inside cover or title page of each field logbook shall contain the following information:

- Contract Task Order Number
- Project name and location
- Name of Field Team Leader
- Baker's address and telephone number
- Start date
- If several logbooks are required, a sequential field logbook number

It is good practice to list important phone numbers and points of contact here.

### 5.2 Daily Entries

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded by each team member.

- Date
- Start time
- Weather
- All field personnel present
- All visitors present
- Other pertinent information (i.e., planned activities, schedule changes, expected visitors, and equipment changes)

During the day, an ongoing record of all site activities should be written in the logbook. The master logbook kept by the field team leader need not duplicate that recorded in other field logbooks, but should summarize the information in other books and, where appropriate, reference the page numbers of other logbooks where detailed information pertaining to a subject may be found.

Some specific information which must be recorded in the logbook includes:

- Equipment used, equipment numbers, calibration, field servicing
- Field measurements
- Sample numbers, media, bottle size, preservatives, collection methods, and time
- Test boring and monitoring well construction information, including boring/well number and location
- Sketches for each sample location including appropriate measurements if required.
- Photograph log
- Drum log
- Other pertinent information



All entries should be made in indelible ink; all pages numbered consecutively; and all pages must be signed or initialed and dated by the responsible field personnel completing the log. No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single line, initialed, and dated.

### **5.3     Photographs**

If photographs are permitted at a site, the record shall be maintained in the field logbook. When movies, slides or photographs are taken of any site location, they are numbered or cross-referenced to correspond to logbook entries. The name of the photographer, date, time, site location, site description, direction of view and weather conditions are entered in the logbook as the photographs are taken. Special lenses, film, or other image-enhancement techniques also must be noted in the field logbook. Once processed, photographs shall be serially numbered and labeled corresponding to the field logbook entries. Note that it may not be permitted to take photographs at all Activities; permission must be obtained from the LANTDIV EIC and the Activity responsible individual.

### **6.0     QUALITY ASSURANCE RECORDS**

Once on-site activities have been completed, the field logbook shall be considered a quality assurance record.

### **7.0     REFERENCES**

None.

**DRAFT**

**REMEDIAL INVESTIGATION/FEASIBILITY STUDY  
QUALITY ASSURANCE PROJECT PLAN**

**OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)**

**CONTRACT TASK ORDER 0344**

**DECEMBER 5, 1996**

*Prepared for:*

**DEPARTMENT OF THE NAVY  
ATLANTIC DIVISION  
NAVAL FACILITIES  
ENGINEERING COMMAND  
*Norfolk, Virginia***

*Under:*

**LANTDIV CLEAN Program  
Contract N62470-89-D-4814**

*Prepared by:*

**BAKER ENVIRONMENTAL, INC.  
*Coraopolis, Pennsylvania***

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## 1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been developed for the field investigation at Operable Unit (OU) No. 17 at Marine Corps Base, Camp Lejeune, North Carolina. The following sites are included in this OU.

- Site 90 - Building BB-9
- Site 91 - Building BB-51
- Site 92 - Building BB-46

The preparation of this QAPP, and other related project plans, is being performed under the Navy CLEAN Contract No. N62470-89-D-4814, Contract Task Order 0344. Baker Environmental, Inc., (Baker) is the prime contractor for the implementation of this project.

This QAPP addresses the quality assurance and quality control steps and procedures that will be administered for the sample collection and analysis for this Remedial Investigation (RI). Detailed information regarding sample handling and analytical methods are provided in Sections 6.0 and 9.0, respectively. Sample collection procedures are provided in the Field Sampling and Analysis Plan (FSAP).

## 2.0 SCOPE OF QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) addresses sample collection and analysis to be conducted for the field investigation of OU No. 17 of Camp Lejeune, North Carolina. The QAPP has been developed for the Department of Navy (DON) in accordance with U.S. Environmental Protection Agency (USEPA) guidelines. Contractors will follow QA/QC practices and procedures, including chain-of-custody procedures, while conducting all sample collection and analysis activities.

In order to provide adequate QA/QC, this investigation will require:

1. The use of a NFESC-certified analytical laboratories;
2. The use of accepted analytical methods for the samples discussed in the FSAP. Analysis of samples for hazardous constituents parameters will be performed using the following documents:
  - "Statement of Work for Organic Analysis," USEPA, OLM01.9, August 1991
  - "Statement of Work for Inorganic Analysis," USEPA, ILM03.0, March 1990
  - "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
  - "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
  - "Test Methods for Evaluating Solid Waste," USEPA SW846, November 1986, 3rd Edition and 1996 updates
  - "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886
3. The conducting of field audit(s) during initial sampling activities to verify that sampling is being performed according to the Plan.

The structure of this QAPP and the QA elements addressed are:

- Title Page
- Table of Contents
- Introduction
- QAPP Scope
- Project Description
- Project Organization
- QA Objectives for Data Measurement
- Sampling Procedures

- Sample and Document Custody
- Calibration Procedures and Frequency
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal QC Checks
- Performance and System Audits
- Preventive Maintenance
- Data Measurement Assessment Procedures
- Corrective Action
- QA Reports to Management

### **3.0 PROJECT DESCRIPTION**

An introduction to the field investigation for OU No. 17 describing the project objectives and scope are given in Sections 4.0 and 5.0 of the RI/FS Work Plan. These sections discuss the objectives of the RI/FS, and the various field sampling and analytical programs. A detailed description of the field investigations, including sample location and designation and sampling procedures and frequency, is presented in Sections 3.0, 4.0, and 5.0 of the FSAP.

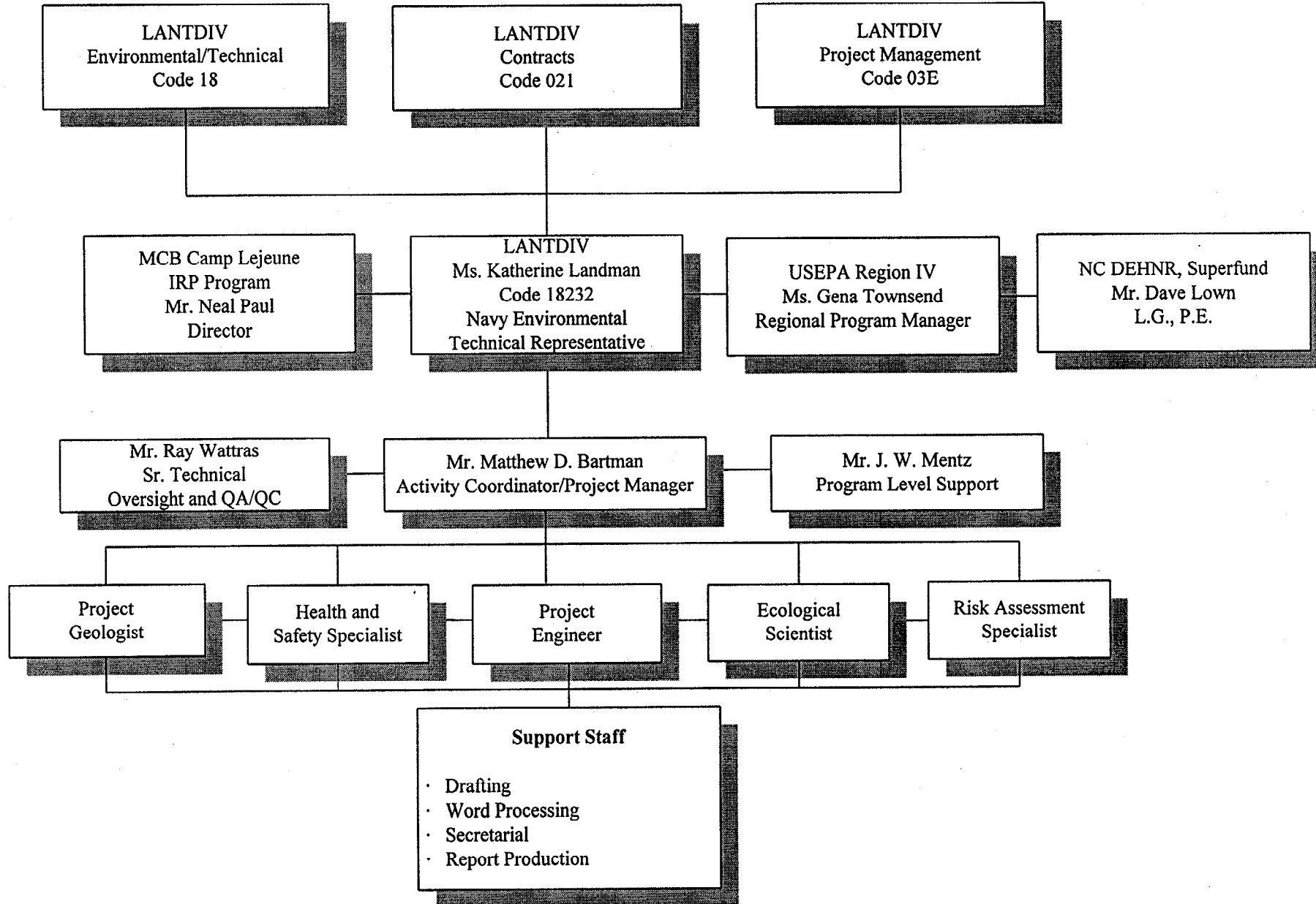


#### **4.0 PROJECT ORGANIZATION**

Technical performance of the investigation for OU No. 17 at Camp Lejeune and key personnel responsible for quality assurance throughout its duration are described in Section 5.0 of the RI/FS Work Plan. The contractor will utilize subcontractors to perform laboratory analysis, data validation, drilling and monitoring well installation, and surveying. Specific subcontractors have not yet been identified. Figure 4-1 shows the project organization, lines of authority, and support personnel/organizations.

FIGURE 4-1

PROJECT ORGANIZATION



4-2

## 5.0 QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT

The purpose of a QA Program is to establish policies for the implementation of regulatory requirements and to provide an internal means for control and review so that the work performed is of the highest professional standards.

### 5.1 Project Quality Assurance Objectives

The following is a list of QA objectives which will be implemented at OU No. 17.

- Obtain scientific data of a quality sufficient to meet scientific and legal scrutiny.
- Gather/develop data in accordance with procedures appropriate for its intended use.
- Ensure that data is of acceptable precision, accuracy, completeness, representativeness, and comparability as required by the project.

The fundamental mechanisms that will be employed to achieve these quality goals can be categorized as prevention, assessment and correction where:

- Prevention of errors through planning, documented instructions and procedures, and careful selection and training of skilled, qualified personnel.
- Assessment of all quality assurance sampling reports furnished by the contract laboratory.
- Assessment of data through data validation, and of procedures through laboratory and field audits.
- Correction for prevention of reoccurrence of conditions adverse to quality.

This QAPP, prepared in direct response to these goals, describes the QA Program to be implemented and the quality control (QC) procedures to be followed by field and laboratory personnel during the course of the project.

This QAPP presents the project organization and specifies or references technical procedures, documentation requirements, sample custody requirements, audit, and corrective action provisions to be applied to provide confidence that all activities meet the intent of the QA program. This QAPP has been prepared in accordance with USEPA guidance as presented in "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," QAMS-005/80.

The procedures contained or referred to herein have been taken from:

- "Statement of Work for Organic Analysis," USEPA, OLM01.9, August 1991
- "Statement of Work for Inorganic Analysis," USEPA, ILM03.0, March 1990

- "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
- "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
- "Test Methods for Evaluating Solid Waste," USEPA SW846, November 1986, 3rd Edition and 1996 updates
- "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886
- "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," USEPA, (QAMS 005/80).

## 5.2 Data Quality Objectives

Data quality objectives (DQOs) are qualitative or quantitative statements developed by the data users to specify the quality of data needed from a particular data collection activity to support a specific decision. The DQOs are expressed in terms of precision, accuracy, representativeness, completeness, and comparability. Definitions for these terms, as well as for the more general term uncertainty, are given in Table 5-1. The Project Manager, in conjunction with the Navy Environmental Technical Representative (NTR), is responsible for defining the DQOs. The intended use of the data, analytical measurements, and the availability of resources are integral in development of DQOs. DQOs define the level of uncertainty in the data that is acceptable for each specific activity during the investigation. This uncertainty includes both field sampling error and analytical instrument error. Ideally, zero uncertainty is the goal; however, the variables associated with sampling and analysis contribute to a degree of uncertainty in any data generated. It is an overall program objective to keep the total uncertainty within an acceptable range, so as not to hinder the intended use of the data. To achieve this objective, specific data quality requirements such as detection limits, criteria for accuracy and precision, sample representativeness, data comparability, and data completeness have been specified.

The data collected will be used:

- To evaluate the presence or absence of contamination resulting from previous disposal activities.
- To assess potential contaminant migration and exposure pathways.
- To monitor health and safety conditions during field activities.
- To identify releases or suspected releases of hazardous waste and/or constituents.
- To screen from further investigation those areas which do not pose a threat to human health or environment.

**TABLE 5-1**

**DEFINITIONS OF DATA QUALITY INDICATORS**

**PRECISION** - A measure of mutual agreement among individual measurements of the sample property, usually under prescribed similar conditions. Precision is expressed in terms of the standard deviation. Comparison of replicate values is best expressed as the relative percent difference (RPD). Various measures of precision exist depending upon the "prescribed similar conditions".

**ACCURACY** - The degree of agreement of a measurement (or an average of replicate measurements),  $X$ , with an accepted reference or true value,  $T$ , expressed as the difference between the two values,  $X-T$ . Accuracy is a measure of the bias in a system.

**REPRESENTATIVENESS** - Expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental concern.

**COMPLETENESS** - A measure of the amount of the valid data obtained from the measurement system compared to the amount that was expected under "normal" conditions.

**COMPARABILITY** - Expresses the confidence with which one data set can be compared with another.

**UNCERTAINTY** - The unlikelihood of all types of errors associated with a particular decision.

All samples for characterizing the site or qualitatively assessing human health and environmental risks will be analyzed and reported by the laboratory as Level IV data (NFESC Level D). All on-site analyses, which will be used to assist in characterizing contamination, will be performed using EPA approved methods Level (NFESC). Field parameters including temperature (aqueous only) and specific conductance will be Level I (NFESC Level A) data quality.

## **6.0 SAMPLE AND DOCUMENT CUSTODY PROCEDURES**

Descriptions of the procedures to be used for sampling the groundwater and soil at the site are provided in the FSAP. The number of samples, sampling locations, and sampling rationale by media also are presented in Section 5.0 of the FSAP.

Sample custody procedures outlined in this section have been developed from "User's Guide to the Contract Laboratory Program," December 1988, OSWER Directive No. 9240.0-01. These procedures are in accordance with "EPA NEIC Policies and Procedure Manual," May 1978, revised November 1984, EPA 330-78-001-R and "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," December 1980, QAMS-005/80.

The purpose of this section is to outline the sample handling and sample documentation procedures to be used during implementation of the FSAP. The objective of the sample handling procedures is to deliver representative samples to the laboratories for analysis. The objectives of the sample documentation procedures are to: (1) ensure complete analysis of the requested parameters within the required turnaround times; and (2) document the sample from the point of collection to the final data report.

### **6.1 Sampling Handling**

New polyethylene or glass bottles containing the proper preservatives will be provided by the laboratory for sample collection. In addition to the chemical preservatives, samples will be stored on ice at 4°C in a waterproof metal or sturdy plastic cooler, if required (see Tables 6-1 through 6-2 for summaries of containers, preservation, and holding times for water and solids, respectively).

### **6.2 Chain-of-Custody Procedures**

A sample is considered to be in an individual's possession if:

- It is in the sampler's possession or it is in the sampler's view after being in his or her possession.
- It was in the sampler's possession and then locked or sealed to prevent tampering.
- It is in a secure area.

Five kinds of documentation will be used in tracking and shipping the analytical samples:

- Field log book
- Sample labels
- Chain-of-Custody (COC) records
- Custody seals
- Commercial carrier airbills

**TABLE 6-1**

**SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES  
OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)  
CTO 0344  
MCB CAMP LEJEUNE, NORTH CAROLINA**

| Parameter           | Container                                   | Preservation                       | Holding Time                                                   |
|---------------------|---------------------------------------------|------------------------------------|----------------------------------------------------------------|
| TCL Volatiles       | Two 40-ml vials with teflon septum caps     | Cool, 4°C<br>HCl pH <2             | 14 days (7 days if unpreserved)                                |
| TCL Semivolatiles   | 1-liter amber glass bottle with teflon caps | Cool, 4°C                          | 7 days to extraction;<br>40 days from extraction to analysis   |
| TCL Pesticides/PCBs | 1-liter amber glass bottle with teflon caps | Cool, 4°C                          | 7 days to extraction;<br>40 days after extraction for analysis |
| TAL Metals          | 1-500 ml polyethylene bottle                | Cool, 4°C<br>HNO <sub>3</sub> pH<2 | 6 months;<br>Mercury 28 days                                   |
| TSS                 | 1-500 ml polyethylene bottle                | Cool, 4°C                          | 2 days                                                         |
| TDS                 | 1-500 ml polyethylene bottle                | Cool, 4°C                          | 7 days                                                         |

6-2

Notes:

- TCL - Target Contaminant List
- TAL - Target Analyte List
- COD - Chemical Oxygen Demand
- BOD - Biological Oxygen Demand
- TSS - Total Suspended Solids
- TDS - Total Dissolved Solids



TABLE 6-2

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOLID SAMPLES  
OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)  
CTO 0344  
MCB CAMP LEJEUNE, NORTH CAROLINA

| Parameter           | Container                         | Preservation | Holding Time                                                   |
|---------------------|-----------------------------------|--------------|----------------------------------------------------------------|
| TCL Volatiles       | One 4-ounce wide-mouth glass jars | Cool, 4°C    | 10 days                                                        |
| TCL Semivolatiles   | One 8-ounce wide-mouth glass jar  | Cool, 4°C    | 7 days to extraction;<br>40 days from extraction to analysis   |
| TCL Pesticides/PCBs | One 8-ounce wide-mouth glass jar  | Cool, 4°C    | 7 days to extraction;<br>40 days after extraction for analysis |
| TAL Metals          | One 8-ounce wide-mouth glass jar  | Cool, 4°C    | 6 months;<br>Mercury, 28 days                                  |

Notes:

- TCL - Target Contaminant List
- TAL - Target Analyte List

At a minimum, the label for each sample bottle will contain the following information:

- Site name
- Sample number
- Date and time of collection
- Sample type (grab or composite)
- Matrix
- Sampler's initials

The sample information, as well as the analysis to be performed on the sample, will be entered in the field log book for each sampling point. Additionally, the following items will be entered:

- Dates and times of entry
- Names of field personnel on site
- Names of visitors on site
- Field conditions
- Description of activities
- Sampling remarks and observations
- QA/QC samples collected
- List of photographs taken
- Sketch of site conditions

Custody of the samples will be maintained by field personnel from the time of sampling until the time they are forwarded to the analytical laboratory.

The sample custody is documented using Chain-of-Custody (COC) records. Field personnel will complete a COC record, in waterproof ink, to accompany each cooler forwarded from the site to the laboratory. Chemical reagents used to preserve the samples will be recorded on the COC record. Any errors on the COC records will not be erased; instead, a line will be drawn through the error and initialed by the person completing the form. The original copy will be placed in a sealable plastic bag and put inside the appropriate cooler, secured to the cooler's lid.

If the sample cooler is to be shipped by commercial air carrier, the cooler must be secured with custody seals so that the seals would be broken if the cooler was opened. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill.

If the sample shipment is hand delivered to the laboratory by field personnel or retrieved by laboratory personnel at the site, then the custody seals are not necessary. The laboratory sample custodian, or his/her designee accepting the sample shipment, whether it is from the air carrier or the field personnel, signs and dates the COC record upon sample receipt. The original COC record will be returned along with the final data report. The laboratory will be responsible for maintaining internal log books and records that provide a custody record during sample preparation and analysis.

## Laboratory Chain-of-Custody Procedures

Upon sample receipt the steps below will be performed.

- Samples will be received and unpacked in the laboratory where the staff checks for bottle integrity (loose caps, broken bottles, etc.).
- Samples will be verified with incoming paperwork (packing slip, etc.) by type of bottle and stabilizer. The paperwork must be either signed or initialed.
- Information concerning the sample (from the sampling record, Chain-of-Custody, and observation) will be recorded along with parameters to be analyzed, date of sampling, and date the sample is received in the laboratory.
- Samples will be placed in an appropriate secured storage area until analysis.
- When analysis is complete, samples will be stored for a 30-day period unless otherwise specified.

If collected samples arrive without Chain-of-Custody or incorrect Chain-of-Custody records, the following steps will be taken:

- The laboratory will prepare a nonconformance form stating the problem.
- The site supervisor and Project Manager will be notified.
- If the missing information cannot be provided by the field staff, the samples affected will not be analyzed.

Primary considerations for sample storage are:

- Secured storage.
- Maintain prescribed temperature, if required, which is typically four degrees Celsius.
- Extract and/or analyze samples within the prescribed holding time for the parameters of interest.

### 6.3 Document Custody Procedures

Project records are necessary to support the validity of the work and to furnish documentary evidence of quality. The evidentiary value of data is dependent upon the proper maintenance and retrieval of quality assurance records. Therefore, procedures will be established to assure that all documents attesting to the validity of work can be accounted for when the work is completed.

Records must be legible, filled out completely, and adequately identified as to the item or activity involved. Records will be considered valid only if initialed, signed, or otherwise authenticated and

dated by authorized personnel. These records may either be originals or reproduced copies. Records submitted to the files, with the exception of correspondence, will be bound, placed in folders or binders, or otherwise secured for filing.

Following receipt of information from external sources, completion of analyses, and issuance of reports or other transmittals, associated records will be submitted to the proper file. In addition, transmitted records must be adequately protected from damage and loss during transfer (e.g, hand carrying or making copies prior to shipment).

The following documents will be transferred to the proper files during the course of the project: calculations and checkprints; reports and other data transmittals; copies of proposals, purchase orders for project services, and contracts; correspondence including incoming and outgoing letters, memoranda, and telephone records; and reference material.

All individuals on the project staff will be responsible for reporting obsolete or superseded project-related information to the Project Manager. In turn, the Project Manager will notify the project and laboratory staffs of the resulting status change in project documents, such as drawings and project procedures.

In general, outdated drawings and other documents will be marked "void." However, the Project Manager may request the copies be destroyed. One copy of void documents is maintained in the project files with the reasons, and date of voiding clearly indicated.

Documents will be marked "preliminary" to denote calculations and other material which have not been formally checked, or based on information which has not been checked, or do not contribute to final project information.

## 7.0 CALIBRATION PROCEDURES AND FREQUENCY

The following section describes calibration procedures and frequency.

### 7.1 Field Instruments

Two field instruments will be used for health and safety monitoring: the O<sub>2</sub>/LEL meter, and the HNu System portable photoionizer. These instruments will be calibrated on site daily according to the manufacturer's instructions in addition to the factory calibration it will receive prior to the start of site sampling. The calibration standards will be recorded in the field log book.

A pH meter and a conductivity meter will be used to analyze groundwater and surface water samples. Procedures from "Test Methods for Evaluating Solid Waste," USEPA, SW846, November 1986, 3rd Edition will be used to calibrate these meters. Specific procedures for the calibration of water quality instruments are presented in the FSAP.

### 7.2 Laboratory Instruments

The laboratory's procedures for calibration and related quality control measures will be conducted according to the protocols presented in the following documents:

- "Statement of Work for Organic Analysis," USEPA, OLM01.9, August 1991
- "Statement of Work for Inorganic Analysis," USEPA, ILM03.0, March 1990
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," USEPA, July 1982
- "Methods for Chemical Analysis of Water and Waste," USEPA, 1979, Revised March 1983
- "Environmental Protection Agency Regulations on Test Procedures for Analysis of Pollutants," USEPA, 40 CFR 136
- "Test Methods for Evaluating Solid Waste," USEPA SW846, November 1986, 3rd Edition and 1996 updates
- "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886

Formal calibration procedures will be established to ensure that instrumentation and equipment used for sample analysis are accurately calibrated and properly functioning. These procedures will apply to all instruments and equipment quantities. All calibrations will be performed by laboratory personnel or external agencies using standard reference materials.

All calibrations will be recorded on in-house calibration forms or instrument vendor forms or in dedicated bound notebooks. The following data will be recorded for all calibrations: the date, target

readings, actual readings, instrument identification number, and the analyst's initials. Other data may be recorded depending upon the calibration performed.

Only properly calibrated and operating equipment and instrumentation will be used. Equipment and instrumentation not meeting the specified calibration criteria will be segregated from active equipment whenever possible. Such equipment will be repaired and recalibrated before reuse.

All equipment will be uniquely identified, either by serial number or internal calibration number, to allow traceability between equipment and calibration records. Recognized procedures (ASTM, USEPA, or manufacturer's procedures) will be used for calibration whenever available.

### **7.2.1 Method Calibration**

Method calibration will be performed as part of the laboratory analytical procedure (calibration curves, tuning). Calibration curves will be prepared using five standards in graduated amounts across the appropriate range of analysis. New calibration curves will be prepared whenever new reagents or standards are prepared or yearly, whichever is more frequent.

### **7.2.2 GC/MS System Calibration Procedure**

This section outlines the requirements for the calibration of GC/MS systems for the determination of organic compounds. The following operations will be performed in support of these requirements:

- Documentation of GC/MS mass calibration and abundance pattern
- Documentation of GC/MS response factor stability
- Internal standard response and retention time monitoring

#### Tuning and Mass Calibration

It will be necessary to establish that a given GC/MS system meets the standard mass spectral abundance criteria prior to initiating data collection. This will be accomplished through the analysis of p-bromofluorobenzene (BFB) for volatile compounds or decafluorotri-phenylphosphine (DFTPP) for semivolatiles compounds. The BFB or DFTPP criteria must be met before any blanks, standards, or samples are analyzed.

A GC/MS system used for organic compound analysis will be tuned to meet the criteria specified for BFB analysis (volatile compounds) or DFTPP (semivolatiles compounds) for an injection of 50 nanograms (ng) of BFB or DFTPP. The analysis must be performed separately from standard or blank analysis. These criteria will be demonstrated every 12 hours of operation. Professional judgment must be used to determine whether background subtraction is required to eliminate column bleed or instrument background (i.e., noise). Calibration documentation will be in the form of a bar graph spectrum and a mass listing.

#### GC/MS System Calibration

After tuning criteria have been met and prior to sample analysis, the GC/MS system is initially calibrated at five concentrations utilizing the compounds to be analyzed to determine the linearity

of response. Internal and surrogate standards will be used with each calibration standard. Standards will be analyzed under the same conditions as the samples.

- **Relative Response Factor (RRF) Calculation** - The USEPA specifies the internal standard to be used on a compound-by-compound basis for quantification. The relative response factor (RRF) will be calculated for each compound at each concentration level.
- **Continuing Calibration** - A calibration check standard containing all semivolatile or volatile compounds and surrogates will be run every 12 hours of analysis. A system performance check will also be performed. The criteria will be the same as for the initial calibration system performance check. A calibration check will also be performed. The percent difference will be determined for each Calibration Check Compound (CCC).

The percent Difference for each CCC must be less than or equal to 25.0 percent. The system performance check and calibration check criteria must be met before sample analysis can be performed. The continuing calibration will be recorded on the continuing calibration forms.

### **7.2.3 GC System Calibration Procedure for Pesticides/PCBs**

This section outlines the requirements for the calibration of GC systems for the determination of pesticides/PCBs. The following operations are performed in support of these requirements:

Three types of analyses will be used to verify the calibration and evaluate instrument performance. The analyses of instrument blanks, Performance Evaluation mixtures (PEMs), and the mid-point concentration of the individual standard mixtures A and B constitute the continuing calibration.

For pesticide/PCB analysis it is necessary to establish resolution criteria by performing a Resolution Check Mixture where the depth of the valley of two adjacent peaks must be greater than or equal to 60.0 percent of the height of the shorter peak.

The breakdown of DDT and Endrin in both of the PEMs must be less than 20.0 percent and the combined breakdown of DDT and Endrin must be less than 30.0 percent. All peaks in both the Performance Evaluation Mixtures must be 100 percent resolved on both columns.

The absolute retention times of each of the single component pesticides and surrogates in both of the PEMs must be within the retention time windows determined from the three point initial calibration.

The relative percent difference of the calculated amount and the true amount for each of the single component pesticides and surrogates in both of the PEMs must be less than or equivalent to 25 percent.

At least one chromatogram between any two adjacent peaks in the midpoint concentrations of Individual Standard Mixtures A and B in the initial calibration must be greater than or equal to 90 percent.

## 7.2.4 System Calibration Procedure for Metals Analysis

This section outlines the requirements for the calibration of atomic absorption (AA) and Inductively Coupled Plasma (ICP) systems for the determination of metals. The following will be performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The AA system utilized for direct aspiration technique analysis will be initially calibrated with a calibration blank and five calibration standards. The standard concentrations will be determined as follows. One standard will be at a concentration near, but above, the MDL. The other concentrations will correspond to the expected range of concentrations found in the actual samples. This five-point calibration must be performed daily.

The AA system utilized for graphite furnace technique analysis will be initially calibrated with a calibration blank and three calibration standards. The standard concentrations will be determined as follows. One standard will be at a concentration at the Contract Required Detection Limit (CRDL). The other concentrations will correspond to the expected range of concentrations found in the actual samples. This three-point calibration must be performed daily.

For AA systems, the calibration standards will be prepared fresh each time an analysis is to be performed and discarded after use. The standards contain the same reagents at the same concentrations as will result in the samples following preparation.

The ICP system will be calibrated initially with a calibration blank and one calibration standard. This calibration must be performed daily. In addition, ICP systems must undergo quarterly linearity checks.

### Correlation Coefficient Calculation

The data points of the blank and the five calibration standards will be utilized to calculate the slope, the intercept, and the correlation coefficient of the best fit line. An acceptable correlation coefficient must be achieved before sample analysis may begin. An acceptable correlation coefficient will be  $>0.995$  for AA analyses and  $>0.995$  for ICP analysis.

### Calibration Verification

The initial calibration curve will be verified on each working day by the measurement of one mid-range calibration standard. The calibration verification acceptance criterion will be as follows:

- ICEP/GFAA - 90 to 110 percent of true value
- Cold Vapor AA - 80 to 120 percent of true value

When measurements exceed the control limits, the analysis will be terminated, the problem corrected, the instrument recalibrated, and the calibration reverified.



### 7.2.5 System Calibration Procedure for Inorganic Analyses

This section outlines the requirements that will be used for calibration of calorimetric systems for analyses of inorganic parameters. The following will be performed in support of these requirements:

- Documentation of standard response
- Correlation coefficient monitoring

The system will be initially calibrated with a blank and five calibration standards. Standard concentrations will be at a concentration near, but above, the MDL with additional concentrations corresponding to the expected range of concentrations found in actual samples. Standards contain the same reagents at the same concentrations as will be present in samples following preparation.

#### Correlation Coefficient Calculation

Data points of the blank and five calibration standards will be utilized to calculate slope, intercept, and correlation coefficient of a best fit line. An acceptable correlation coefficient must be achieved before sample analysis may begin. An acceptable correlation coefficient will be  $>0.995$  for all systems.

#### Calibration Verification

The initial calibration curve will be verified on each working day by the measurement of two calibration standards.

- ICEP/GFAA - 90 to 110 percent of true value
- Cold Vapor AA - 80 - 120 percent of true value

When measurements exceed control limits, analysis will be terminated, the problem will be corrected, the instrument will be recalibrated, and calibration will be reverified.

### 7.2.6 Periodic Calibration

Periodic calibration must be performed on equipment required in analyses but not routinely calibrated as part of the analytical methodology. Equipment that falls within this category includes ovens, refrigerators, and balances. The calibration will be recorded either on specified forms or in bound notebooks. Discussed below are the equipment, the calibration performed, and the frequency at which the calibration must be performed.

- Balances will be calibrated weekly with class S weights.
- The pH meter will be calibrated daily with pH 4 and 7 buffer solutions and checked with pH 10 buffer solution.
- The temperatures of the refrigerators will be recorded daily.
- All liquid in glass thermometers will be calibrated annually with the N.B.S. certified thermometer. Dial thermometers will be calibrated quarterly.

- The N.B.S. Certified Thermometer will be checked annually at the ice point.

The following equipment must maintain the following temperatures:

- Sample Storage and Refrigerators - within 2 degrees of 4 degrees Celsius
- Water Bath, Mercury - within 2 degrees of 95 degrees Celsius

## **8.0 ANALYTICAL PROCEDURES**

This next section discusses analytical procedures.

### **8.1 Field Analysis**

A O<sub>2</sub>/LEL and HNu PI-101 meters will be used to analyze ambient air for health and safety monitoring, as well as to screen soil during the soil sampling. The O<sub>2</sub>/LEL meter detects explosive gases that may be present (i.e., methane). The HNu PI-101 detects total organic vapor. These instruments will be operated in accordance with the manufacturer's instructions.

The pH, temperature, and specific conductivity of aqueous samples also will be measured in the field. These analyses will be obtained in accordance with "Handbook for Sampling and Sample Preservation of Water and Wastewater," September 1982, EPA/600/4-82-029.

### **8.2 Laboratory Analysis**

The samples that will be collected during the investigation and performed by the on-site laboratory will be analyzed for constituents listed in Tables 8-1. The samples that are collected for fixed based analysis will be analyzed for the constituents listed on Table 8-2 through 8-5. The samples that will be collected to evaluate IDW disposal will be analyzed for constituents listed on Table 8-6 and 8-7. Additionally, engineering parameters are listed on Table 8-7. Method performance limits for each constituent are provided on the respective tables.

TABLE 8-1

**VOLATILE ORGANIC COMPOUNDS  
METHOD PERFORMANCE LIMITS**

| Parameter                 | Water MDL <sup>(1)</sup> (µg/L) | Soil MDL <sup>(1)</sup> (µg/kg) | Method                                               |
|---------------------------|---------------------------------|---------------------------------|------------------------------------------------------|
| Benzene                   | 1                               | 1                               | USEPA SW846 - Method 8240 3rd Edition <sup>(2)</sup> |
| Bromodichloromethane      | 1                               | 1                               |                                                      |
| Bromoform                 | 1                               | 1                               |                                                      |
| Bromomethane              | 1                               | 1                               |                                                      |
| Carbon tetrachloride      | 1                               | 1                               |                                                      |
| Chlorobenzene             | 1                               | 1                               |                                                      |
| 2-Chloroethylvinyl ether  | 1                               | 1                               |                                                      |
| Chloroform                | 1                               | 1                               |                                                      |
| Chloromethane             | 1                               | 1                               |                                                      |
| Dibromochloromethane      | 1                               | 1                               |                                                      |
| 1,2-Dichlorobenzene       | 1                               | 1                               |                                                      |
| 1,3-Dichlorobenzene       | 1                               | 1                               |                                                      |
| 1,4-Dichlorobenzene       | 1                               | 1                               |                                                      |
| 1,1-Dichloroethane        | 1                               | 1                               |                                                      |
| 1,2-Dichloroethane        | 1                               | 1                               |                                                      |
| 1,1-Dichloroethene        | 1                               | 1                               |                                                      |
| trans-1,2-dichloroethene  | 1                               | 1                               |                                                      |
| 1,2-Dichloropropane       | 1                               | 1                               |                                                      |
| cis-1,3-Dichloropropene   | 1                               | 1                               |                                                      |
| trans-1,3-Dichloropropene | 1                               | 1                               |                                                      |
| Ethyl benzene             | 1                               | 1                               |                                                      |
| Methylene chloride        | 1                               | 1                               |                                                      |
| 1,1,2,2-Tetrachloroethane | 1                               | 1                               |                                                      |
| Tetrachloroethene         | 1                               | 1                               |                                                      |
| Toluene                   | 1                               | 1                               |                                                      |
| 1,1,1-Trichloroethane     | 1                               | 1                               |                                                      |
| 1,1,2-Trichloroethane     | 1                               | 1                               |                                                      |
| Trichloroethene           | 1                               | 1                               |                                                      |
| Trichlorofluoromethane    | 1                               | 1                               |                                                      |
| Vinyl chloride            | 10                              | 10                              |                                                      |

## Notes:

- (1) Method Detection Limit  
 (2) "Test Methods for Evaluating Solid Waste," USEPA, November 1986, 3rd Edition

TABLE 8-2

**TCL VOLATILE ORGANICS  
METHOD PERFORMANCE LIMITS**

| Compound                  | Water<br>CRQL <sup>(1)</sup><br>(µg/L) | Soil/Sediment<br>CRQL <sup>(1)</sup><br>(µg/kg) | Method                 |
|---------------------------|----------------------------------------|-------------------------------------------------|------------------------|
| Chloromethane             | 10                                     | 10                                              | CLP/SOW <sup>(2)</sup> |
| Bromomethane              | 10                                     | 10                                              |                        |
| Vinyl Chloride            | 10                                     | 10                                              |                        |
| Chloroethane              | 10                                     | 10                                              |                        |
| Methylene Chloride        | 10                                     | 10                                              |                        |
| Acetone                   | 10                                     | 10                                              |                        |
| Carbon Disulfide          | 10                                     | 10                                              |                        |
| 1,1 -Dichloroethene       | 10                                     | 10                                              |                        |
| 1,1 -Dichloroethane       | 10                                     | 10                                              |                        |
| 1,2 -Dichloroethene       | 10                                     | 10                                              |                        |
| Chloroform                | 10                                     | 10                                              |                        |
| 1,2 -Dichloroethane       | 10                                     | 10                                              |                        |
| 2-Butanone                | 10                                     | 10                                              |                        |
| 1,1,1-Trichloroethane     | 10                                     | 10                                              |                        |
| Carbon Tetrachloride      | 10                                     | 10                                              |                        |
| Bromodichloromethane      | 10                                     | 10                                              |                        |
| 1,2-Dichloropropane       | 10                                     | 10                                              |                        |
| cis-1,3-Dichloropropene   | 10                                     | 10                                              |                        |
| Trichloroethene           | 10                                     | 10                                              |                        |
| Dibromochloromethane      | 10                                     | 10                                              |                        |
| 1,1,2-Trichloroethane     | 10                                     | 10                                              |                        |
| Benzene                   | 10                                     | 10                                              |                        |
| trans-1,3-Dichloropropene | 10                                     | 10                                              |                        |
| Bromoform                 | 10                                     | 10                                              |                        |
| 4-Methyl-2-pentanone      | 10                                     | 10                                              |                        |
| 2-Hexanone                | 10                                     | 10                                              |                        |
| Tetrachloroethene         | 10                                     | 10                                              |                        |
| Toluene                   | 10                                     | 10                                              |                        |
| 1,1,2,2-Tetrachloroethane | 10                                     | 10                                              |                        |
| Chlorobenzene             | 10                                     | 10                                              |                        |
| Ethylbenzene              | 10                                     | 10                                              |                        |
| Styrene                   | 10                                     | 10                                              |                        |
| Xylenes (total)           | 10                                     | 10                                              |                        |

## Notes:

(1) Contract Required Quantitation Limit

(2) "Statement of Work for Organic Analysis," USEPA Contract Laboratory Program, OLM01.9

TABLE 8-3

**TCL SEMIVOLATILE ORGANICS  
METHOD PERFORMANCE LIMITS**

| Compound                                             | Water<br>CRQL <sup>(1)</sup><br>(µg/L) | Soil/Sediment<br>CRQL <sup>(1)</sup><br>(µg/kg) | Method                 |
|------------------------------------------------------|----------------------------------------|-------------------------------------------------|------------------------|
| Phenol                                               | 10                                     | 330                                             | CLP/SOW <sup>(2)</sup> |
| bis(2-Chloroethyl)ether                              | 10                                     | 330                                             |                        |
| 2-Chlorophenol                                       | 10                                     | 330                                             |                        |
| 1,3-Dichlorobenzene                                  | 10                                     | 330                                             |                        |
| 1,4-Dichlorobenzene                                  | 10                                     | 330                                             |                        |
| Benzyl alcohol                                       | 10                                     | 330                                             |                        |
| 1,2-Dichlorobenzene                                  | 10                                     | 330                                             |                        |
| 2-Methylphenol                                       | 10                                     | 330                                             |                        |
| bis(2-Chloroisopropyl)ether                          | 10                                     | 330                                             |                        |
| 4-Methylphenol                                       | 10                                     | 330                                             |                        |
| N-Nitroso-di-n-dipropylamine                         | 10                                     | 330                                             |                        |
| Hexachloroethane                                     | 10                                     | 330                                             |                        |
| Nitrobenzene                                         | 10                                     | 330                                             |                        |
| Isophorone                                           | 10                                     | 330                                             |                        |
| 2-Nitrophenol                                        | 10                                     | 330                                             |                        |
| 2,4-Dimethylphenol                                   | 10                                     | 330                                             |                        |
| Benzoic acid                                         | 25                                     | 1600                                            |                        |
| bis(2-Chloroethoxy)methane                           | 10                                     | 330                                             |                        |
| 2,4-Dichlorophenol                                   | 10                                     | 330                                             |                        |
| 1,2,4-Trichlorobenzene                               | 10                                     | 330                                             |                        |
| Naphthalene                                          | 10                                     | 330                                             |                        |
| 4-Chloroaniline                                      | 10                                     | 330                                             |                        |
| Hexachlorobutadiene                                  | 10                                     | 330                                             |                        |
| 4-Chloro-3-methylphenol<br>(para-chloro-meta-cresol) | 10                                     | 330                                             |                        |
| 2-Methylnaphthalene                                  | 10                                     | 330                                             |                        |
| Hexachlorocyclopentadiene                            | 10                                     | 330                                             |                        |
| 2,4,6-Trichlorophenol                                | 10                                     | 330                                             |                        |
| 2,4,5-Trichlorophenol                                | 25                                     | 1600                                            |                        |
| 2-Chloronaphthalene                                  | 10                                     | 330                                             |                        |
| 2-Nitroaniline                                       | 25                                     | 1600                                            |                        |
| Dimethylphthalate                                    | 10                                     | 330                                             |                        |
| Acenaphthylene                                       | 10                                     | 330                                             |                        |

Notes:

<sup>(1)</sup> Contract Required Quantitation Limit<sup>(2)</sup> "Statement of Work for Organic Analysis," USEPA Contract Laboratory Program, OLM01.9

TABLE 8-3 (Continued)

TCL SEMIVOLATILE ORGANICS  
METHOD PERFORMANCE LIMITS

| Compound                    | Water<br>CRQL <sup>(1)</sup><br>(µg/L) | Soil/Sediment<br>CRQL <sup>(1)</sup><br>(µg/kg) | Method                 |
|-----------------------------|----------------------------------------|-------------------------------------------------|------------------------|
| 2,6-Dinitrotoluene          | 10                                     | 330                                             | CLP/SOW <sup>(2)</sup> |
| 3-Nitroaniline              | 25                                     | 1600                                            |                        |
| Acenaphthene                | 10                                     | 330                                             |                        |
| 2,4-Dinitrophenol           | 25                                     | 1600                                            |                        |
| 4-Nitrophenol               | 25                                     | 1600                                            |                        |
| Dibenzofuran                | 10                                     | 330                                             |                        |
| 2,4-Dinitrotoluene          | 10                                     | 330                                             |                        |
| Diethylphthalate            | 10                                     | 330                                             |                        |
| 4-Chlorophenyl-phenyl ether | 10                                     | 330                                             |                        |
| Fluorene                    | 10                                     | 330                                             |                        |
| 4-Nitroaniline              | 25                                     | 1600                                            |                        |
| 4,6-Dinitro-2-methylphenol  | 25                                     | 1600                                            |                        |
| N-nitrosodiphenylamine      | 10                                     | 330                                             |                        |
| 4-Bromophenyl-phenylether   | 10                                     | 330                                             |                        |
| Hexachlorbenzene            | 10                                     | 330                                             |                        |
| Pentachlorophenol           | 25                                     | 1600                                            |                        |
| Phenanthrene                | 25                                     | 1600                                            |                        |
| Anthracene                  | 10                                     | 330                                             |                        |
| Di-n-butylphthalate         | 10                                     | 330                                             |                        |
| Fluoranthene                | 10                                     | 330                                             |                        |
| Pyrene                      | 10                                     | 330                                             |                        |
| Butylbenzylphthalate        | 10                                     | 330                                             |                        |
| 3,3'-Dichlorobenzidine      | 10                                     | 660                                             |                        |
| Benzo(a)anthracene          | 10                                     | 330                                             |                        |
| Chrysene                    | 10                                     | 330                                             |                        |
| bis(2-Ethylhexyl)phthalate  | 10                                     | 330                                             |                        |
| Di-n-octylphthalate         | 10                                     | 330                                             |                        |
| Benzo(b)fluoranthene        | 10                                     | 330                                             |                        |
| Benzo(k)fluoranthene        | 10                                     | 330                                             |                        |
| Benzo(a)pyrene              | 10                                     | 330                                             |                        |
| Indeno(1,2,3-cd)pyrene      | 10                                     | 330                                             |                        |
| Dibenzo(a,h)anthracene      | 10                                     | 330                                             |                        |
| Benzo(g,h,i)perylene        | 10                                     | 330                                             |                        |

Notes:

<sup>(1)</sup> Contract Required Quantitation Limit

<sup>(2)</sup> "Statement of Work for Organic Analysis," USEPA Contract Laboratory Program, OLM01.9

TABLE 8-4

TCL PESTICIDES/PCBS  
METHOD PERFORMANCE LIMITS

| Compound            | Water<br>CRQL <sup>(1)</sup><br>(µg/L) | Soil/Sediment<br>CRQL <sup>(1)</sup><br>(µg/kg) | Method                 |
|---------------------|----------------------------------------|-------------------------------------------------|------------------------|
| alpha-BHC           | 0.05                                   | 8.0                                             | CLP/SOW <sup>(2)</sup> |
| beta-BHC            | 0.05                                   | 8.0                                             |                        |
| delta-BHC           | 0.05                                   | 8.0                                             |                        |
| gamma-BHC (Lindane) | 0.05                                   | 8.0                                             |                        |
| Heptachlor          | 0.05                                   | 8.0                                             |                        |
| Aldrin              | 0.05                                   | 8.0                                             |                        |
| Heptachlor epoxide  | 0.05                                   | 8.0                                             |                        |
| Endosulfan I        | 0.05                                   | 8.0                                             |                        |
| Dieldrin            | 0.10                                   | 16.0                                            |                        |
| 4,4'-DDE            | 0.10                                   | 16.0                                            |                        |
| Endrin              | 0.10                                   | 16.0                                            |                        |
| Endosulfan II       | 0.10                                   | 16.0                                            |                        |
| 4,4'-DDD            | 0.10                                   | 16.0                                            |                        |
| Endosulfan sulfate  | 0.10                                   | 16.0                                            |                        |
| 4,4'-DDT            | 0.10                                   | 16.0                                            |                        |
| Methoxychlor        | 0.5                                    | 80.0                                            |                        |
| Endrin ketone       | 0.10                                   | 16.0                                            |                        |
| alpha-Chlordane     | 0.5                                    | 80.0                                            |                        |
| gamma-Chlordane     | 0.5                                    | 80.0                                            |                        |
| Toxaphene           | 5.0                                    | 160.0                                           |                        |
| Aroclor-1016        | 1.0                                    | 80.0                                            |                        |
| Aroclor-1221        | 2.0                                    | 80.0                                            |                        |
| Aroclor-1232        | 1.0                                    | 80.0                                            |                        |
| Aroclor-1242        | 1.0                                    | 80.0                                            |                        |
| Aroclor-1248        | 1.0                                    | 80.0                                            |                        |
| Aroclor-1254        | 1.0                                    | 160.0                                           |                        |
| Aroclor-1260        | 1.0                                    | 160.0                                           |                        |

Notes:

<sup>(1)</sup> Contract Required Quantitation Limit

<sup>(2)</sup> "Statement of Work for Organic Analysis," USEPA Contract Laboratory Program, OLM01.9



**TABLE 8-5**  
**TAL METALS**  
**METHOD PERFORMANCE LIMITS**

| Analyte   | Method Number <sup>(1)</sup> | CRDL <sup>(2)</sup> (µg/L) | Method Description                                                 |
|-----------|------------------------------|----------------------------|--------------------------------------------------------------------|
| Aluminum  | 200.7                        | 200                        | Inductively Coupled Plasma                                         |
| Antimony  | 200.7<br>204.2               | 60                         | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique |
| Arsenic   | 200.7<br>206.2               | 10                         | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique |
| Barium    | 200.7                        | 200                        | Inductively Coupled Plasma                                         |
| Beryllium | 200.7<br>210.2               | 5                          | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique |
| Cadmium   | 200.7<br>213.2               | 5                          | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique |
| Calcium   | 200.7<br>215.1               | 5,000                      | Inductively Coupled Plasma<br>Atomic Absorption, Direct Aspiration |
| Chromium  | 200.7<br>218.2               | 10                         | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique |
| Cobalt    | 200.7                        | 50                         | Inductively Coupled Plasma                                         |
| Copper    | 200.7                        | 25                         | Inductively Coupled Plasma                                         |
| Iron      | 200.7                        | 100                        | Inductively Coupled Plasma                                         |
| Lead      | 200.7<br>239.2               | 3                          | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique |

Notes:

- (1) Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM03.0, March 1990
- (2) Contract Required Detection Limit
- (3) Extraction method for arsenic, lead, selenium, and thallium taken from USEPA Method 3020, "Test Methods for Evaluating Solid Waste," USEPA, November 1986, 3rd Edition
- (4) Extraction method for all other metals taken from USEPA Method 3010, "Test Methods for Evaluating Solid Waste," USEPA, November 1986, 3rd Edition

TABLE 8-5 (Continued)

TAL METALS  
METHOD PERFORMANCE LIMITS

| Analyte                       | Method Number <sup>(2,3,4)</sup> | CRDL <sup>(1)</sup> (µg/L) | Method Description                                                                                                              |
|-------------------------------|----------------------------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <b>Metals<br/>(Continued)</b> |                                  |                            |                                                                                                                                 |
| Magnesium                     | 200.7<br>242.1                   | 5000                       | Inductively Coupled Plasma<br>Atomic Absorption, Direct Aspiration                                                              |
| Manganese                     | 200.7                            | 15                         | Inductively Coupled Plasma                                                                                                      |
| Mercury                       | 245.1<br>245.2<br>245.5          | 0.2                        | Water by manual cold vapor technique<br>Water by automated cold vapor technique<br>Soil/sediment by manual cold vapor technique |
| Nickel                        | 200.7                            | 40                         | Inductively Coupled Plasma                                                                                                      |
| Potassium                     | 200.7<br>258.1                   | 5000                       | Inductively Coupled Plasma<br>Atomic Absorption, Direct Aspiration                                                              |
| Selenium                      | 200.7<br>270.2                   | 5                          | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique                                                              |
| Silver                        | 200.7<br>272.2                   | 10                         | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique                                                              |
| Sodium                        | 200.7<br>273.1                   | 5000                       | Inductively Coupled Plasma<br>Atomic Absorption, Direct Aspiration                                                              |
| Thallium                      | 200.7<br>279.2                   | 10                         | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique                                                              |
| Vanadium                      | 200.7                            | 50                         | Inductively Coupled Plasma                                                                                                      |
| Zinc                          | 200.7                            | 20                         | Inductively Coupled Plasma                                                                                                      |

Notes:

- <sup>(1)</sup> Methods taken from "Statement of Work for Inorganic Analysis," USEPA Contract Laboratory Program, ILM03.0, March 1990
- <sup>(2)</sup> Contract Required Detection Limit
- <sup>(3)</sup> Extraction method for arsenic, lead, selenium, and thallium taken from USEPA Method 3020, "Test Methods for Evaluating Solid Waste," USEPA, November 1986, 3rd Edition
- <sup>(4)</sup> Extraction method for all other metals taken from USEPA Method 3010, "Test Methods for Evaluating Solid Waste," USEPA, November 1986, 3rd Edition

TABLE 8-6

**TCLP ORGANICS AND METALS  
METHOD PERFORMANCE LIMITS**

| Parameter                        | Aqueous PQL <sup>(1)</sup><br>(µg/l) | Solid PQL <sup>(1)</sup><br>(µg/kg) | Method                              |
|----------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| <b><u>TCLP Volatiles</u></b>     |                                      |                                     | EPA Method 3550/<br>EPA Method 8240 |
| Benzene                          | 5                                    | 10                                  |                                     |
| Carbon Tetrachloride             | 5                                    | 5                                   |                                     |
| Chloroform                       | 5                                    | 5                                   |                                     |
| 1,2-Dichloroethane               | 5                                    | 5                                   |                                     |
| 1,1-Dichloroethylene             | 5                                    | 5                                   |                                     |
| Methyl ethyl ketone              | NA                                   | NA                                  |                                     |
| Tetrachloroethylene              | 5                                    | 5                                   |                                     |
| Trichloroethylene                | 5                                    | 5                                   |                                     |
| Vinyl Chloride                   | 10                                   | 10                                  |                                     |
| <b><u>TCLP Semivolatiles</u></b> |                                      |                                     | EPA Method 3550/<br>EPA Method 8240 |
| o-Cresol                         | 10                                   | 660                                 |                                     |
| m-Cresol                         | 10                                   | 660                                 |                                     |
| p-Cresol                         | 10                                   | 660                                 |                                     |
| Cresol                           | 10                                   | 660                                 |                                     |
| 1,4-Dichlorobenzene              | 10                                   | 660                                 |                                     |
| 2,4-Dinitrotoluene               | 10                                   | 660                                 |                                     |
| Hexachlorobenzene                | 10                                   | 660                                 |                                     |
| Hexachlorobutadiene              | 10                                   | 660                                 |                                     |
| Hexachloroethane                 | 10                                   | 660                                 |                                     |
| Nitrobenzene                     | 10                                   | 660                                 |                                     |
| Pentachlorophenol                | 50                                   | 3,300                               |                                     |
| Pyridine                         | 50                                   | 660                                 |                                     |
| 2,4,5-Trichlorophenol            | 10                                   | 660                                 |                                     |
| 2,4,6-Trichlorophenol            | 10                                   | 660                                 |                                     |

## Notes:

- <sup>(1)</sup> Practical Quantitation Limit, taken from "Test Methods for Evaluating Solid Waste," USEPA, November 1986 and 1996 updates.

Note: These methods will be used to analyze the Toxicity Characteristic Leaching Procedure (TCLP) extract. The extract will be prepared using Method 1311, described in "Hazardous Waste Management Systems; Identification and Listing of Hazardous Waste; Toxicity Characteristics revision; Final Rule," USEPA, 52FR 26886.

TABLE 8-6 (Continued)

**TCLP ORGANICS AND METALS  
METHOD PERFORMANCE LIMITS**

| Parameter                      | Aqueous PQL <sup>(1)</sup><br>(µg/l) | Solid PQL <sup>(1)</sup><br>(µg/kg) | Method                              |
|--------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| <b><u>TCLP Pesticides</u></b>  |                                      |                                     |                                     |
| Chlordane                      | 0.14                                 | 9.4                                 | EPA Method 3550/<br>EPA Method 8240 |
| Endrin                         | 0.06                                 | 4.0                                 |                                     |
| Heptachlor (and its hydroxide) | 0.03                                 | 20                                  |                                     |
| Lindane                        | 0.04                                 | 2.7                                 |                                     |
| Methoxychlor                   | 1.8                                  | 120                                 |                                     |
| Toxaphene                      | 2.4                                  | 160                                 |                                     |
| <b><u>TCLP Herbicides</u></b>  |                                      |                                     |                                     |
| 2,4-D                          | 12                                   | 240                                 | EPA Method 8150                     |
| 2,4,5-TP Silvex                | 1.7                                  | 34                                  |                                     |

| Analyte                   | Water PQL <sup>(1)</sup><br>(µg/L) | Soil PQL <sup>(1)</sup><br>(mg/kg) | Method         | Method Description                                                              |
|---------------------------|------------------------------------|------------------------------------|----------------|---------------------------------------------------------------------------------|
| <b><u>TCLP Metals</u></b> |                                    |                                    |                |                                                                                 |
| Arsenic                   | 10                                 | 30                                 | 6010A<br>7060  | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique              |
| Barium                    | 20                                 | 1                                  | 6010A          | Inductively Coupled Plasma                                                      |
| Cadmium                   | 1                                  | 2                                  | 6010A<br>7131A | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique              |
| Chromium                  | 20                                 | 4                                  | 6010A<br>7191A | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique              |
| Lead                      | 10                                 | 2                                  | 6010A<br>7421A | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique              |
| Mercury                   | 2                                  | 0.002                              | 7470A          | Water by manual cold vapor technique<br>Water by automated cold vapor technique |
| Selenium                  | 20                                 | 40                                 | 6010A<br>7740A | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique              |
| Silver                    | 2                                  | 4                                  | 6010A<br>7760A | Inductively Coupled Plasma<br>Atomic Absorption, Furnace Technique              |

## Notes:

- <sup>(1)</sup> Practical Quantitation Limit, taken from "Test Methods for Evaluating Solid Waste," USEPA, November 1986 and 1996 updates.

Note: These methods will be used to analyze the Toxicity Characteristic Leaching Procedure (TCLP) extract. The extract will be prepared using Method 1311, described in "Hazardous Waste Management Systems; Identification and Listing of Hazardous Waste; Toxicity Characteristics revision; Final Rule," USEPA, 52FR 26886.

TABLE 8-7

RCRA AND ENGINEERING PARAMETERS  
METHOD PERFORMANCE LIMITS

| Parameter                    | Aqueous Performance Limit | Solid Performance Limit | Method      |
|------------------------------|---------------------------|-------------------------|-------------|
| <b>RCRA</b>                  |                           |                         |             |
| pH/Corrosivity               | N/A <sup>(1)</sup>        | N/A <sup>(1)</sup>      | SW-846 9010 |
| Ignitability                 | N/A <sup>(1)</sup>        | N/A <sup>(1)</sup>      | SW-846 1010 |
| Reactive Cyanide             | 10 mg/l <sup>(1)</sup>    | 10 mg/l <sup>(1)</sup>  | SW-846 9012 |
| Reactive Sulfide             | 50 mg/l <sup>(1)</sup>    | 50 mg/kg <sup>(1)</sup> | SW-846 9030 |
| <b>Engineering</b>           |                           |                         |             |
| Total Suspended Solids (TSS) | N/A                       | N/A                     | EPA 160.1   |
| Total Dissolved Solids (TDS) | N/A                       | N/A                     | EPA 160.2   |

Notes:

- <sup>(1)</sup> Practical Quantitation Limit, taken from "Test Methods for Evaluating Solid Waste," USEPA, November 1986.
- <sup>(2)</sup> Method Detection Limit taken from "Methods for Chemical Analysis of Water and Wastes," USEPA, 1979, Revised March 1983.

N/A - Not Applicable

## **9.0 DATA REDUCTION, VALIDATION AND REPORTING**

The following section presents data reduction, validation, and reporting procedures.

### **9.1 Field Data Procedures**

Data validation practices as described by "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses," USEPA, June 1988, and "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses - Draft," USEPA, June 1991 will be followed to insure that raw data are not altered and that an audit trail is developed for those data which require reduction. The documentation of sample collection will include the use of bound field log books in which all information on sample collection will be entered in indelible ink. Appropriate information will be entered to reconstruct the sampling event, including site name (top of each page), sample identification, brief description of sample, date and time of collection, sampling methodology, field measurements and observations, and sampler's initials (bottom of each page, and dated).

A rigorous data control program will insure that all documents for the investigations are accounted for when they are completed. Accountable documents include items such as log books, field data records, correspondence, chain-of-custody records, analytical reports, data packages, photographs, computer disks, and reports. The project manager will be responsible for maintaining a project file in which all accountable documents will be inventoried. The project records will be retained for a period of three years after project close-out; then the files will be forwarded to the Navy.

All the field data, such as those generated during field measurements, observations and field instrument calibrations, will be entered directly into a bound field notebook. Each project team member will be responsible for proofing all data transfers made, and the Project Manager or his designee will proof at least ten percent of all data transfers.

### **9.2 Laboratory Data Procedures**

The following procedures summarize the practices routinely used by laboratory staff for data reduction, validation, and reporting. Numerical analyses, including manual calculations, will be documented and subjected to quality control review. Records of numerical analyses must be legible and complete enough to permit reconstruction of the work by a qualified individual other than the originator.

#### **9.2.1 Laboratory Data Validation**

Data validation begins with data reduction and continues through to the reporting of data.

Data processing will be checked by an individual other than the analyst who performed the data processing. The checker will review the data for the following:

- Utilization of the proper equations
- Correctness of numerical input
- Correctness of computations
- Correct interpretation of raw data (chromatographs, strip charts, etc.)

The checking process will be sufficient thorough enough to verify the results.

All entries made in benchbooks, data sheets, computation sheets, input sheets, etc. will be made in ink. No entry will be rendered unreadable.

### **9.2.2 Analytical Reports**

The items listed below will be required of analytical reports.

- Data will be presented in a tabular format.
- Analytical reports will be approved by appropriate laboratory personnel.
- The following information will be included on the report: client name and address, report date, sample date, analysis dates, number of samples, purchase order number, project number, and project type. All pages must be numbered.
- The sample numbers and corresponding laboratory numbers will be identified.
- The parameters analyzed, report units, and values will be identified.
- Method, trip, and field blank results will be reported.
- Matrix spike, matrix spike duplicate, and replicate recoveries will be reported.
- Calibration summaries will be reported.
- Surrogate recoveries will be reported.
- Holding times and sample analysis dates will be reported.
- The detection limit of the procedure will be identified.
- Consistent significant figures will be used.
- Referenced footnotes will be used when applicable.
- A letter of transmittal will accompany the report if any anomalies are associated with the data.

### **9.3 Independent (Third Party) Data Validation**

Review of all pertinent analytical data will be performed by Baker personnel and an independent third party data validator.

A preliminary review will be performed by the Project Manager or designee to verify that all necessary paperwork (e.g., chain-of-custodies, traffic reports, analytical reports, and laboratory personnel signatures) and deliverables are present. A detailed and independent data validation will be performed by a data validation subcontractor to verify the qualitative and quantitative reliability of the data presented and adherence to stated analytical protocols. This review will include a detailed review and interpretation of all data generated by the laboratory for Level IV deliverables. The primary tools which will be used by experienced data validation personnel will be analytical method operating practices, statements of work (for CLP), guidance documents, established criteria, and professional judgment.

During the data review, a data support documentation package will be prepared which will provide the back-up information that will accompany all qualifying statements present in the quality assurance review.



## **10.0 INTERNAL QUALITY CONTROL CHECKS**

The following section describes internal quality control checks.

### **10.1 Field Quality Control Checks**

Four types of field quality assurance/quality control samples will be submitted to the laboratory: trip blanks, equipment rinsates, field blanks, and field duplicates. The results from the field quality control samples will be used by the data validator to determine the overall quality of the data. A breakdown by type of sample with which the QA/QC samples will be submitted to the laboratories is given in Table 10-1. A summary of the number of environmental and QA/QC samples to be submitted for analysis will be given in the FSAP.

#### **Field Blanks**

Field blanks consist of the source water used in decontamination, steam cleaning, and drilling. At a minimum, one field blank from each vent and each source of water must be collected and analyzed for the same parameters as the related samples. Organic-free deionized water is taken to the field in sealed containers and poured into the appropriate sample containers at predesignated locations. This will be done to determine if any contaminants present in the area may have an affect on the sample integrity.

#### **Trip Blank**

Analysis of trip blanks will be performed to monitor possible contamination during shipment and collection of samples. Trip blanks are initiated in the laboratory prior to the shipping of sample packs. A corresponding trip blank will be prepared for each set of samples to be analyzed for volatile organic compounds.

Trip blank samples will be prepared by adding four drops of concentrated hydrochloric acid and then filling the container with organic-free deionized water (ASTM Type II). The trip blanks accompany the samples through shipment to the sample site, sample collection, shipment to the laboratory, and storage of the samples.

If the analyses indicate contamination of the trip blank, the sample sources may be resampled. If the extent and nature of the contamination does not warrant such actions, the data will be accepted as valid.

#### **Field Duplicates**

Duplicates for soil samples are collected, homogenized, and split. All samples except VOCs are homogenized, and split. Volatiles are not mixed, but select segments of the soil are taken from the length of the core and placed in 4-ounce glass jars. Cores may be sealed and shipped to the laboratory for subsampling if the project deems this appropriate. The duplicate for water samples should be collected simultaneously. Field duplicates should be collected at a frequency of 10% per sample matrix for Levels III and IV. All the duplicates should be sent to the primary laboratory responsible for analysis. The same samples used for field duplicates shall be split by the laboratory

**TABLE 10-1**

**QA/QC SAMPLE FREQUENCY  
OPERABLE UNIT NO. 17 (SITES 90, 91, AND 92)  
CTO 0344  
MCB CAMP LEJEUNE, NORTH CAROLINA**

| Type of Sample                   | Metal                                   | Organic                                 |
|----------------------------------|-----------------------------------------|-----------------------------------------|
| Trip Blank (for volatiles only)  | NA <sup>(1)</sup>                       | One per cooler or one per shipping day  |
| Equipment Rinsate <sup>(2)</sup> | One per day                             | One per day                             |
| Field Blank                      | One per source per event <sup>(3)</sup> | One per source per event <sup>(3)</sup> |
| Field Duplicate <sup>(4)</sup>   | 10%                                     | 10%                                     |

<sup>(1)</sup> Not Applicable

<sup>(2)</sup> Samples are collected daily; however, only samples from every other day are analyzed. Other samples are held and analyzed only if evidence of contamination exists

<sup>(3)</sup> Source water includes water used in decontamination, steam cleaning, and drilling

<sup>(4)</sup> The duplicate must be taken from the sample which will become the laboratory matrix spike/matrix spike duplicate for organics or for the sample used as a duplicate in inorganic analysis

and used by the laboratory as the laboratory duplicate or matrix spike. This means that for the duplicate sample, there will be analyses of the normal sample, the field duplicate, and the laboratory matrix spike/duplicate.

### **Equipment Rinsates**

Equipment rinsates are the final organic-free deionized water rinse from equipment cleaning collected daily during a sampling event. Initially, samples from every other day should be analyzed. If analytes pertinent to the project are found in the rinsate, the remaining samples must be analyzed. The results of the blanks will be used to flag or assess levels of analytes in the samples. This comparison is made during validation. The rinsates are analyzed for the same parameters as the related samples.

## **10.2 Laboratory Quality Control Checks**

This section provides descriptions of the laboratory quality control checks.

### **Method Blank**

Analysis of method blanks will be performed to verify that method interferences caused by contamination in reagents, glassware, solvents, etc. are minimized and known.

Method blanks will be initiated by the analyst prior to the preparation and/or analysis of the sample set. A method blank consists of a volume of organic-free deionized water equal to the sample volume which is carried through the entire analytical procedure. For solid samples to be analyzed by GC/MS, the method blank consists of a purified solid matrix approximately equal to the sample weight. A method blank will be analyzed with each set of samples or at the very least, daily. If the analytical data of the method blank indicates excessive contamination, the source of contaminant will be determined. The samples may be re-analyzed or the data may be processed "as is" depending upon the nature and extent of the contamination.

### **Replicate Sample Analysis**

Replicate sample analysis will be performed to demonstrate the precision of an analysis. An interlaboratory replicate sample is initiated by the analyst prior to sample preparation and carried through the entire analytical procedure. The frequency of interlaboratory replicate analysis for each analyte is summarized in Table 10-2.

### **Spike Analysis**

Spike analysis will be performed to demonstrate the accuracy of an analysis. The analyst initiates the spike prior to sample preparation and analysis by adding a known amount of analyte(s) to a sample. The spike sample is carried through the entire analytical procedure. The frequency of spike analysis for each analyte(s) is summarized in Table 10-2.

### **Surrogate Standards**

Surrogate standard analysis will be performed to monitor the preparation and analyses of samples. All samples and blanks analyzed by GC/MS and GC are fortified with a surrogate spiking solution prior to extraction or purging.

### **Internal Standards**

Internal standard analyses will be performed to monitor system stability. Prior to injection or purging, internal standards are added to all blanks and samples analyzed by GC/MS (refer to Section 5.1.1.).

### **Matrix Spikes and Matrix Spike Duplicates**

A matrix spike is an aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery. A matrix spike duplicate is a second aliquot of the same matrix as the matrix spike that is spiked in order to determine the precision of the method. A matrix spike and matrix spike duplicate will be performed at a frequency of 1 per 20 samples for organics.

### **10.3 Laboratory Control Limits**

Control limits will be established for QC checks (spikes, duplicates, blanks, etc.). CLP control limits for surrogate standards spikes, and duplicates associated with GC/MS analyses and pesticides/PCB analyses. Control limits for spikes, duplicates, and reference samples will be determined internally through statistical analysis.

Whenever an out-of-control situation occurs, the cause is determined. Any needed corrective actions must be taken.

### **Method Blanks**

For metals analyses, the criteria below are used for method blank analysis.

- If the concentration of the method blank is less than or equal to the detection level, no correction of sample results is performed.
- If the concentration of the blank is above the detection level for any group of samples associated with a particular blank, the concentration of the sample with the least concentrated analyte must be ten times the blank concentration. Otherwise, all samples associated with the blank and less than ten times the blank concentration must be redigested (reprepared) and reanalyzed, if possible. If the affected samples cannot be reprepared and reanalyzed within method holding times, the flagged sample result and the blank result are both to be reported. The sample value is not corrected for the blank value.

For GC/MS, GC analyses, the criteria below are used for method blank analysis:

- A method blank for volatiles analysis must contain no greater than five times the detection limit of common laboratory solvents (common laboratory solvents are: methylene chloride, acetone, toluene, 2-butanone, and chloroform).
- A method blank for semivolatiles analysis must contain no greater than five times the detection limit of common phthalate esters.
- For all other compounds not listed above, the method blank must contain less than the detection limit of any single compound. If a method blank exceeds the criteria, the analytical system is considered to be out of control. The source of the contamination is investigated and appropriate corrective measures are taken and documented before sample analysis proceeds. All samples processed with a method blank that is out of control (i.e., contaminated), are reextracted/repurged and reanalyzed, when possible. If the affected samples cannot be reextracted/repurged and reanalyzed within method holding times, the flagged sample result and the blank result are both to be reported. The sample value is not corrected for the blank value.
- No positive result for pesticides/PCBs should be reported unless the concentration of the compound exceeds five times the amount in the blank.
- A method blank for pesticides/PCBs must contain no greater than five times the detection limit for any pesticides/PCBs.

#### **Surrogate Standards**

For method blank surrogate standard analysis, corrective action will be taken if any one of the conditions below exist.

- Recovery of any one surrogate compound in the volatile fraction is outside the required surrogate standard recovery limit.
- Recovery of any one surrogate compound in the semivolatile fraction is outside surrogate standard recovery limits.

Corrective action will include steps listed below:

- A check of: the calculations for errors; the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and instrument performance.
- Recalculation or reinjection/repurging of the blank or extract if the above corrective actions fail to solve the problem.
- Reextraction and reanalysis of the blank. For sample surrogate standard analysis, corrective action will be taken if any one of the following conditions exist:

- ▶ Recovery of any one surrogate compounds in the volatile fraction is outside the surrogate spike recovery limits;
- ▶ Recovery of any one surrogate compound in either semivolatile fraction is below ten percent; or
- ▶ Recoveries of two or more surrogate compounds in either semivolatile fraction are outside surrogate spike recovery limits.

Corrective action will include the steps listed below.

- A check of: the calculations for errors; of the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and of instrument performance.
- Recalculating or reanalysis the sample or extract if the above corrective action fails to solve the problem.
- Reextraction and reanalysis of the sample if none of the above are a problem.

## **11.0 PERFORMANCE AND SYSTEM AUDITS**

A field audit will be conducted during the field investigation to verify that sampling is being performed according to the plan. A report will be submitted within 30 calendar days of completion of the audit. Serious deficiencies will be reported within 24 hours of the time of discovery of the deficiency, including actions taken or to be taken to correct such deficiencies.

The following table (Table 11-1) is used for audits. At the appropriate time, the Project Manager or Program QA/QC designee will conduct field audits. Additionally, personnel adhere to Baker's Standard Operating Procedures which cover procedures, reporting and quality.

**FIELD SITE AUDIT INSPECTION FORM**

**Legend**  
**X = Yes**  
**O = No**  
**NA = Not Applicable**

Site Name \_\_\_\_\_ CTO No. \_\_\_\_\_

Location \_\_\_\_\_ Date \_\_\_\_\_

**SECTION 1 - DOCUMENTATION/SAFETY/QA/QC PROCEDURES**

1. Were sampling locations adequately documented in a bound field log book using indelible ink?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
2. Were photos taken and a photo log maintained?  
Yes \_\_\_\_\_ No \_\_\_\_\_
3. What field instruments were used during this study?  
\_\_\_\_\_  
\_\_\_\_\_
4. Were field instruments properly calibrated and calibrations recorded in a bound field log book?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
5. Was sampling equipment properly wrapped and protected from possible contamination prior to sample collection?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
6. Was sampling equipment constructed of Teflon®, glass, or stainless steel?  
\_\_\_\_\_
7. Were samples collected in proper order (least suspected contamination to most contaminated)?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
8. Were clean disposable latex or vinyl gloves worn during sampling?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
9. Were gloves changed for each sample station?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
10. Was any equipment field cleaned?  
Yes \_\_\_\_\_ No \_\_\_\_\_
11. Type of equipment cleaned?  
\_\_\_\_\_



**FIELD SITE AUDIT INSPECTION FORM**

- 12. Were proper field cleaning procedures used?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 13. Were equipment rinse blanks collected after field cleaning?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 14. Were proper sample containers used for samples?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 15. Were split samples offered to the facility owner or his representative?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 16. Was a receipt for samples form given to facility representative?  
Yes \_\_\_\_\_ No \_\_\_\_\_
- 17. Were any duplicate samples collected?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 18. Were samples properly field preserved?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 19. Were preservative blanks utilized?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 20. Were field and/or trip blanks utilized?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 21. Were samples adequately identified with labels or tags?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 22. Were samples sealed with custody seals after collection?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 23. What security measures were taken to insure custody of the samples after collection?  
\_\_\_\_\_
- 24. Were chain-of-custody and receipt for samples forms properly completed?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
- 25. Were any samples shipped to a laboratory?  
Yes \_\_\_\_\_ No \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

26. If yes to No. 25, were samples properly packed?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
27. If shipped to a CLP lab, were Traffic Report Forms properly completed?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
28. What safety monitoring equipment, protection, and procedures were used prior to and during sampling?  
\_\_\_\_\_
29. Was safety monitoring equipment properly calibrated and calibrations recorded in a bound field log book?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

**SECTION 2 - SAMPLING - GROUNDWATER WELLS**

1. Type of wells sampled (monitoring, potable, industrial, etc.)?  
\_\_\_\_\_
2. Were wells locked and protected?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
3. Were identification marks and measurement points affixed to the wells?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
4. What were the sizes and construction materials of the well casings?  
\_\_\_\_\_
5. Were the boreholes sealed with a concrete pad to prevent surface infiltration?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
6. Was there a dedicated pump in the well?  
Yes \_\_\_\_\_ No \_\_\_\_\_
7. Was clean plastic sheeting placed around the wells to prevent contamination of sampling equipment and containers?  
Yes \_\_\_\_\_ No \_\_\_\_\_
8. Were total depths and depths to water determined before purging?  
Yes \_\_\_\_\_ No \_\_\_\_\_
9. What device was used to determine depths?  
\_\_\_\_\_
10. Were measurements made to the nearest 0.01 foot?  
Yes \_\_\_\_\_ No \_\_\_\_\_
11. Was the measuring device properly cleaned between wells?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
12. Was the standing water volume in each well determined?  
Yes \_\_\_\_\_ No \_\_\_\_\_
13. How was the volume determined?  
\_\_\_\_\_
14. Was a sufficient volume purged prior to sampling?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

15. How many volumes?  
\_\_\_\_\_
16. How was the purged volume measured?  
\_\_\_\_\_
17. What was the method of purging?  
\_\_\_\_\_
18. Were pH, conductivity, and temperature measurements taken and recorded at least once during each well volume purged?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
19. Were pH, conductivity, and temperature readings stable prior to sampling?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
20. How many wells were sampled? \_\_\_ Upgradient? \_\_\_ Downgradient? \_\_\_
21. How were the samples collected? Bailer \_\_\_ Pump \_\_\_ Other \_\_\_  
Comments \_\_\_\_\_
22. If pump was used, what type?  
\_\_\_\_\_
23. If a pump was used, was it properly cleaned before and/or between wells?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
24. What were the cleaning procedures?  
\_\_\_\_\_
25. Did bailers have Teflon® coated wire leaders to prevent rope from coming into contact with water?  
Yes \_\_\_\_\_ No \_\_\_\_\_
26. Were bailers open or closed top?  
\_\_\_\_\_
27. Was a clean bailer and new rope used at each well?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
28. Were samples properly transferred from the sampling device to the sample containers (i.e., purgeable sample first - not aerated, etc.)?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
29. Was pH of preserved samples checked to insure proper preservation? ✓  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

30. Were samples iced immediately after collection?  
Yes \_\_\_\_\_ No \_\_\_\_\_

31. For what analyses were the samples collected?

\_\_\_\_\_

32. If samples were split, what were the sample/station numbers for these?

\_\_\_\_\_

\_\_\_\_\_

Other comments or observations \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

**SECTION 3 - SAMPLING - SOIL, SEDIMENT, SLUDGE, ETC. (Non-Containerized)**

1. Type of samples collected?  
\_\_\_\_\_
2. General description of samples?  
\_\_\_\_\_
3. How many samples were collected?  
\_\_\_\_\_
4. Were background and/or control samples collected?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
5. Were representative samples collected?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
6. Were grab or composite samples collected?  
\_\_\_\_\_
7. Were composite samples areal or vertical?  
\_\_\_\_\_
8. How many aliquots were taken for the composite sample?  
\_\_\_\_\_
9. What procedures and equipment were used to collect samples?  
\_\_\_\_\_  
\_\_\_\_\_
10. Were samples thoroughly mixed prior to putting them into the sample containers?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
11. Were samples properly placed into sample containers?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
12. Were samples iced immediately after collection?  
Yes \_\_\_\_\_ No \_\_\_\_\_
13. For what analyses were the samples collected?  
\_\_\_\_\_
14. If samples were split, what were the sample/station numbers for these?  
\_\_\_\_\_
15. Was a drilling rig, backhoe, etc., used to collect soil samples?  
Yes \_\_\_\_\_ No \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

16. Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
17. What was the condition of the drilling and sampling equipment when it arrived on site?  
\_\_\_\_\_
18. Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
19. Was clean equipment properly wrapped and stored in a clean area?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
20. Was the drilling rig(s) properly cleaned between well borings?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
21. Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
22. Other comments or observations  
\_\_\_\_\_  
\_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

**SECTION 4 - SAMPLING - SURFACE WATER (Pond, Stream, River, Leachate, etc.)**

1. Type of samples collected?  
\_\_\_\_\_
2. General description of samples?  
\_\_\_\_\_
3. How many samples were collected?  
\_\_\_\_\_
4. Were background and/or control samples collected?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
5. Were grab or composite samples collected?  
\_\_\_\_\_
6. How many aliquots were taken for the composite sample?  
\_\_\_\_\_
7. What procedures and equipment were used to collect samples?  
\_\_\_\_\_  
\_\_\_\_\_
8. Were samples collected directly into sample containers?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
9. Did the sampler wade in the stream to collect the samples?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
10. Were the samples collected upstream from the sampler?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
11. Did the sampler insure that roiled sediments were not collected along with the water samples?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
12. Were representative samples collected?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
13. Was the pH of preserved samples checked to insure proper preservation?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
14. Were samples iced immediately after collection?  
Yes \_\_\_\_\_ No \_\_\_\_\_



**FIELD SITE AUDIT INSPECTION FORM**

15. For what analyses were the samples collected?

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16. If samples were split, what were the sample/station numbers for these?

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Other comments or observations

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**FIELD SITE AUDIT INSPECTION FORM**

**SECTION 5 - OTHER SAMPLING - DRUMS, TANKS, BARRELS, ETC. (Containerized)**

1. Type of samples collected (oil, sludge, waste)?  
\_\_\_\_\_  
\_\_\_\_\_
2. Description of containers or sources sampled?  
\_\_\_\_\_  
\_\_\_\_\_
3. How many samples were collected?  
\_\_\_\_\_  
\_\_\_\_\_
4. What type of equipment was used to collect the samples?  
\_\_\_\_\_  
\_\_\_\_\_
5. What procedures were used to collect the samples?  
\_\_\_\_\_  
\_\_\_\_\_
6. For what analyses were the samples collected?  
\_\_\_\_\_  
\_\_\_\_\_
7. If samples were split, what were the sample/station numbers for these?  
\_\_\_\_\_  
\_\_\_\_\_
8. Were any special safety measures taken during collection of the samples?  
\_\_\_\_\_  
\_\_\_\_\_
9. What level of safety protection was required for collection of the samples?  
\_\_\_\_\_  
\_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

Other comments or observations

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**FIELD SITE AUDIT INSPECTION FORM**

**SECTION 6 - MONITORING WELL INSTALLATION**

**General**

1. Were the wells installed in the proper locations in accordance with the study plan and/or project operations plan (POP)?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
2. Were the wells installed starting in the least contaminated area and proceeding to the most contaminated area?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
3. Were proper safety protocols employed during the well installations?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
4. Were samples of the drilling mud, water, bentonite pellets, filter pack materials, etc., collected for quality control analyses?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_

**Equipment Decontamination**

5. Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
6. What was the condition of the drilling and sampling equipment when it arrived on site?  
\_\_\_\_\_
7. Was a decontamination area located where the cleaning activities could cross-contaminant clean and/or drying equipment?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
8. Was clean equipment properly wrapped and stored in a clean area?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
9. Was the drilling rig(s) properly cleaned between well borings?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
10. Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

**Drilling**

11. What type of drilling method(s) was used to install the wells?  
\_\_\_\_\_
12. Was this drilling method(s) the same as proposed in the study plan and/or POP?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
13. Were soil samples collected for logging and analyses as the wells were installed?  
Yes \_\_\_\_\_ No \_\_\_\_\_
14. If yes to 13, at what intervals and by what method?  
\_\_\_\_\_
15. If air rotary was used:  
Was an in-line organic air filter employed?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
  
Was a cyclone velocity dissipator used?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
16. What diameter borehole(s) were installed?  
\_\_\_\_\_
17. Were surface outer casings used?  
Yes \_\_\_\_\_ No \_\_\_\_\_
18. If yes to 17, what size and to what depth?  
\_\_\_\_\_
19. Were the wells double cased?  
Yes \_\_\_\_\_ No \_\_\_\_\_
20. If yes to 19, explain procedure.  
\_\_\_\_\_

**Well Installation**

21. What type of well casing(s) and screen(s) were used?  
\_\_\_\_\_
22. What diameter were the well casing(s)? \_\_\_\_\_ screen(s)? \_\_\_\_\_
23. Was there a minimum two-inch annulus around the casing (between casing and borehole wall or inside augers)?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

24. What was the length of the well screen(s)?  
\_\_\_\_\_
25. What was the slot size of the well screen(s)?  
\_\_\_\_\_
26. Was the well screen(s) commercially manufactured?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
If yes, by whom? \_\_\_\_\_
27. Was the bottom of the well screen(s) plugged or capped?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
28. Were sand and/or gravel (filter) packs installed?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
29. Specify type of materials in 28 [(play sand, Ottawa sand, etc.) and grain size (20/30, 20/40, etc.)], if known.  
\_\_\_\_\_
30. Was a sieve analysis conducted to determine well screen slot size and filter pack grain size?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
31. Were the wells installed to the proper depths?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
32. Were well screens placed at the proper intervals?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
33. Were the filter packs placed a minimum of two feet above the well screens?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
34. Was the tremie tube method used to place the filter packs?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
35. Were seals placed above the filter packs?  
Yes \_\_\_\_\_ No \_\_\_\_\_
36. If yes to 35, what materials was used for the seals?  
\_\_\_\_\_
37. Was the vertical thickness of the seals a minimum of two feet?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

38. If bentonite pellets were used for the seals above the filter packs, were they allowed to hydrate a minimum of 8 hours?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
39. Did contractor/driller have documentation from manufacturer stating recommended hydration time?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
40. Was the tremie tube method used to place the bentonite pellets?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
41. Was the annulus grouted from the seal to within two feet of the ground surface, or below the frost line?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
42. Was the tremie tube method used to place the grout in the annulus?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
43. If no to 42, what method was used?  
Yes \_\_\_\_\_ No \_\_\_\_\_
44. What type of grout was used to seal the annulus (neat cement, cement/bentonite, cement/sand, etc.)?  
\_\_\_\_\_
45. What grout mix ratio was used (should be stated in the POP)?  
\_\_\_\_\_
46. What was the density of the grout (lb./gal., etc.)?  
\_\_\_\_\_
47. If bentonite grout was used, was the density at least 9.4 lb./gal.?  
Yes \_\_\_\_\_ No \_\_\_\_\_
48. Was the density determined using a mud balance?  
Yes \_\_\_\_\_ No \_\_\_\_\_
49. Was the grout allowed to set a minimum of 24 hours before the surface pad was installed?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
50. Was a concrete surface pad installed with an outer protective casing and locking cap?  
Yes \_\_\_\_\_ No \_\_\_\_\_  
Comments \_\_\_\_\_
51. How far below the ground surface did the concrete pad extend?  
\_\_\_\_\_

**FIELD SITE AUDIT INSPECTION FORM**

52. What were the dimensions of the concrete pads?

\_\_\_\_\_

53. Did the well casings extend to a minimum of 2.5 feet above the ground surface?

Yes \_\_\_\_\_ No \_\_\_\_\_

Comments \_\_\_\_\_

54. How far above the ground surface did the outer protective casings extend?

\_\_\_\_\_

55. Did the outer protective casings have weep holes?

Yes \_\_\_\_\_ No \_\_\_\_\_

Comments \_\_\_\_\_

56. Were the wells properly developed?

Yes \_\_\_\_\_ No \_\_\_\_\_

Comments \_\_\_\_\_

57. Describe method of development.

\_\_\_\_\_

58. Give a general evaluation of the activities observed during installation of the wells.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



## **12.0 PREVENTIVE MAINTENANCE**

The following section outlines preventative maintenance.

### **12.1 Field Maintenance**

The O<sub>2</sub>/LEL meter and the HNu PI-101 are to be used in site characterization and will be maintained as described by the manufacturer's instructions. The pH and specific conductance meters to be used during sampling will be maintained according to Baker's Standard Operating Procedure (SOP) F201. A full set of SOPs will be maintained in the field trailer.

### **12.2 Laboratory Maintenance**

Preventive maintenance is an organized program of actions to prevent instruments and equipment from failing during use and to maintain proper performance of equipment and instruments. A comprehensive preventive maintenance program is implemented to increase the reliability of the measurement system. The preventive maintenance program will address the following:

- Schedules of important preventive maintenance tasks that are carried out to minimize downtime.
- Lists of critical spare parts that are available to minimize downtime.

The laboratory maintains histories, in instrument/equipment logs, of all major equipment. Trouble shooting, maintenance, and spare parts inventory will be recorded in the logs. Instruments and equipment will be maintained periodically in accordance with procedures described in individual analytical methods, manufacturer's recommendation, and/or service contracts.

The modern analytical laboratory depends heavily upon instrumentation and equipment; therefore, cleaning and preventive maintenance are primary considerations in the sustained production of satisfactory data. Specific requirements for proper care of laboratory instrumentation and equipment are contained in the manufacturer's instructions; however, some general guidelines are considered, and are listed below.

- Special precautions must be taken to avoid spillage of corrosive chemicals on or around equipment and instrumentation not only to extend the life of the item, but also to eliminate contamination.
- Where available, covers must be placed on instrumentation when not in use.
- Instrument parts must be cleaned as required (i.e., mirrors, probes, detector cells).

## 13.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

The following section outlines data measurement assessment procedures.

### 13.1 Overall Project Assessment

Overall data quality will be assessed by a thorough understanding of the data quality objectives. By maintaining thorough documentation of all decisions made during each phase of sampling, performing field and laboratory audits, thoroughly reviewing the analytical data as they are generated by the laboratory, and providing appropriate feedback as problems arise in the field or at the laboratory, data accuracy, precision, and completeness will be closely monitored.

### 13.2 Field Quality Assessment

To assure that all field data are collected accurately and correctly, specific written instructions will be issued to all personnel involved in field data acquisition by the Project Manager. The Project Manager will perform field audit(s) during the investigation to document that the appropriate procedures are being followed with respect to sample (and blank) collection. These audits will include a thorough review of the field books used by the project personnel to insure that all tasks were performed as specified in the instructions. The field audits will necessarily enable the data quality to be assessed with regard to the field operations.

The evaluation (data review) of field blanks, and other field QC samples will provide definitive indications of the data quality. If a problem that can be isolated arises, corrective actions can be instituted for future field efforts.

### 13.3 Laboratory Data Quality Assessment

As part of the analytical QA/QC program, the laboratory applies precision and accuracy criteria for each parameter that is analyzed. When analysis of a sample set is completed, QC data generated will be reviewed and evaluated to ensure acceptance criteria are met. These criteria will be method and matrix specific.

QA/QC data review is based on the following criteria:

- Method Blank Evaluation - The method blank results will be evaluated for high readings characteristic of background contamination. If high blank values are observed, laboratory glassware and reagents are checked for contamination and the analysis of future samples halted until the system can be brought under control. A high background is defined as a background value sufficient to result in a difference in the sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid. A method blank must contain no greater than two times the parameter detection limit for most parameters.
- Trip Blank Evaluation - Trip blank results will be evaluated for high readings similar to the method blanks described above. If high trip blank readings are encountered (i.e. a value sufficient to result in a difference in sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid),

procedures for sample collection, shipment, and laboratory analysis are reviewed. If both the method and the trip blanks exhibit significant background contamination, the source of contamination is probably within the laboratory. Ambient air in the laboratory and reagents will be checked as possible sources of contamination.

- Standard Calibration Curve Verification - The calibration curve or midpoint calibration standard (check standard) will be evaluated daily to determine curve linearity through its full range and that sample values are within the range defined by the low and high standards. If the curve is not linear, sample values are corrected. If average response factors are used to calculate sample concentrations, these factors are verified on a daily basis. Verification of calibration curves and response factors will be accomplished when the evaluated response for any parameter varies from the calibrated response by less than ranges specified in Section 7.0.
- Duplicate Sample Analyses - Duplicate sample analyses will be used to determine the precision of the analytical method for the sample matrix. Two types of duplicate samples will be analyzed for this project, field, and laboratory. Duplicate results will be used to calculate precision as defined by the relative percent difference (RPD). If laboratory duplicate values exceeds the control limit, the sample set may be reanalyzed for the parameter in question. Precision limits will be updated periodically following review of data.
- Reference Sample Analyses - The results of reference sample analysis will be compared with true values, and the percent recovery of the reference sample will be calculated. If correction is required (excessive or inadequate percent recovery), the reference sample must be reanalyzed to demonstrate that the corrective action has been successful.
- Surrogate Standard Analyses - Surrogate standard determinations will be performed on all samples and blanks for GC/MS analyses. All samples and blanks are fortified with surrogate spiking compounds before purging or extraction to monitor preparation and analysis of samples. Recoveries must meet specific criteria. If acceptance criteria are not met, corrective action must be taken to correct the problem and the affected sample must be reanalyzed.
- Matrix Spike Analyses - The observed recovery of spike versus theoretical spike recovery will be used to calculate accuracy as defined by the percent recovery. If the accuracy value exceeds the control limit for the given parameter, the appropriate laboratory personnel notified and corrective action will be taken before the sample set is reanalyzed for the parameter in question.

For completeness, it is expected that the methodology proposed for chemical characterization of the samples will meet QC acceptance criteria for at least 95 percent of all sample data. To ensure this completeness goal, data that does not meet the acceptance criteria will be recollected, reextracted, or reanalyzed, if necessary.

Data representativeness will be ensured through the use of appropriate analytical procedures, and analysis of samples performed within the allowed holding times.

Comparability is a qualitative characteristic of the data. By using standard methods for sampling and analyses, data generated in past or future investigations will be comparable with this investigation data.

## 14.0 CORRECTIVE ACTION

Corrective action will be taken whenever a nonconformance occurs. A nonconformance will be defined as an event which is beyond the limits established for a particular operation by the plan. Nonconformances can occur in a number of activities. Such activities include sampling procedures, sample receipt, sample storage, sample analysis, data reporting, and computations.

The following personnel will be responsible for detecting and reporting nonconformances:

- Project Staff - during testing and preparation and verification of numerical analyses.
- Laboratory Staff - during the preparation for analyses, performance of analytical procedures, calibration of equipment, and quality control activities.

### 14.1 Limits of Operation

The limits of operation that are used to identify nonconformances will be established by the contents of the Work Plan, QAPP, and FSAP. Interlaboratory control limits produced by statistical analyses will also be considered as limits of operation.

### 14.2 Corrective Action

Nonconformances will be identified and communicated to Baker to avoid delays with respect to project schedules and prevent the submission of non-valid data. Documentation will include the following:

- Personnel identifying the nonconformance(s) will be identified.
- The nonconformance(s) will be described and communicated to the Baker Project Manager.
- For serious nonconformances, the site supervisor will have the authority to initiate corrective action.
- For less serious nonconformances, corrective action will be decided upon and signatures will be obtained prior to implementation of corrective action.
- All nonconformances and corrective actions will be documented and reside with the Baker Activity Coordinator. This documentation will be available to LANTDIV.

The Baker Project Manager will be notified of laboratory or field nonconformances and corrective actions taken if:

- A nonconformance causes a delay in work beyond the schedule completion date.
- A nonconformance affects information already reported.
- A nonconformance affects the validity of the data.

If the nonconformance(s) are serious and corrective action cannot resolve the problem(s), NFESC Contract Representatives (NCRs) and the LANTDIV NTR may be notified by Baker.

## **15.0 QUALITY ASSURANCE REPORTING PROCEDURES**

The Project Manager will be responsible for assessing the performance of measurement systems and data quality related to the field investigation. A written record will be maintained of: the results of laboratory QC reports and other periodic assessments of measurement, data accuracy, precision, and completeness; performance and system audits; and any significant QA problems and recommended solutions. Each deliverable will contain a QA/QC assessment section. Also, a QA/QC assessment will be performed any time a significant problem is identified.

The Project Manager will keep in contact with the LANTDIV NTR through informal, verbal reports during the project as well as through monthly progress reports.