Draft Final

Remedial Investigation Report for Operable Unit No. 3 (Site 48)

Marine Corps Base Camp Lejeune Jacksonville, North Carolina

Volume 1 of 2

Prepared For:

Department of the Navy
Atlantic Division
Naval Facilities
Engineering Command

Norfolk, Virginia

Under the

LANTDIV CLEAN Program

Comprehensive Long-Term Environmental Action Navy

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EXECUTIVE SUMMARY

INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) that became effective on November 4, 1989 (54 Federal Register 41015, October 4, 1989). The United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (N.C. DEHNR) and the United States Department of the Navy (DoN) then entered into a Federal Facilities Agreement (FFA) for MCB Camp Lejeune in February 1991. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the MCB were thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives were developed and implemented as necessary to protect public health and the environment.

Site Description

Camp Lejeune is a training base for the Marine Corps, located in Onslow County, North Carolina. The base covers approximately 170 square miles with 14 miles of coastline. It is bounded to the southeast by the Atlantic Ocean, to the northeast by State Road 24, and to the west by U.S. Route 17. The town of Jacksonville, North Carolina is north of the base.

The study area, Operable Unit No. 3 (Site 48) is one of twelve operable units located within MCB Camp Lejeune. In general, Site 48 is bordered by Longstaff Road to the west, an intermittent tributary of the New River to the north, the New River to the east, and Building 811 to the south (see Figure 1-2 in this report). The study area covers approximately 4 acres. The site is actually located within the Marine Corps Air Station (MCAS) area of MCB Camp Lejeune.

Site 48 lies on the west bank of the New River at an approximate elevation of 5 feet above msl. It is approximately 17 miles north of the New River's outlet into the Atlantic Ocean. A marsh area is present north of Site 48 and drains into the New River. Marshes are also present along the northwestern, northern, and eastern boundaries of the site where the surface waters cut through the land. Surface water runoff at Site 48 tends to drain to the New River and to an

intermittent tributary that borders the site on the north. The intermittent tributary also flows into the New River. Some surface water runoff is collected in the storm water sewers located along Longstaff Road and Curtis Street.

United States Geological Survey (USGS) studies at MCB Camp Lejeune indicate that the Base is underlain by seven sand and limestone aquifers separated by confining units of silt and clay. These include the water table (surficial), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The principal water supply aquifer for the Base is the series of sand and limestone beds that occur between 50 and 300 feet below land surface. This series of sediments generally is known as the Castle Hayne aquifer. The Castle Hayne aquifer is about 150 to 350 feet thick in the area and is the most productive aquifer in North Carolina. In general, the site is underlain by unconsolidated deposits of silty clay, silty sand, and silt with clay and sand being the predominant soils. These soils represent the Quatenary "undifferentiated" formation which characterize the surficial aquifer.

The average groundwater gradient across the site was calculated based on the September 30 and October 8 groundwater level data. Based on these measurements, the average groundwater gradient across the site is 4×10^{-3} feet/feet. This low groundwater gradient indicates a relatively flat water table. The groundwater gradient appears to gradually slope in a northeast direction toward the New River.

Hydrogeologic aquifer characteristics (i.e., hydraulic conductivity, transmissivity, and storativity) for the surficial aquifer were not evaluated during this investigation. However, recent hydrogeologic investigations conducted by Baker (December 1992) at the New River Air Station (less than one mile from Site 48) have generated estimates of the hydrogeologic conditions within the surficial aquifer. Hydraulic conductivity (k) testing within the clays has indicated k values ranging from 10^{-2} to 10^{-3} feet/day (10^{-6} to 10^{-7} cm/s). Aquifer pump test results obtained from the deeper silty-sands (25 to 30 feet bgs.) indicated an average transmissivity of 70 gallons/day/feet, an average k of 6.3 feet/day, and an average storativity of 1.4×10^{-2}.

Site Background

Buildings 804, 805, and 807 are located within the Site 48 study area boundary. Building 804 was constructed in 1955 and was used as the Administration Office and Photographic Laboratory from 1955 to 1990. The building was vacant for a few months in 1990, but is

currently being used as the Nuclear, Biological, and Chemical (NBC) instruction classroom. The use of the other two buildings on the site are not known.

During the ten year period between 1956 and 1966, mercury was reportedly drained from delay lines of radar units and periodically disposed at Site 48. Approximately one gallon of mercury per year was reportedly hand-carried and dumped or buried in small quantities at random areas around Building 804. The general disposal area was thought to be an 100- to 200-foot wide corridor extending from the rear of Building 804 to the bank of the New River. Review of aerial photographs recently received from the USEPA Environmental Photographic Interpretation Center (EPIC) appear to indicate that the disposal activities may have occurred at other areas within the site (north and west of Building 804). The aerial photographs date back to 1956.

Previous Investigations

In 1983, an Initial Assessment Study (IAS) was conducted at Camp Lejeune by Water and Air Research (WAR), a consulting firm. The study identified a number of areas within Camp Lejeune, including Site 48, as potential sources of contamination.

In 1984, Environmental Science and Engineering, Inc. (ESE) conducted a Confirmation Study at Site 48 which focused on the potential source areas identified in the IAS. The study consisted of collecting a limited number of soil samples and sediment samples which were analyzed for mercury. The results of this sampling indicated that low levels of mercury were detected in both media.

A Supplemental Characterization Investigation was conducted at Site 48 in January 1991 by ESE. This investigation consisted of surface water and sediment sampling and analysis. Mercury, the primary contaminant of concern, was not detected in any sample collected during this investigation.

In 1991, ESE prepared a Site Assessment (SA) Report for the site. The assessment was based on the results of the IAS, the Confirmation Study, and the Supplemental Characterization Investigation. No additional sampling was conducted. The SA also included a preliminary risk evaluation for the site. The risk evaluation did not indicate that mercury was a contaminant of concern at the site. The risk evaluation results indicated that the only potential contaminants of concern appeared to be cadmium, copper, nickel, and silver in

surface water. The risk evaluation indicated that the detected concentrations of these four metals of concern may be representative of background levels for the area.

Remedial Investigation Scope of Work

Baker Environmental, Inc. (Baker) conducted an RI at Site 48 beginning in August 1992 in accordance with the FFA and Fiscal Year 1992 Site Management Plan. The field program at Site 48 was initiated to characterize potential environmental impacts and threats to human health resulting from previous mercury disposal activities. According to information provided by the DoN and MCB Camp Lejeune personnel, these disposal areas were reported to have been located behind Building 804, between the building and the shoreline of the New River. Sequentially, the field program outlined in the Final Remedial Investigation/Feasibility Study (RI/FS) Work Plan (submitted in May 1992) for this investigation focused on these areas of concern.

Review of historical aerial photographs, supplied from the USEPA Environmental Photographic Interpretation Center (EPIC) in September 1992, depicted several different areas at the site that appeared to have been previously excavated and trenched. These areas are located north and west of Building 804 and across Longstaff Street as shown on Figure 2-1 in this report. Accordingly, the initial soil boring and monitoring well locations proposed in the Final RI/FS Work Plan were relocated to areas near the excavated trenches depicted on the aerial photographs by EPIC.

The RI field investigative activities at Site 48 commenced on August 24, 1992 and continued through November 9, 1992. Activities conducted during the field program consisted of a preliminary site survey; a geophysical survey investigation; a soil investigation including drilling and sampling; a groundwater investigation including monitoring well installation, development and sampling; a surface water and sediment investigation; and an aquatic and ecological survey.

Nature and Extent of Contamination

Based on the soil samples collected from the three areas of concern at Site 48, the analytical results do not indicate the presence of mercury at Site 48. Other contaminants detected in soil (e.g., pesticides, metals) are similar to background levels, or were detected infrequently and at

low levels and are not present in the environment as a result of previous disposal activities at the site.

Mercury levels reported in groundwater samples were below the Contract Required Detection Limit of 0.04 ug/l. Trace levels of trichloroethene (TCE) (1 ug/l) and phenol (3 ug/l) were detected in groundwater below drinking water standards. These contaminants were only detected in two monitoring wells. Soil did not exhibit either TCE or phenol. The source of this contamination is unknown.

Elevated levels of manganese (above State drinking water standards and Secondary MCLs) were present in groundwater; however, elevated levels of manganese are reportedly present throughout MCB Camp Lejeune and therefore may be naturally occurring in the environment (Greenhorne & O'Mara, 1992).

Surface water quality in the intermittent tributary and the marsh exhibited levels of mercury (0.04 to 0.05 ug/l) above the AWQC of 0.025 ug/l. However, upstream sampling locations also exhibited mercury above AWQC.

Surface water quality in the New River exhibited low levels of volatile organic contamination (toluene and total xylenes) below Ambient Water Quality Criteria (AWQC) for the protection of aquatic life. Because these constituents were also present in the New River upstream of the site, the presence of these constituents are not likely related to previous waste disposal activities at Site 48. In addition, neither soil or groundwater exhibited toluene or total xylenes.

Sediment in the intermittent tributary, the marsh, and the New River exhibited low levels of mercury (0.03 mg/kg to 0.17 mg/kg). Only one location (at the marsh) exceeded the EPA Region IV Sediment Quality Criteria of 0.015 mg/kg at this level, no response actions are required based on EPA guidelines. Samples collected during previous investigations (prior to this RI) also exhibited mercury at similar concentrations.

Low levels of pesticides and PAHs were detected in two sediment samples collected from the New River. The source of these contaminants is not likely from Site 48 since PAHs were not detected in soil and only one surface soil sample exhibited pesticides at low levels.

The results of the benthic macroinvertebrate study and fish study did not indicate adverse impacts to the ecology of the New River or marsh. The results of the these studies were comparable to the White Oak River, which was included in the study as a reference station.

Fish and crab samples collected for chemical analysis did not exhibit mercury. Low levels of pesticides and inorganics were present in fish.

Human Health Risk Assessment

The baseline human health risk assessment evaluated the potential for chemicals to affect human health, both now and in the future, under a no action scenario. The baseline RA identified chemicals of concern and corresponding environmental concentrations at the site with respect to the physical characteristics of the study area. This information was used to estimate the extent of potential exposure to hypothetical receptors. Finally, theoretical chemical intakes were determined for each receptor and each potential exposure route and combined with the most recent toxicological data to inferentially estimate the potential human health effects.

The components of the baseline RA include: identification of chemicals of concern; the exposure assessment; the toxicity assessment; risk characterization; and uncertainty analysis.

Human receptors at Operable Unit No. 3 (Site 48) could be potentially exposed to chemicals of concern (COCs) in more than one medium and through multiple exposure pathways associated with each medium. Under current and future land use conditions, the site does not pose an unacceptable risk to any potential receptor group by USEPA standards.

Ecological Risk Assessment

A qualitative ecological risk assessment was performed based on the information collected during the aquatic survey. The results indicated that the ecology of the New River and marsh area appears to be healthy and are comparable to other similar waters (i.e., the White Oak River).

Conclusions/Recommendations

The environmental quality at Site 48 is good. Neither soil nor groundwater were impacted from the disposal of mercury at the site. Under current or future land uses, the site does not pose an unacceptable risk to any potential receptor group (e.g., base personnel or future residents)..

The ecology of the study area appears to be healthy. Contaminants detected in surface water and sediment do not appear to be related to Site 48.

No further environmental investigations are recommended. The sampling and analysis performed is sufficient to characterize the site and develop conclusions with respect to potential impacts to the public health and the environment.

No remedial response actions are justifiable at Operable Unit No. 3 since the site media pose no current or potential adverse impacts to public health or the environment. Therefore, a feasibility study is not recommended.

1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) that became effective on November 4, 1989 (54 Federal Register 41015, October 4, 1989). The United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (N.C. DEHNR) and the United States Department of the Navy (DoN) then 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 were thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives were developed and implemented as necessary to protect public health and the environment.

The Fiscal Year 1993 Site Management Plan for MCB Camp Lejeune, a primary document identified in the FFA, identifies 18 sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. These 18 sites have been divided into nine operable units to simplify proceeding with RI/FS activities. This report describes the RI conducted at Operable Unit No. 3 which is comprised of Site 48, Marine Corps Air Station (MCAS) Mercury Dump.

The purpose of this RI is to fully determine the nature and extent of the threat to public health, welfare or the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants. The RI serves as the basis for the baseline risk assessment (RA) and provides information in support of the FS and record of decision for final remedial action.

This was accomplished by sampling all media (soil, groundwater, sediment, and surface water) at Site 48, evaluating the analytical data, and performing a human health and ecological RA. This RI report contains the results of all field investigations and the human health RA. An ecological RA has been prepared under separate cover.

Site 48 is entitled the MCAS Mercury Dump and is located on Longstaff Road next to Building 804. MCAS is situated west of the New River in the northwestern section of MCB Camp Lejeune (see Figure 1-1). Building 804 was previously utilized as a photography laboratory for the base. Mercury was reported to have been deposited over an area of approximately

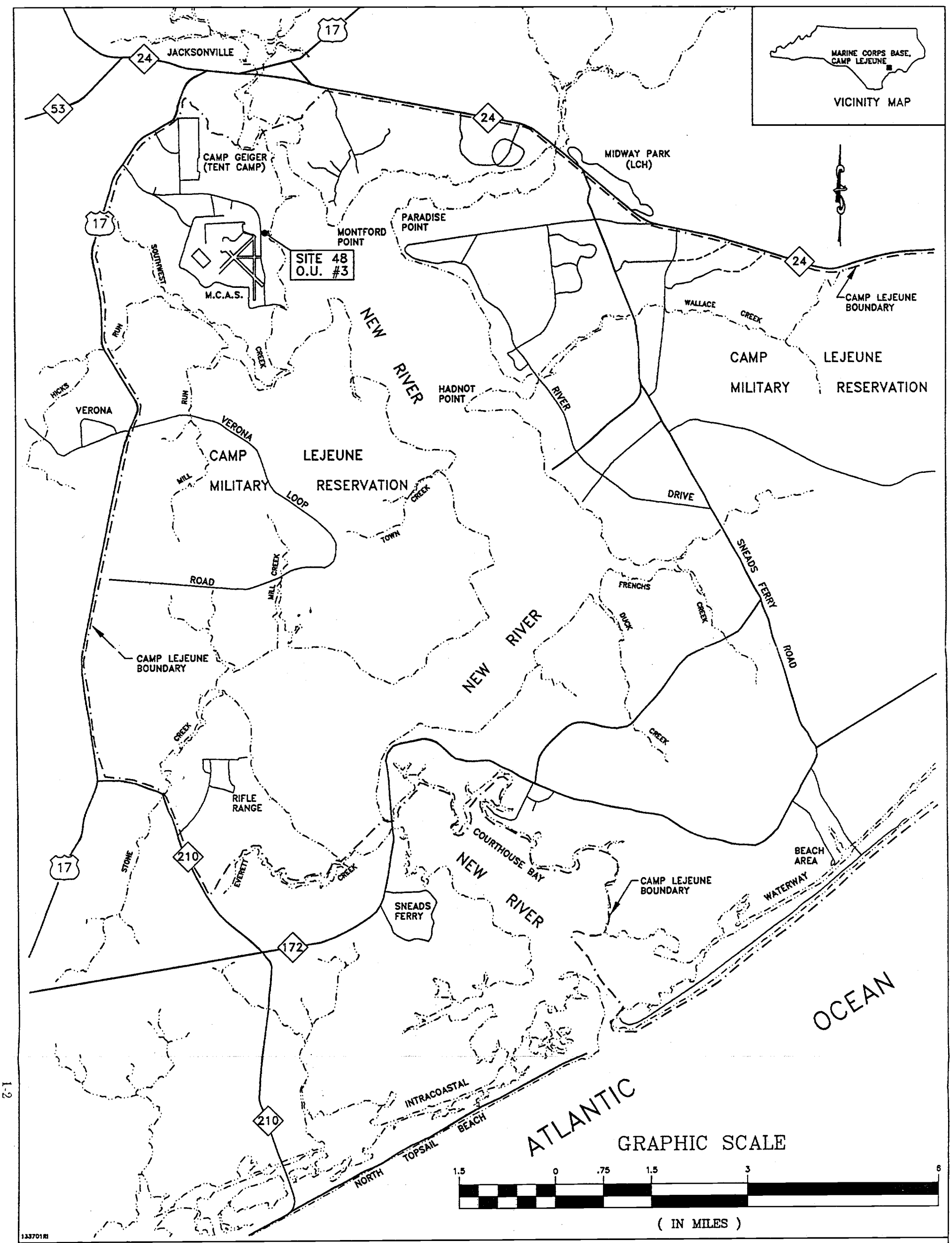

FIGURE 1–1
LOCATION MAP
OPERABLE UNIT No. 3, SITE 48

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

SOURCE: U.S.G.S. WATER–RESOURCES INVESTIGATIONS REPORT 89–4096

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20,000 square feet at a rate of one gallon per year from 1956 to 1966 (ESE, 1991). Detailed site background and site history descriptions follow in Section 1.2 of this RI report.

This RI Report is to be submitted to the USEPA Region IV, the N.C. DEHNR, and to members of the Technical Review Committee (TRC) for their review by the DoN, Naval Facilities Engineering Command, Atlantic Division (LANTDIV).

1.1 Operable Unit Description

Operable units are formed as an incremental step toward addressing individual site problems. There are currently 18 Installation Restoration Program (IRP) sites on MCB Camp Lejeune which have been grouped into nine operable units to simplify the specific problems associated with a site or a group of sites. Figure 1-2 shows all of the Operable Units on MCB Camp Lejeune. Operable Unit No. 3 is comprised of Site 48. Mercury from radar lines was reportedly disposed of during the period from 1956 to 1966. Because of the specific characteristics of the waste disposed of at the site and its geographical location, Site 48 is the only site comprising Operable Unit No. 3.

1.2 Site Background

This section provides a description of Site 48 and its specific areas of concern as well as the history of the site.

1.2.1 Site Description

In general, Site 48 is located between Longstaff Road and the New River. Based on existing information on the extent of mercury disposal activities and review of historical aerial photographs, the RI field activities focused of the area bordered by the New River to the east, an intermittent tributary of the New River to the north, the area west of Longstaff Road to the west, and Building 811 to the south (see Figure 1-3). A marsh area exists north and northeast of the site that joins the New River directly east of Building 804. Two additional buildings, Building 805 and Building 807, are located south of Building 804. Five antennae are located around Building 805. The investigation area for Site 48 covers approximately 4 acres and the reported mercury dumping area covers about 0.5 acres.

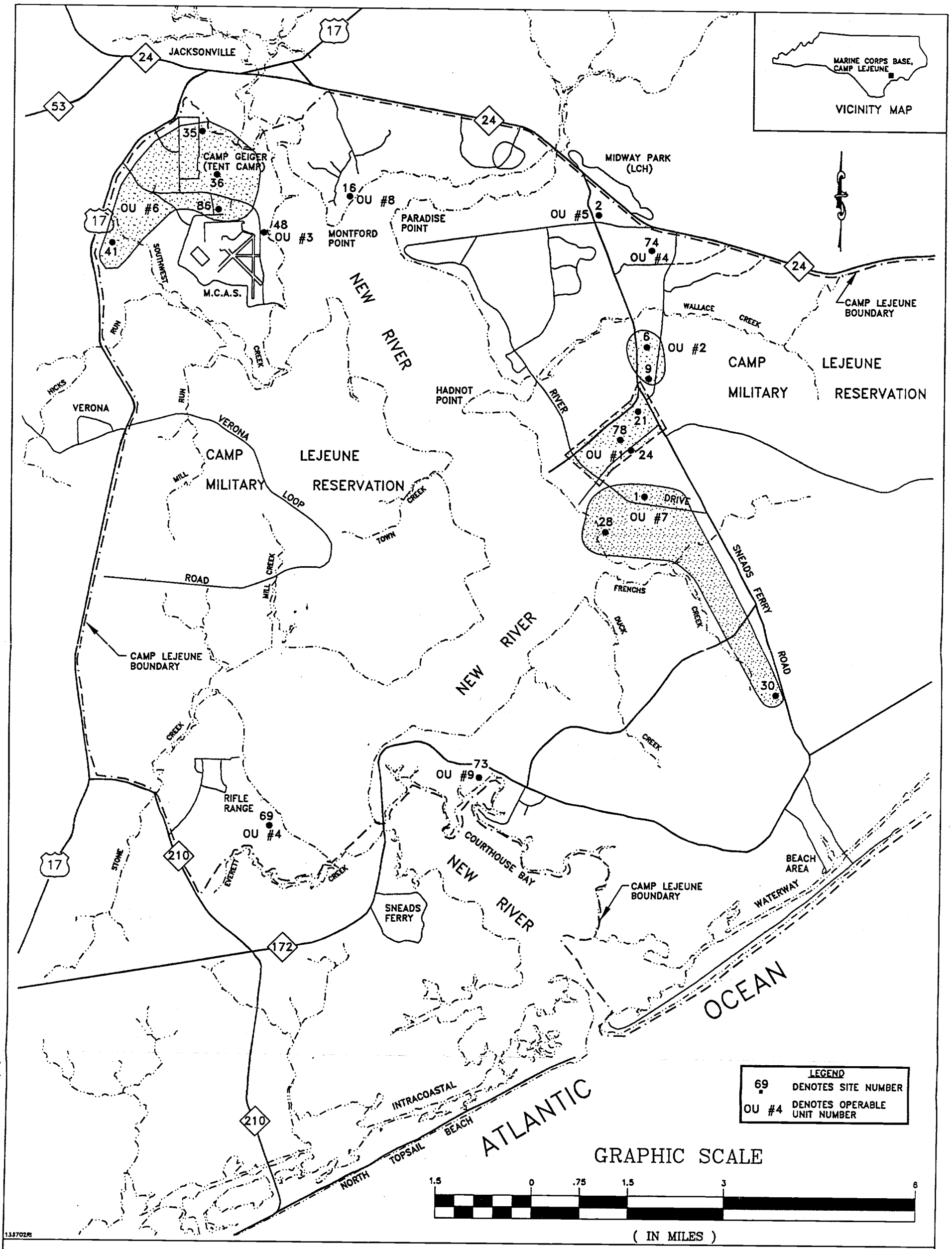

FIGURE 1–2
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

SOURCE: U.S.G.S. WATER-RESOURCES INVESTIGATIONS REPORT 89-4096

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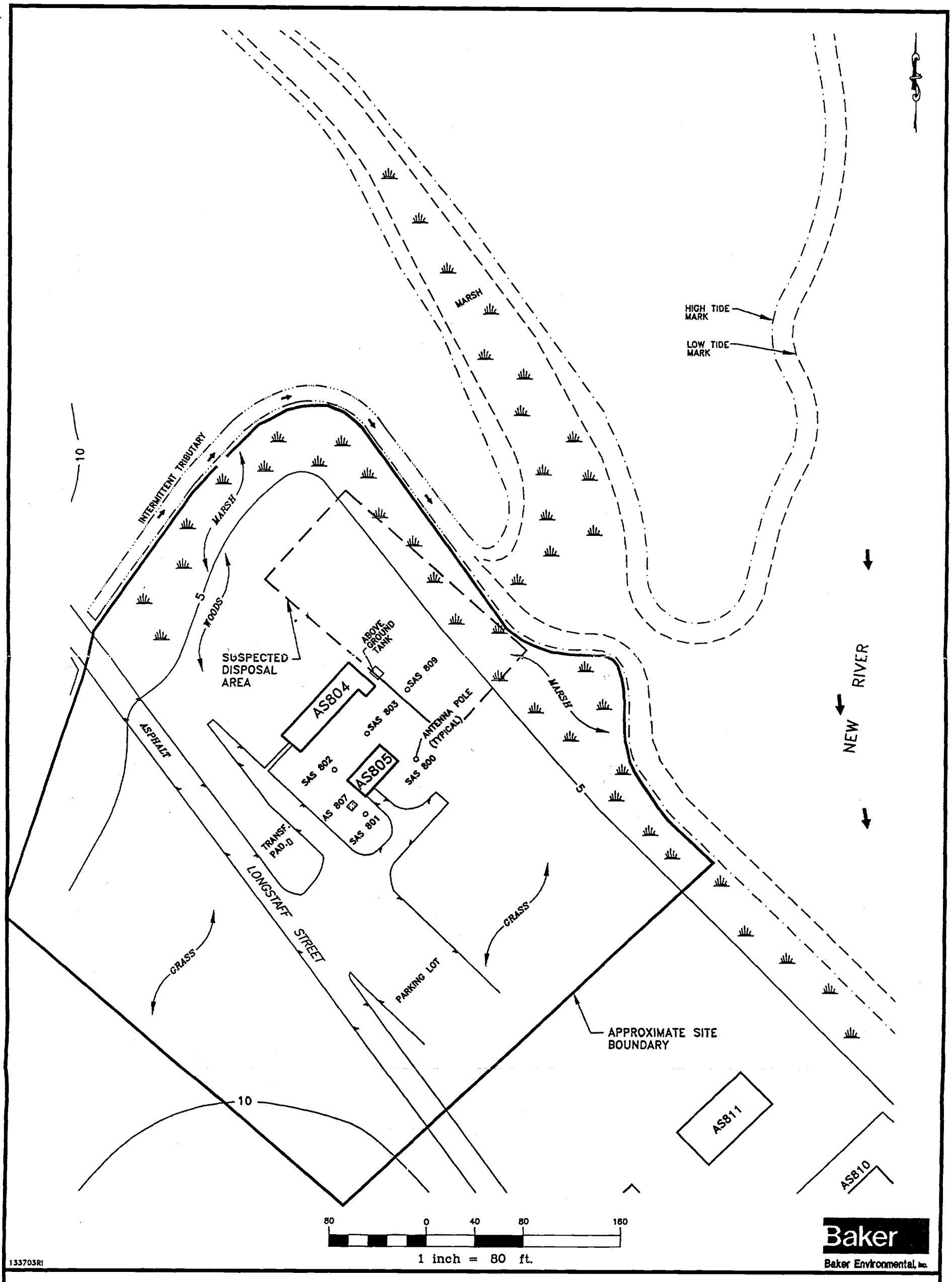


FIGURE 1-3
SITE PLAN
OPERABLE UNIT No. 3, SITE 48

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

SOURCE: LANTDIV, FEB. 1992

Building 804 is located in the center of Site 48. This building formerly operated as a photography laboratory. An aboveground storage tank is located behind Building 804. This tank replaced an underground storage tank which previously contained diesel fuel used for a generator in Building 804. The area around Building 804 is relatively flat and grass covered. The grassed area is maintained and extends to the banks of the New River. At the edge of the New River and the intermittent tributary, heavy vegetation and young saplings are present. No stressed vegetation was noted at the site by field personnel during the RI sampling activities.

1.2.2 Site History

During the period between 1956 to 1966, it was reported that mercury was periodically drained from delay lines of radar units and disposed in a 100- to 200-foot wide corridor extending from the rear of Building 804 to the bank of the New River. Approximately one gallon of mercury was reportedly dumped per year during the ten year period. The mercury was reportedly carried by hand and dumped or buried in small quantities at random areas behind Building 804 (WAR, 1983). Based on a review of historic aerial photographs dating back to 1956, several other potential disposal areas at the site have been identified (EPIC, 1992). These other areas are located to the north and to the west of Building 804. Therefore, based on the available information, it is unclear where the actual disposal activities at the site took place. Additional information pertaining to the aerial photographs is included in Section 2.0 of this report.

The Administration Office and Photographic Laboratory (Building 804) was built in 1955. Building 804 operated as a photo lab from 1955 to 1990. During this period, the photo lab discharged approximately 50 gallons of developers and stop bath (photography chemicals) per month to a sanitary sewer. The fix bath solution was sent for metals recycling. The building was vacant for 2 to 3 months in 1990. Since then, Building 804 has been used as a classroom for NBC (nuclear, biological and chemical) instruction.

1.3 Previous Investigations

In response to 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 consisted of Initial Assessment Studies (IASs) and Confirmation Studies. When the Superfund Amendments and

Reauthorization Act (SARA) was passed in 1986, the DoN aborted the NACIP Program in favor of the Installation Restoration Program (IRP), which adopted USEPA Superfund procedures.

A summary of the previous studies and investigations conducted at Site 48 either under the NACIP Program or the IRP are presented in the following subsections.

1.3.1 Initial Assessment Study, 1983

An IAS was conducted under the NACIP Program at MCB Camp Lejeune in 1983. The purpose of the IAS was to collect and evaluate evidence which indicates existence of pollutants that may have contaminated a site or that pose a potential health hazard for people located on or off an installation. The IAS was conducted by the environmental consulting firm, Water and Air Research, Inc. (WAR). The IAS report identified a number of areas within MCB Camp Lejeune as potential sources of contamination, including Site 48 (WAR, 1983).

The results of the IAS with respect to Site 48 indicated that mercury may have been dumped over a ten-year period behind Building 804. The mercury was generated from draining delay lines at the radar site. No evidence was found to indicate a central disposal place, therefore, disposal possibly occurred at random places. The IAS recommended that groundwater wells be installed and sampled for total mercury (WAR, 1983).

1.3.2 Confirmation Study, 1984

Based on the results of the IAS, a Confirmation Study was conducted at Site 48 by Environmental Science and Engineering, Inc. (ESE) in 1984. Under NACIP Program protocol, the Confirmation Study typically was conducted as two separate investigations: the Verification Step followed by the Characterization Step. The Verification Step was the only study conducted for Site 48. The findings from this study are described below. The analytical findings for this study are presented in Appendix A.

The Verification Step at Site 48 was conducted in August 1984. During this study, five soil samples were collected at the soil-groundwater interface from four soil borings. The sampling locations were not recorded. The samples were analyzed for mercury. Mercury was detected in all five samples ranging in concentration of 0.009 milligram per kilogram (mg/kg) to 0.03 mg/kg (ESE, 1991). The analytical methods and level of data quality are unknown.

In addition, in August 1984, four sediment samples were collected from a marshy area north of Building 804. Like the soil borings, the locations of these samples were not recorded. All of the samples were analyzed for mercury. Mercury was detected in all sediment samples collected from the site. The detected concentrations ranged from 0.02 mg/kg to 0.03 mg/kg (ESE, 1991).

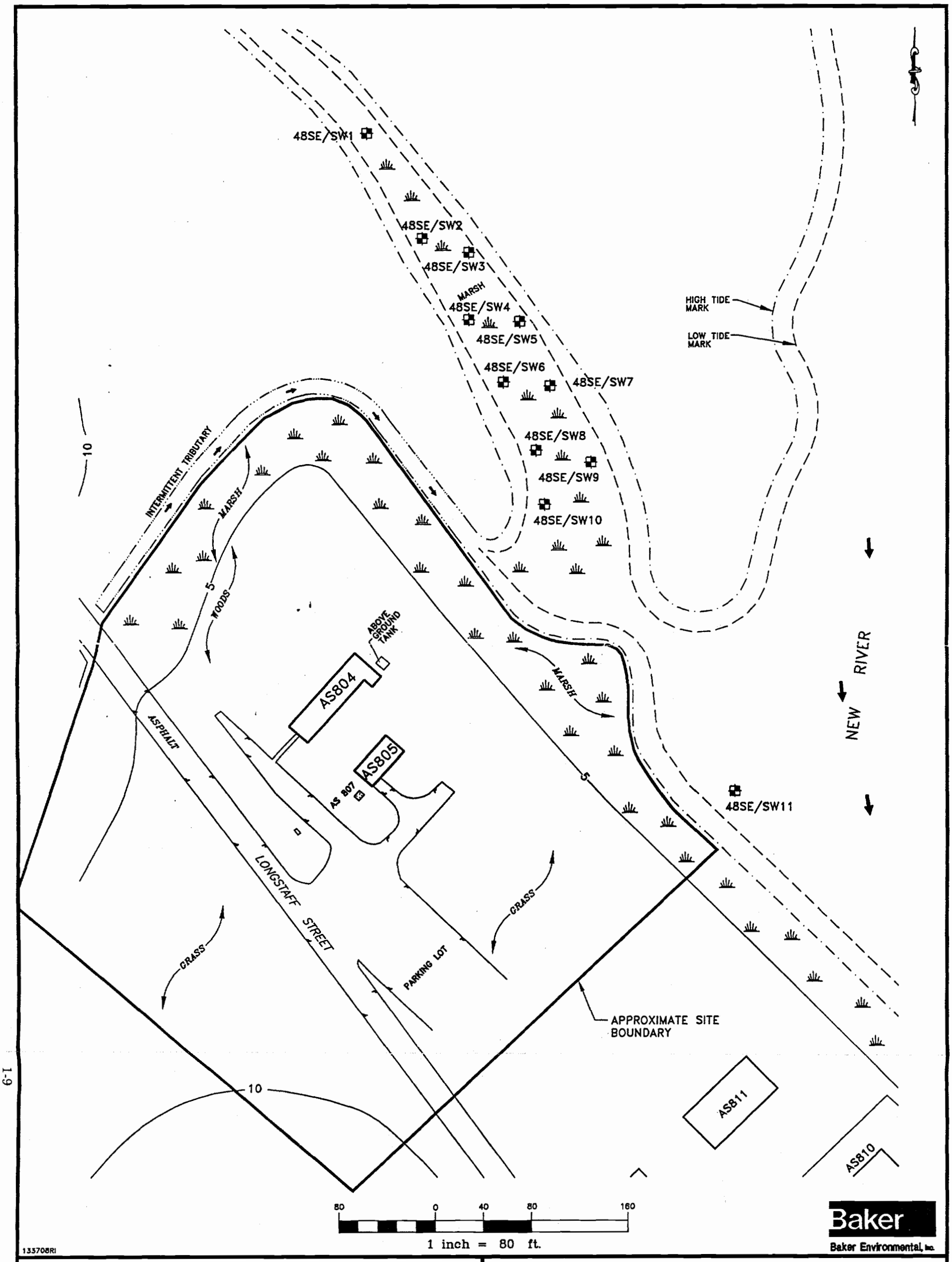
1.3.3 Supplemental Characterization Investigation, 1991

In January 1991, a Supplemental Characterization Investigation was conducted at Site 48 by ESE. Ten surface water samples and ten sediment samples were collected from the marsh area and inlet northeast of Building 804. One surface water and one sediment sample were also collected in the New River at a background location upstream and outside of the Site 48 marsh area. The sampling locations are identified on Figure 1-4. The samples were analyzed for Target Analyte List (TAL) metals (ESE, 1991). The analytical data from this study can be found in Appendix A.

Mercury was not detected in any surface water sample. Calcium, iron, magnesium, potassium and sodium were detected in all of the surface water samples (including the background sample). Other typical metals of concern such as arsenic, cadmium, chromium, and lead were not detected in any surface water sample (ESE, 1991).

Mercury was not detected in any sediment sample. Aluminum, iron, and sodium were detected in all of the sediment samples including the background location. Background concentrations were lower than the downstream locations. Cadmium, chromium, magnesium, manganese, and zinc were detected in the majority of the samples. Cadmium, chromium, and manganese concentrations were all below a general level of 25 mg/kg. The maximum detected concentrations of magnesium and zinc were 2970 mg/kg and 61.8 mg/kg, respectively. Other less frequently detected inorganics included copper, vanadium, and calcium (ESE,1991).

During this study, fish tissue sampling was attempted on two separate days - January 14 and 17, 1991, at periods of high and low tide. Two seine hauls were pulled through a small area of the sample site, however, no fish or shellfish were caught. Observations of the entire sampling area revealed that shellfish did not occur along the shore or within the channel. The bottom was comprised of silty material, which may not provide a solid enough substrate for the shellfish to survive (ESE,1991).



LEGEND

48SE/SW1 SUPPLLEMENTAL CHARACTERIZATION SURFACE WATER AND SEDIMENT SAMPLING LOCATION

SOURCE: ESE, 1991

FIGURE 1-4
APPROXIMATE SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS FROM THE SUPPLEMENTAL CHARACTERIZATION INVESTIGATION AT SITE 48

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

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1.3.4 Site Assessment Report, 1991

In June 1991, ESE prepared a Site Assessment (SA) Report for Site 48 (the report also included Sites 6 and 69 at MCB Camp Lejeune). The SA for Site 48 was based on the results of the IAS, the Confirmation Study, and the Supplemental Characterization Investigation. The SA Report also included a preliminary risk evaluation. The risk evaluation of the data from the site revealed four potential contaminants of concern in the surface water: cadmium, copper, nickel and silver (these compounds exceeded water quality standards). Whether the observed concentrations are actually attributable to former waste disposal activities at Site 48 is unknown. These concentrations may be representative of background levels for the area (ESE, 1991).

1.4 Report Organization

The following sections are presented in the remainder of this RI report:

- Section 2.0 Study Area Investigation
- Section 3.0 Physical Characteristics of the Study Area
- Section 4.0 Nature and Extent of Contamination
- Section 5.0 Contaminant Fate and Transport
- Section 6.0 Baseline Risk Assessment
- Section 7.0 Summary and Conclusions

Section 2.0 describes the field sampling activities conducted during the RI at Site 48. This section describes the purpose of the study of individual media, sampling procedures, sampling grids, and sampling locations for all media. Figures are included to show sampling locations, drilling logs and well installation information. This section also discusses quality control conducted during the sampling.

Section 3.0 addresses the physical features of Site 48. This section discusses the surface features, meteorology, surface water hydrology, geology, soils, hydrogeology, demography and land use, and the ecology of the Site 48 area.

Section 4.0 presents the nature and the extent of contamination found at Site 48. This section presents the results of the field sampling activities conducted as part of this RI. The results

are presented by media: soil, groundwater, surface water, and sediments. This section also discusses the potential sources of contaminants detected during the sampling activities.

Section 5.0 characterizes the contaminants found at Site 48. This characterization includes: potential routes of contaminant migration, contaminant persistence, and contaminant migration.

Section 6.0 contains the Baseline Risk Assessment conducted for the site. The Baseline Risk Assessment (RA) contains a human health evaluation and an environmental evaluation. An ecological risk assessment has been provided under separate cover.

Section 7.0 includes the Summary and Conclusions. This section summarizes the nature and extent of contamination, contaminant fate and transport, and the RA. In addition, the conclusions address any data limitations and recommended remedial action objectives.

This RI report is being submitted in two volumes. Volume I contains the RI report and Volume II contains the appendices. A listing of the appendices is located in the Table of Contents.

2.0 STUDY AREA INVESTIGATION

2.1 Introduction

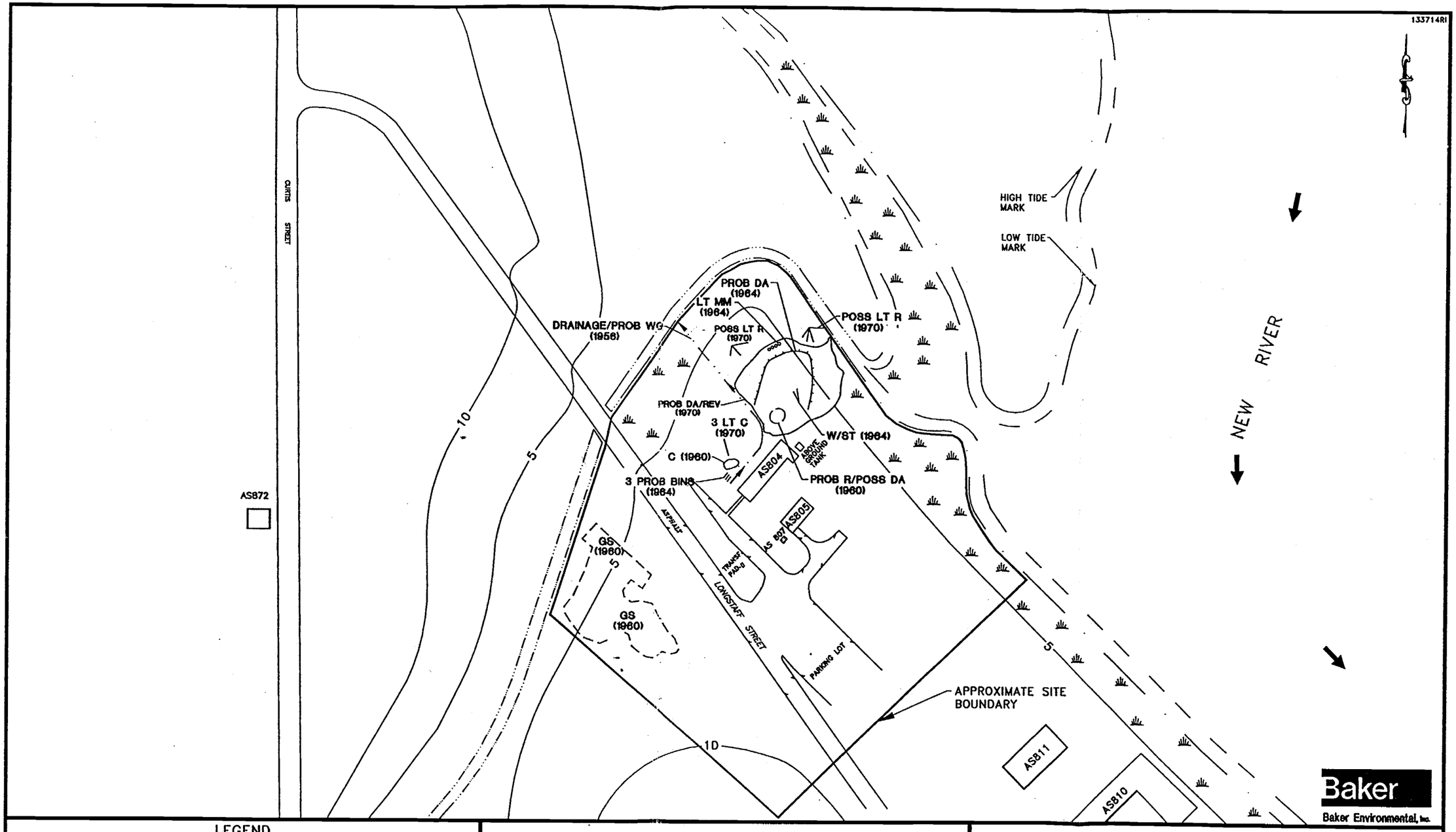
The field program at Site 48 was initiated to characterize potential environmental impacts and threats to human health resulting from previous mercury disposal activities. According to information provided by the DoN and MCB Camp Lejeune personnel, these disposal areas were reported to have been located behind Building 804, between the building and the shoreline of the New River. Sequentially, the field program outlined in the Final Remedial Investigation/Feasibility Study (RI/FS) Work Plan (submitted in May 1992) for this investigation focused on these areas of concern.

Review of historical aerial photographs, supplied from the USEPA Environmental Photographic Interpretation Center (EPIC) in September 1992, depicted several different areas at the site that appeared to have been previously excavated and trenched. These areas are located north and west of Building 804 and across Longstaff Street as shown on Figure 2-1. Accordingly, the initial soil boring and monitoring well locations proposed in the Final RI/FS Work Plan were relocated to areas near the excavated trenches depicted on the aerial photographs by EPIC.

The RI field investigative activities at Site 48 commenced on August 24, 1992 and continued through November 9, 1992. Activities conducted during the field program consisted of a preliminary site survey; a geophysical survey investigation; a soil investigation including drilling and sampling; a groundwater investigation including monitoring well installation, development and sampling; a surface water and sediment investigation; and an aquatic and ecological survey. The following sections discuss these investigative activities, in addition to the decontamination procedures employed and the methods used to handle the investigation derived wastes generated during the field program.

2.2 Preliminary Site Survey

Prior to initiating the drilling program, a preliminary survey of the site was conducted, and the locations of the proposed soil borings and monitoring wells were surveyed in place. A registered surveyor in the State of North Carolina, the firm of Hoggard-Eure Associates (Hoggard-Eure), was retained to perform the survey. The survey was completed on August 24, 1992.



LEGEND

PROB = PROBABLE		REV = REVEGETATED	
POSS = POSSIBLE		C = CONTAINER	
DA = DISPOSAL AREA		GS = GROUND SCAR	
R = REFUSE		W/ST = WETT OR STAINED GROUND	
LT = LIGHT-TONED		WG = WET GROUND	
MM = MOUNDED-MATERIAL			

SOURCE: EPIC, 1992

120 0 60 120 240

1 inch = 120 ft.

FIGURE 2-1
EPIC STUDY FINDINGS FOR
SITE 48

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

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The proposed soil boring locations were identified as "primary" and "secondary" locations or Areas of Concern (AOC) based on the review of the EPIC historical aerial photographs. Each of the "primary" sampling locations were located in the field by the surveyors using the aerial photographs, as a reference, to determine the approximate center of each AOC. Additional potential sampling locations, referred to as "secondary" locations or AOC, were also identified in the field by the surveyors. These secondary locations represent what is believed to be the outer boundary of each AOC. The primary locations were later sampled (soil samples) since they were located near the suspected disposal trenches, while the secondary locations were only sampled if evidence of contamination was identified at the primary locations. No soil samples were collected from any of the secondary locations since mercury or other contaminants were not detected at elevated levels in "primary samples." Sampling details are discussed in Section 2.4.

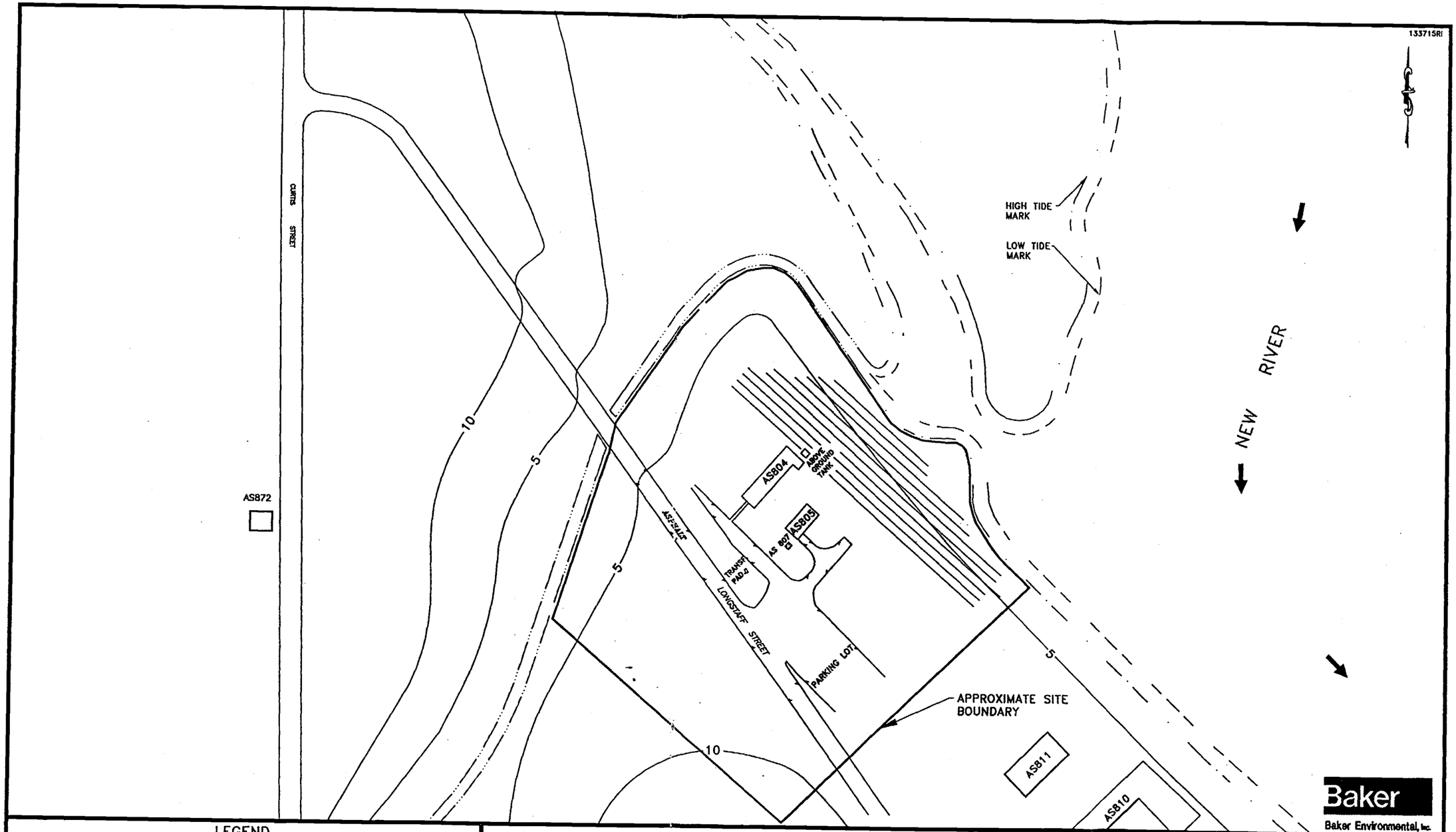
2.3 Geophysical Survey Investigation

A geophysical survey was conducted at Site 48 on August 25 and 26, 1992 to identify areas where past disposal practices may have occurred. This survey was conducted prior to receiving the EPIC aerial photographs. Therefore, the investigation focused on the area behind Building 804 where mercury was reported to have been disposed. The firm of Weston Geophysical Corporation (Weston) was retained to perform the geophysical survey. Prior to the survey, a geophysical survey grid was established by the surveying firm of Hoggard-Eure that consisted of 100-foot and 10-foot spaced lines as shown on Figure 2-2.

Several geophysical techniques were employed during the investigation including electromagnetic terrain conductivity (ETC), magnetometry, and ground penetrating radar (GPR). ETC profiling was performed to map the lateral extent of buried material and to identify buried metal objects and other debris. The magnetometry survey was performed to complement the ETC interpretation of subsurface objects and debris. Lastly, GPR techniques were initiated to reveal a graphical cross-sectional view of subsurface stratigraphy and buried objects such as drums, pipelines, and tanks.

Appendix B contains the report prepared by Weston Geophysical (a subsidiary of Baker Environemntal) for the geophysical investigation at Site 48.

133715RI



LEGEND

——— GEOPHYSICAL (GPR/EM) TRANSECTS (10 ft. apart)

SOURCE: EPIC, 1992

120 0 60 120 240

1 inch = 120 ft.

FIGURE 2-2
GEOPHYSICAL SURVEY STUDY LAYOUT
SITE 48

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

00187W042

2.4 Soil Investigation

The environmental sampling program developed for Site 48 was intended to identify contaminants of concern (i.e., possibly mercury and other contaminants) and evaluate their distribution at the site. Moreover, the program was developed to consider potential human health risks and ecological impacts associated with the contaminants of concern. A summary of the soil sampling program at Site 48 describing the sample locations, the number of sampling points, and analytical methods is provided on Table 2-1.

Field quality assurance and quality control (QA/QC) samples were also collected during the sampling program. These samples were obtained to: 1) ensure that decontamination procedures are properly implemented (i.e., equipment rinsate samples); 2) evaluate field methodology (i.e., duplicate samples); 3) establish field background conditions (i.e., field blanks); and 4) evaluate whether cross-contamination occurred during sampling and/or shipping (i.e., trip blanks). Data Quality Objectives (DQOs) for the QA/QC samples were implemented in accordance with DOQ Level IV as defined in the Environmental Compliance Branch Standard Operating Procedures (SOPs) and Quality Assurance Manual, EPA Region IV (1991).

Several types of field QA/QC samples were collected and analyzed including duplicate samples, equipment rinsates, field blanks, and trip blanks. These sampling definitions are listed below (USEPA, 1991):

- Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under identical conditions.

- Equipment Blanks: Equipment field blanks are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. These samples will be used to determine if cleaning procedures were adequate. (The equipment could have been cleaned in the field or prior to the field operation.)

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at pre-designated locations. This is done to determine if any contaminants present in the area may have an affect on the sample integrity. Field blanks should be collected in dusty environments and/or from areas

TABLE 2-1

SUMMARY OF SOIL SAMPLING PROGRAM
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Number of Samples	Sampling Intervals (feet, bgs)	Analytical Parameters
SB3A	7	1	0 - 0.5	TCL Organics (1)/TAL Inorganics (2)
		1	3 - 5	TCL Organics/TAL Inorganics
SB4A	5	1	0 - 0.5	TCL Organics/TAL Inorganics
		1	1 - 3	TCL Organics/TAL Inorganics
SB3B/48GW3(3)	24.5	1	0 - 0.5	TCL Organics/TAL Inorganics
		1	7 - 9	TCL Organics/TAL Inorganics
		1	9 - 11	TCL Organics/TAL Inorganics
SB3C	9	1	0 - 0.5	TCL Organics/TAL Inorganics
		1	5 - 7	TCL Organics/TAL Inorganics
SB6	20	1	4 - 6	Permeability, Classification, and Bulk Density (4)
		1	8 - 20	Grain Size (5)

Notes: (1) Target Compound List (TCL) organics (volatiles, semivolatiles, PCBs, and pesticides) analyzed by Contract Laboratory Program (CLP) Protocols.

(2) Target Analyte List (TAL) inorganics (total metals) analyzed by CLP Protocols.

(3) Soil boring SB3C/48GW3 combined and converted into a monitoring well.

(4) Permeability,classification, and bulk density tests performed according to SW-846 Method 9100, ASTM Method D2489, and Agronomy No. 9, respectively.

(5) Grain size analysis performed according to ASTM Method D422.

(6) Full Toxicity Characteristic Leaching Procedure (TCLP) and RCRA Hazardous Characteristics analyzed by 40CFR261 Procedures.

(7) Inorganic engineering parameters analyzed by the following methods:

Chlorine, Residual	-	EPA 330.5
Total Fluoride	-	SM 4500-F
Nitrogen (Organic)	-	EPA 350.2
Alkalinity (total)	-	SM2320-B

(8) Sample above water table was not recovered during sampling. Accordingly, a sample from ground surface to two feet was submitted for analysis.

TABLE 2-1 (Continued)

SUMMARY OF SOIL SAMPLING PROGRAM
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Number of Samples	Sampling Intervals (feet, bgs)	Analytical Parameters
SB7	9	1	0 - 0.5	Full TCLP (6)/ RCRA Hazardous Characteristics (6)/ Inorganic Engineering Parameters (7)
		1	5 - 7	Full TCLP (6)/ RCRA Hazardous Characteristics (6)/ Inorganic Engineering Parameters (7)
48GW1	20	1	4 - 5	TCL Organics/TAL Inorganics
		1	5 - 6	TCL Organics/TAL Inorganics
48GW2	23	1	0 - 2 (8)	TCL Organics/TAL Inorganics
		1	6 - 8	TCL Organics/TAL Inorganics
48GW4	24.5	1	6 - 8	TCL Organics/TAL Inorganics
		1	8 - 10	TCL Organics/TAL Inorganics

Notes: (1) Target Compound List (TCL) organics (volatiles, semivolatiles, PCBs, and pesticides) analyzed by Contract Laboratory Program (CLP) Protocols.

(2) Target Analyte List (TAL) inorganics (total metals) analyzed by CLP Protocols.

(3) Soil boring SB3C/48GW3 combined and converted into a monitoring well.

(4) Permeability,classification, and bulk density tests performed according to SW-846 Method 9100, ASTM Method D2489, and Agronomy No. 9, respectively.

(5) Grain size analysis performed according to ASTM Method D422.

(6) Full Toxicity Characteristic Leaching Procedure (TCLP) and RCRA Hazardous Characteristics analyzed by 40CFR261 Procedures.

(7) Inorganic engineering parameters analyzed by the following methods:
- Chlorine, Residual - EPA 330.5
- Total Fluoride - SM 4500-F
- Nitrogen (Organic) - EPA 350.2
- Alkalinity (total) - SM2320-B

(8) Sample above water table was not recovered during sampling. Accordingly, a sample from ground surface to two feet was submitted for analysis.

TABLE 2-1 (Continued)

SUMMARY OF SOIL SAMPLING PROGRAM
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Number of Samples	Sampling Intervals (feet, bgs)	Analytical Parameters
48GW5	25	1	4 - 6	TCL Organics/TAL Inorganics
		1	8 - 10	TCL Organics/TAL Inorganics

Notes: (1) Target Compound List (TCL) organics (volatiles, semivolatiles, PCBs, and pesticides) analyzed by Contract Laboratory Program (CLP) Protocols.

(2) Target Analyte List (TAL) inorganics (total metals) analyzed by CLP Protocols.

(3) Soil boring SB3C/48GW3 combined and converted into a monitoring well.

(4) Permeability,classification, and bulk density tests performed according to SW-846 Method 9100, ASTM Method D2489, and Agronomy No. 9, respectively.

(5) Grain size analysis performed according to ASTM Method D422.

(6) Full Toxicity Characteristic Leaching Procedure (TCLP) and RCRA Hazardous Characteristics analyzed by 40CFR261 Procedures.

(7) Inorganic engineering parameters analyzed by the following methods:

Chlorine, Residual	-	EPA 330.5
Total Fluoride	-	SM 4500-F
Nitrogen (Organic)	-	EPA 350.2
Alkalinity (total)	-	SM2320-B

(8) Sample above water table was not recovered during sampling. Accordingly, a sample from ground surface to two feet was submitted for analysis.

where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

- Trip Blanks: Trip blanks are prepared prior to the sampling event in the actual sample container and are kept with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. Field sampling teams utilize volatile organic trip blanks to determine if samples were contaminated during storage and transportation back to the laboratory. If samples are to be shipped, trip blanks are to be provided per shipment but not per cooler.

Table 2-2 summarizes field QA/QC sample types, frequency, and analytical methods.

In general, the field procedures and sampling methods employed for this study were implemented in accordance with EPA Region IV standard operating procedures as referenced in the previous paragraphs. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in the Final RI/FS Work Plan for Site 48.

The soil investigation program for Site 48 included soil boring drilling, soil sampling, and field screening and air monitoring. These activities are discussed in the following sections.

2.4.1 Drilling Procedures

Drilling activities at Site 48 commenced on September 26, 1992 and continued through September 30, 1992. The firm of Hardin and Huber Inc. (HHI) was retained to perform the drilling services. During the drilling program, ten soil borings (SB3A, SB4A, SB3C, SB6, SB7, and 48GW1 through 48GW5) were advanced in the vicinity of Site 48 with five of the boreholes converted into shallow Type II monitoring wells. The number of soil borings was modified from 19, as stated in the Final RI/FS Work Plan, to 10 after historical aerial photographs became available. Based on these photographs, the investigation strategy was modified at Site 48. A modification to the scope of work was submitted to the EPA on September 30, 1992. Figure 2-3 shows the locations of the soil boring points.

TABLE 2-2

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL
SAMPLING PROGRAM FOR THE SOIL INVESTIGATIONS
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Analytical Parameters (3)
Trip Blanks (2)	One per Cooler	TCL Volatiles
Field Blanks	One per Event (4)	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined on page 2-5 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.
(3) Parameters analyzed according to procedures outlined on Table 2-1.
(4) An event is defined as one 14 day period. Field blank collected during soils investigation in the vicinity of soil boring 48GW3.
(5) Equipment rinsates collected from various sampling equipment (e.g. split spoons, stainless steel spoons, hollow stem augers, etc.).
(6) Field duplicate samples collected from soil borings SB3B and 48GW4 analyzed for TCL organics and TAL inorganics; field duplicate sample collected from soil boring SB7 analyzed for total TCLP.

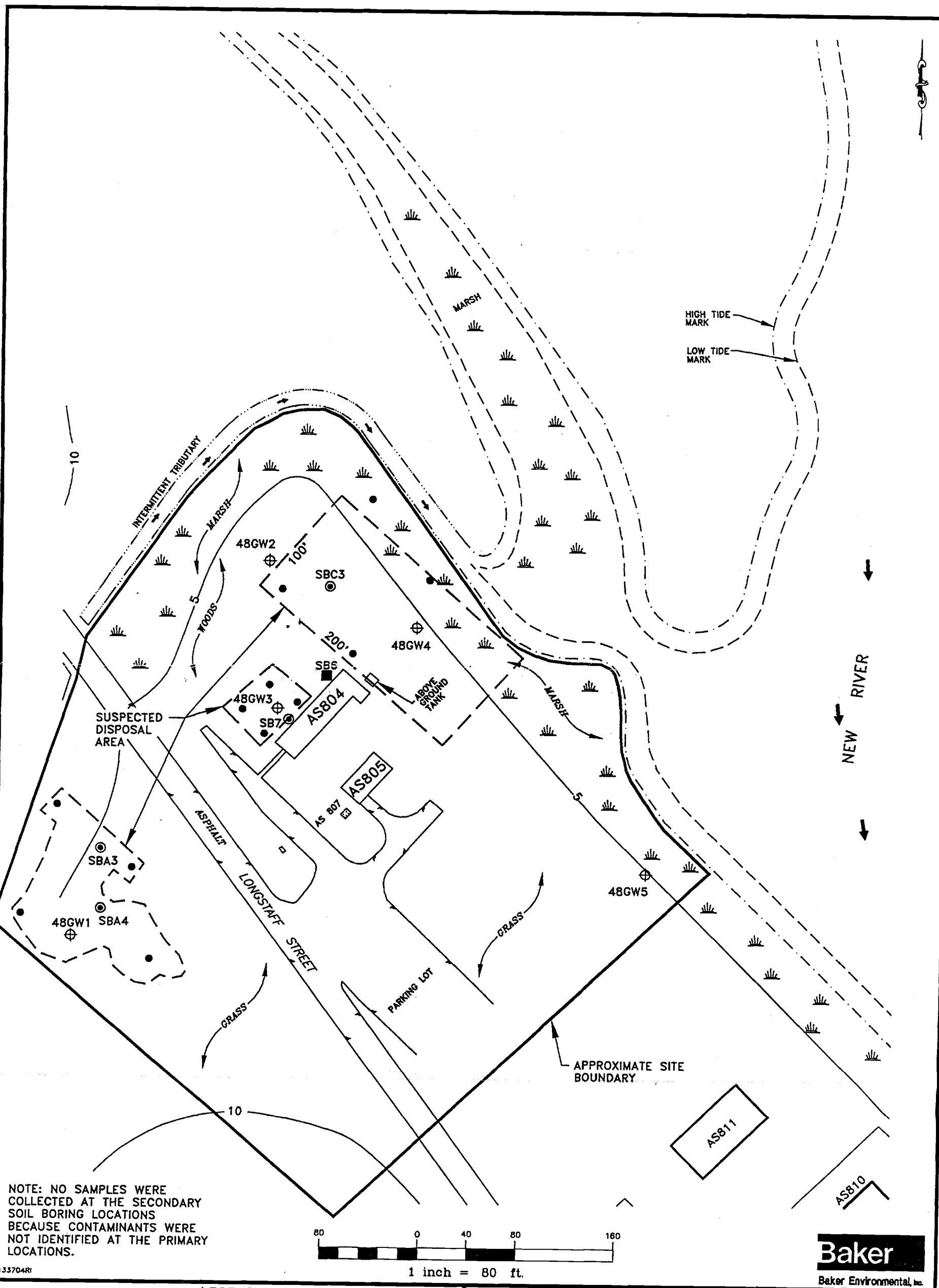


FIGURE 2-3
SOIL BORING AND MONITORING WELL SAMPLING LOCATION MAP

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

00187W052

The drilling and sampling program implemented at Site 48 focused on several suspected disposal areas. As discussed in Section 2.1, historical aerial photographs were reviewed to assist in locating suspected disposal areas or other anomalies that may be associated with waste disposal. In general the suspected disposal areas, and subsequent proposed drilling locations, were situated southwest of Building 804 across Longstaff Street and north-northeast of Building 804.

The boreholes were advanced using a truck-mounted drill rig and by employing the hollow-stem auger technique. During drilling, 3-1/4 inch inside diameter (ID) augers were used to advance the boreholes. Split-spoon samples were collected from inside the augers per ASTM Method D 1586-84 (ASTM, 1984). For installation of soil borings, soil samples were collected from the surface (ground surface to one-foot) then at continuous 2-foot intervals until the water table was encountered, where the borings were terminated. Samples collected during installation of monitoring wells were obtained at continuous 2-foot intervals until the water table was encountered, then at approximate 5-foot intervals thereafter. These borings (for well installation) were terminated from 20 to 25 feet bgs. Two-foot samples were obtained to ensure a sufficient quantity of sample was retained for analysis. Drilling and sampling activities at the site were performed using Level C personal protection because of the potential of mercury exposure. Soil cuttings obtained during the drilling program were containerized and handled according to the procedures outlined in Section 2.9.

Each split-spoon sample was classified visually by the on-site geologist. Soils were classified using a general geological description and according to the Unified Soil Classification System (USCS). The classification included characterization of soil type, color, moisture content, relative density, plasticity, and other pertinent information such as evidence of contamination. Lithological descriptions of site soils are provided on the Test Boring and Well Construction Records in Appendix C.

One soil boring (SB6) was also advanced on the northwest side of Building 804 to collect an undisturbed (Shelby Tube) sample. The sample was collected from 4 to 6 feet below ground surface (bgs) using a thin-walled Shelby Tube per ASTM Method D 1587-84 (ASTM, 1984). The sample was retained for physical property testing (i.e., bulk density, permeability, classification, etc.). The borehole was further advanced to approximately 20 feet bgs. Cuttings from 8 to 20 feet bgs (predominantly silty sands) were retained for grain-size analysis.

2.4.2 Soil Sampling

2.4.2.1 Sampling Procedures

Surface (0 to 12 inches bgs) and subsurface (deeper than one foot) soil samples were collected from September 26 through September 29, 1993 for chemical analysis at nine of the ten soil boring locations (SB3A, SB4A, SB3C, SB7, and 48GW1 through 48GW5). Surface samples were collected for risk assessment evaluation while subsurface samples were collected to evaluate the horizontal and vertical extent of potentially impacted soils. Figure 2-3 depicts the locations of the sampling points. Table 2-1 summarizes the sample depths, locations, and parameters analyzed.

Soil samples were obtained by employing two methods. For the surface samples, hollow-stem augers were advanced to approximately six inches bgs so that soil cuttings could be retained for the grab sample. The first few inches of top soil and matted roots were removed prior to advancing the augers (the area is covered with grass and is maintained on a periodic basis). Deeper subsurface soil samples were collected with a split-spoon sampler in accordance with ASTM Method D 1586-84 as detailed in Section 2.4.1. In general, samples collected from the soil borings for chemical analysis were obtained from the surface and just above the water table; samples collected during drilling for the monitoring wells for chemical analysis were obtained from just above and just below (so that groundwater results can be correlated with soil conditions) the water table. Both the hollow-stem augers and split-spoon sampler were decontaminated prior to sample collection according to the procedures outlined in Section 2.8.

Soil samples retained for analysis were prepared according to EPA Region IV SOPs. Samples collected for volatile organic analysis were extracted from the split-spoon with a stainless-steel spoon from different sections on the spoon (i.e., composite of split-spoon). Precautions were taken not to mix the sample which can promote volatilization. Samples obtained for other analytical parameters [i.e., Target Compound List (TCL) semivolatiles, polychlorinated biphenyls (PCBs), pesticides, toxicity characteristic leaching procedure (TCLP) compounds, and engineering parameters] were first thoroughly mixed and then placed into the appropriate laboratory containers. Following sample collection, each sample was stored on ice in a cooler. Sample preparation also included documentation of sample number, depth, location, date, time, and analytical parameters in a field log book. Chain-of-custody documentation accompanied the samples to the laboratory.

2.4.2.2 Analytical Requirements

The analytical program for the soils investigation is summarized on Table 2-1. Surface and subsurface samples obtained from soil borings SB3B, SB3C, SB4A, and 48GW1 through 48GW5 were analyzed for TCL organics and Target Analyte List (TAL) inorganics. Two grab samples (surface and subsurface) collected at soil boring SB7 were analyzed for total TCLP, residual chloride, total fluoride, organic nitrogen, total alkalinity (engineering parameters), and RCRA hazardous waste characteristics to evaluate general soil conditions for potential treatment and disposal options. Geotechnical engineering samples (i.e., grain size, permeability, bulk density, classification, etc.) were collected at boring SB6 to evaluate subsurface physical conditions. Samples for the geotechnical testing were obtained by using a thin-walled Shelby Tube when an undisturbed sample was required (permeability, bulk density) or by advancing the hollow-stem augers and retaining the soil cuttings (grain size analysis).

2.4.3 Field Screening and Air Monitoring

Several air monitoring and field screening procedures were implemented during drilling and sampling activities for health and safety and initial contaminant monitoring. During drilling, ambient air monitoring in the vicinity of the borehole was performed with a lower explosive limit (LEL) meter, Drager tubes, a flame ionization detector (FID) or photoionization detector (PID), and a radiation meter to monitor for airborne contaminants. Samples (i.e., split-spoon samples) were screened with a PID or FID, Drager tubes, and the radiation meter to measure for volatile organic vapor, mercury, and radioactive particles, respectively. Data obtained in the field was recorded in a field logbook, and PID/FID measurements are provided on the Test Boring and Well Construction Records in Appendix C. Prior to daily monitoring, the instruments were calibrated. Calibration documentation was recorded in field log books and on calibration forms.

2.5 Groundwater Investigation

The environmental sampling program developed for Site 48 was intended to identify contaminants of concern (i.e., possibly mercury and other contaminants) and evaluate their distribution at the site. The primary objective of this investigation was to determine if former waste disposal practices adversely impacted the quality of groundwater. Moreover, the program was developed to consider potential human and ecological health risks associated

with the contaminants of concern. A summary of the groundwater sampling program at Site 48 describing the sample locations, well screen intervals, and analytical parameters is provided on Table 2-3.

Several types of field QA/QC samples were collected and analyzed during the groundwater investigation including duplicate samples, equipment rinsates, field blanks, and trip blanks. These sample types were defined in Section 2.4. Table 2-4 summarizes field QA/QC sample types, frequencies, and analytical parameters.

In general, the field procedures and sampling methods employed for this study were implemented in accordance with EPA Region IV SOPs. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in the Final RI/FS Work Plan for Site 48.

The following sections describe monitoring well installation, groundwater sampling, well development, and water level measurement procedures.

2.5.1 Monitoring Well Installation

Five shallow Type II monitoring wells (denoted as 48GW1 through 48GW5) were installed at Site 48 at the locations shown on Figure 2-3. The monitoring wells were installed to collect shallow groundwater samples for characterizing the nature and horizontal extent of potentially impacted groundwater and to evaluate groundwater flow patterns at the site. As stated previously, the locations of the wells were based on review of the historical aerial photographs. Accordingly, the wells were installed in areas believed to be in the vicinity of the suspected disposal trenches.

Prior to well installation, a permit for the Construction of a Well or Well System was obtained from the North Carolina Environmental Commission, Department of Environmental, Health and Natural Resources of Raleigh, North Carolina. A copy the permit is provided in Appendix D.

The monitoring wells were installed upon completion of advancing the boreholes. Each borehole was over-drilled with 8-1/4 inch ID augers prior to well installation. Wells depths ranged from 19.4 feet bgs (48GW1) to 24.7 feet bgs (48GW5). In general, the wells were installed approximately 15 feet below where the water table was encountered during drilling.

TABLE 2-3

SUMMARY OF GROUNDWATER SAMPLING PROGRAM
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Monitoring Well Number	Sample Location - Explanation	Screen Interval (feet, bgs)	Analytical Parameter
48GW1	Former Ground Scar Location North of Longstaff Road	3.9 - 19.0	TCL Organics (1)/TAL Inorganics (2)
48GW2	North of Former Trench/Suspected Disposal Area	5.0 - 20.4	TCL Organics/TAL Inorganics
48GW3	North of Building 804 Near Light-Toned Soil Possible Ground Scar	9.4 - 23.4	TCL Organics/TAL Inorganics/ Engineering Parameters (3)
48GW4	Northeast of Building 804 Near Light-Toned Soil-Refuse	8.5 - 23.6	TCL Organics/TAL Inorganics
48GW5	Southeast of Building 804 - Background Well	10.1 - 24.3	TCL Organics/TAL Inorganics

Notes: (1) Target Compound List (TCL) organics (semivolatiles, PCBs, and pesticides) analyzed by Contract Laboratory Program (CLP) Protocols. TCL volatiles analyzed by Purgeable Halocarbon (EPA 601) and Purgeable Aromatics (EPA 602) Methods.

(2) Target Analyte List (TAL) inorganics (total and dissolved metals, and cyanide) analyzed by CLP Protocols.

(3) Engineering Parameters analyzed by the following methods:

Biological Oxygen Demand (BOD)	-	SM510
Chemical Oxygen Demand (COD)	-	EPA 410.1
Total Suspended Solids (TSS)	-	EPA 160.2
Total Dissolved Solids (TDS)	-	EPA 160.1
Total Volatile Solids (TVS)	-	EPA 160.4

Engineering parameters collected at 48GW3 only.

TABLE 2-4

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM
FOR THE GROUNDWATER INVESTIGATION
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Analytical Parameters (3)
Trip Blanks (2)	One per Cooler	TCL Volatiles
Field Blanks	One per Event (4)	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined on page 2-5 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.
(3) Parameters analyzed according to procedures outlined on Table 2-3.
(4) An event is defined as one 14 day period. Field blank collected during the groundwater investigation in the vicinity of monitoring well 48GW2.
(5) Equipment rinsates collected from various sampling equipment (e.g., bailer).
(6) Field duplicate sample collected at monitoring well 48GW3.

Further, the wells were installed at depths to compensate for seasonal and daily (tidal influences) variations in the water table.

Well construction details for the newly installed wells are summarized on Table 2-5 and well construction diagrams are shown on the Test Boring and Well Construction Records provided in Appendix C. The wells were constructed of 4-inch nominal diameter Schedule 40, flush-joint and threaded PVC casing with a 15-foot long, 0.01-inch screen section. Four-inch diameter wells were selected for the site so that the wells could be utilized for pump and treatment of groundwater, if necessary. A medium-grained sand pack (Number 2 sand), extending approximately 2 feet (where conditions permitted) above the top of the screen, was placed in the annulus between the screen and the borehole wall (12-inch borehole diameter) from inside the hollow-stem augers. A 1- to 2-foot bentonite pellet seal was then placed above the sand pack and hydrated with potable water. The seal was installed to prevent cement from intruding onto the sand pack. The remaining annular space (approximately one foot) was backfilled with Portland cement for construction of the pad. An above ground ("stick-up") steel protective casing and a PVC locking cap were fitted at the top of each well. The wells were tagged with the North Carolina well permit information and mark "Not for Consumptive Use". Typical well construction details are shown on Figure 2-4.

2.5.2 Well Development Procedures

Following well construction and curing of the bentonite seal, each newly installed well was developed to remove fine-grained sediment from the screen and to establish interconnection between the well and the formation. The wells were developed by a combination of surging and pumping. Pumping hoses were dedicated for each well to minimize the potential for cross contamination.

Three to five well volumes were removed from each well until the water was essentially sediment-free. Measurements of pH, specific conductance, and temperature were recorded to assist in determining well stabilization. Periodic flow and volume measurements were also recorded during development to evaluate flow rates of the shallow water-bearing zone. Well Development Forms summarizing this information are provided in Appendix E.

TABLE 2-5

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation[1] (feet, above msl)	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Depth to Sand Pack (feet, below ground surface)	Depth to Bentonite (feet, below ground surface)	Stick-Up (feet, above ground surface)
48GW1	9/29/92	9.87	7.6	20.0	19.4	3.9-19.0	3.0	1.5	2.3
48GW2	9/27/92	8.16	5.7	23.0	20.7	5.0-20.4	3.0	1.5	2.5
48GW3	9/26/92	12.11	9.2	24.5	24.0	9.4-23.4	7.0	5.0	2.9
48GW4	9/27/92	9.98	7.4	24.5	24.0	8.5-23.6	6.0	4.3	2.6
48GW5	9/28/92	10.10	7.5	25.0	24.7	10.1-24.3	7.0	5.0	2.6

Notes: [1] msl - mean sea level

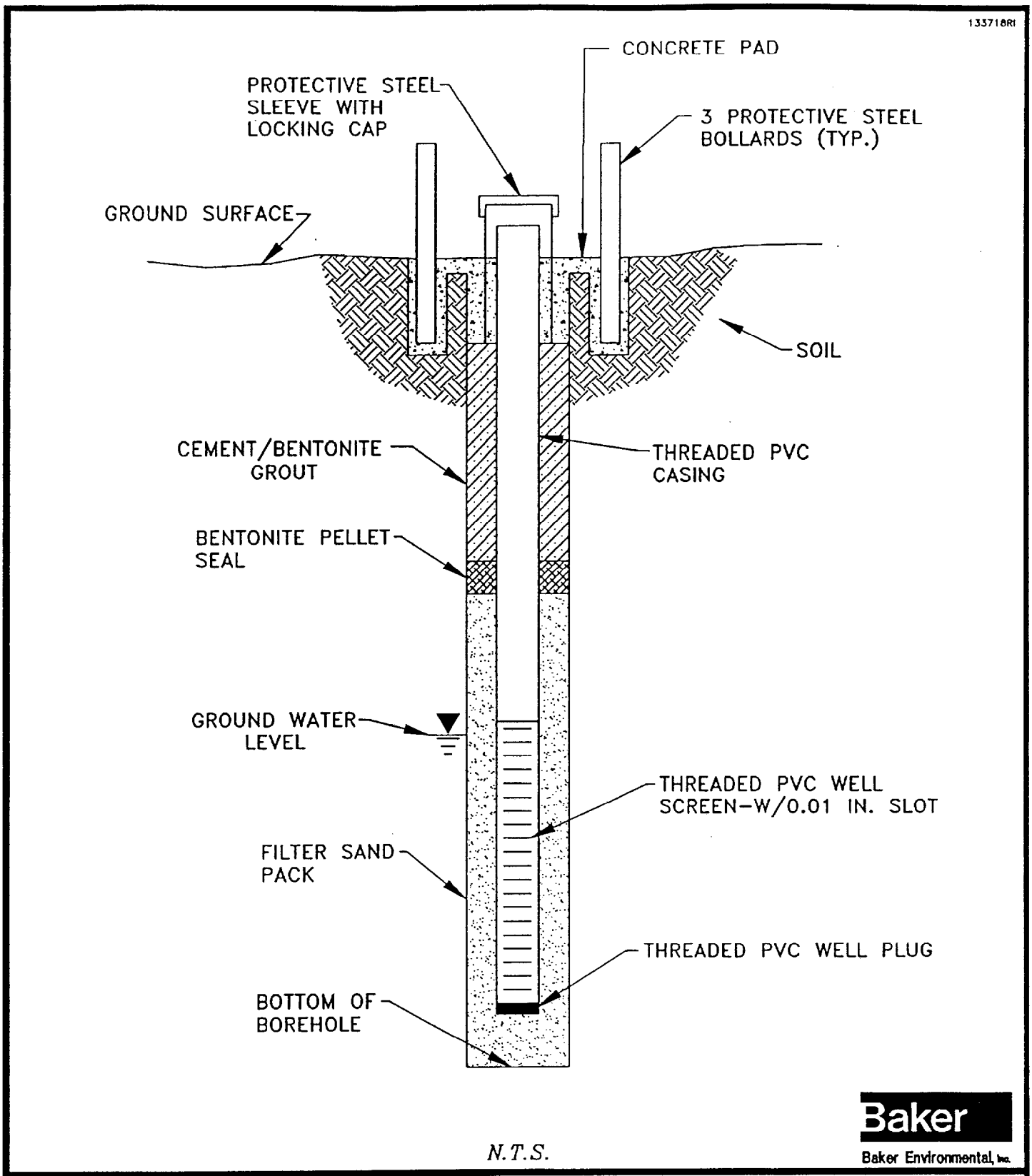


FIGURE 2-4
TYPICAL SHALLOW ABOVE GRADE TYPE II GROUNDWATER MONITORING WELL CONSTRUCTION DIAGRAM

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

2.5.3 Water Level Measurements and Surveying

Static water level measurements were collected on three different dates (September 30, October 8, and October 26, 1993) from top-of-casing (TOC) reference points at each well. Water level data was used to evaluate groundwater flow patterns at the site and potential tidal influences. Measurements were recorded using an electric measuring tape to the nearest 0.01-foot from TOC. Water level data was collected at the site within a one hour period. Additionally, the water level was monitored at Well 48GW2 over a 22-hour period (data logger did not record water levels for full 24 hours) with a data logger to evaluate tidal influences on the shallow groundwater at the site.

All newly installed monitoring wells were surveyed to establish vertical elevation in relationship to mean sea level (msl) and horizontal control. The firm of Hoggard-Eure was retained for the survey. Vertical accuracy of each well (established to TOC at each well) was measured to 0.01 feet and horizontal accuracy within 0.1 foot. Control was established by using horizontal and vertical control points near the site which are tied into the North Carolina State Plane Coordinate System (NCSPCS). In cases where the points could not be established, temporary benchmarks were established from the closest United States Geological Survey (USGS) benchmark.

2.5.4 Groundwater Sampling

2.5.4.1 Sampling Procedures

Groundwater samples were collected from the five newly installed monitoring wells on October 8 and 9, 1992. The samples were collected to confirm the presence or absence of contaminants of concern (primarily mercury) and evaluate overall groundwater chemistry. Groundwater sampling procedures were performed in accordance with EPA Region IV SOPs.

Prior to groundwater purging, water levels from each well were measured according to procedures outlined in Section 2.5.3. The total well depth was also recorded from each well to the nearest 0.1-foot using a steel tape. Water level and well depth measurements were used to calculate the volume of water in each well and the minimum volume of water necessary to purge the well.

Following well volume calculations, a minimum of three to five well volumes were purged from each well prior to sampling. Water was purged from each well using a decontaminated submersible pump and teflon hoses. A constant flow rate of 1 to 2 gallons per minute (GPM) was maintained during purging. Purge water was containerized and handled as described in the Section 2.9. Measurements of pH, specific conductance, and temperature were made prior to purging and after each well volume was removed to ensure the groundwater stabilized before sampling. These measurements were recorded in a field log book.

Groundwater samples were collected using decontaminated teflon bailers equipped with a teflon-coated leader. The samples were introduced into laboratory-prepared, preserved sample containers and stored on ice. Samples bottles for the volatile organic analysis were filled first, followed by semivolatiles, PCBs, pesticides, TAL metals (total and dissolved), and cyanides. Samples analyzed for volatiles were collected by slowly pouring water from the bailer into the appropriate container to minimize volatilization. Samples analyzed for dissolved metals were collected in laboratory-prepared bottles and filtered prior to placement in preserved bottles. The samples were filtered in the field through a disposable 0.45 micron membrane. A peristaltic pump was used for the filtering procedure.

Preparation of groundwater samples incorporated similar procedures to those described for the other samples. Sample collection information including well number, sample identification, time, date, samplers, analytical parameters, and required laboratory turnaround time were recorded in the field logbook and on the sample labels. Chain-of-custody documentation accompanied the samples to the laboratory.

2.5.4.2 Analytical Requirements

Groundwater samples were obtained from the five monitoring wells for analysis of TCL organics and TAL inorganics (total and dissolved metals, cyanide). EPA Methods 601 and 602 were implemented for analysis of volatiles. Additionally, a groundwater sample was collected from monitoring well 48GW3 for analysis of biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), and total volatile solids (TVS) to evaluate the general groundwater chemistry for potential treatment options.

2.6 Surface Water and Sediment Investigations

Surface water and sediment investigations were conducted on the New River and the intermittent tributary which discharges into the New River to assess human health and ecological impacts associated with these waters. The environmental sampling program developed for Site 48 was intended to identify contaminants of concern (i.e., possibly mercury and other contaminants) and evaluate their distribution at the site. A summary of the surface water/sediment sampling program at Site 48 describing the sample locations, sample designations, and analytical methods is provided on Table 2-6.

Several types of field QA/QC samples were collected and analyzed including duplicate samples, equipment rinsates, field blanks, and trip blanks. Table 2-7 summarizes field QA/QC sample types, frequencies, and analytical methods.

In general, the field procedures and sampling methods employed for this study were implemented in accordance with EPA Region IV SOPs. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in the Final RI/FS Work Plan for Site 48.

The following sections outline the sampling locations, procedures, and analytical requirements for both surface water and sediment investigations.

2.6.1 Surface Water

2.6.1.1 Sample Locations

Ten surface water samples were collected at Site 48; five of the stations were located in the New River, three of the stations were located in the intermittent tributary, and two of the stations were located in the marsh area. All the water samples were collected from areas less than three feet in depth. The sampling locations are shown on Figure 2-5. Surface water samples were collected at Site 48 on August 30 and September 2, 1992. There was minimal, if any, precipitation at least 10 days prior to the beginning of the sampling events, and there was no precipitation during the sampling events.

TABLE 2-6

SUMMARY OF SURFACE WATER/SEDIMENT SAMPLING PROGRAM
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Activity	Sample Location	Sample Station	Number of Samples	Analytical Parameters
Surface Water	**Intermittent Tributary**			
	Upgradient of Site	48-IT1-SW	1	TAL Inorganics (1)
	Adjacent to Site	48-IT2-SW	1	TAL Inorganics
	Adjacent to Site	48-IT3-SW	1	TAL Inorganics
	New River			
	Adjacent to Site	48-NR4-SW	1	TCL Organics (2)/TAL Inorganics
	Adjacent to Site	48-NR5-SW	1	TCL Organics/TAL Inorganics
	Downstream of Site	48-NR6-SW	1	TAL Inorganics
	Upstream of Site	48-NR9-SW	1	TCL Organics/TAL Inorganics
	Offshore from Site	48-NR10-SW	1	TAL Inorganics
	Marsh Area		1	
	Upstream of Site	48-MA7-SW	1	TAL Inorganics
	Upstream of Site	48-MA8-SW	1	TAL Inorganics
Sediment (3)	**Intermittent Tributary**			
	Upgradient of Site	48-IT1-SW	2	TAL Inorganics
	Adjacent to Site	48-IT2-SW	2	TAL Inorganics
	Adjacent to Site	48-IT3-SW	2	TAL Inorganics
	New River			
	Adjacent to Study Area Site	48-NR-SD1	2	TAL Inorganics
	Adjacent to Study Area Site	48-NR-SD2	2	TAL Inorganics
	Adjacent to Study Area Site	48-NR-SD3	2	TAL Inorganics
	Adjacent to Study Area Site	48-NR-SD4	2	TAL Inorganics
	Adjacent to Study Area Site	48-NR-SD5	2	TAL Inorganics
	Adjacent to Study Area Site	48-NR-SD6	1	TAL Inorganics
	Adjacent to Study Area Site	48-NR-SD7	2	TAL Inorganics

Notes: (1) Target Analyte List (TAL) inorganics (total metals and cyanide) analyzed by Contract Laboratory Program (CLP) Protocols.

(2) Target Compound List (TCL) organics (volatiles, semivolatiles, PCBs, and pesticides) analyzed by CLP Protocols.

(3) Two samples were collected from each station (0-6 inches and 6-12 inches) with the exception of Station 48-NR6-SD.

(4) The two sample stations that were selected to represent the marsh area were chosen to access sediment quality in the middle portion and upper reaches of the marsh. Sufficient sediment data have been collected near the mouth of the marsh. Note that all sample locations were approved by EPA Region IV (refer to Final RI/FS Work Plan).

TABLE 2-6 (Continued)

SUMMARY OF SURFACE WATER/SEDIMENT SAMPLING PROGRAM
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Activity	Sample Location	Sample Station	Number of Samples	Analytical Parameters
Sediment (Contd.)	**New River** (Contd.)			
	Adjacent to Site	48-NR4-SD	2	TCL Organics/TAL Inorganics
	Adjacent to Site	48-NR5-SD	2	TCL Organics/TAL Inorganics
	Downgradient of Site	48-NR6-SD	2	TAL Inorganics
	Upgradient of Site	48-NR9-SD	2	TCL Organics/TAL Inorganics
	Offshore from Site	48-NR10-SD	2	TAL Inorganics
	Marsh Area (4)			
	Upgradient of Site	48-MA7-SD	2	TAL Inorganics
	Upgradient of Site	48-MA8-SD	2	TAL Inorganics

Notes: (1) Target Analyte List (TAL) inorganics (total metals and cyanide) analyzed by Contract Laboratory Program (CLP) Protocols.

(2) Target Compound List (TCL) organics (volatiles, semivolatiles, PCBs, and pesticides) analyzed by CLP Protocols.

(3) Two samples were collected from each station (0-6 inches and 6-12 inches) with the exception of Station 48-NR6-SD.

(4) The two sample stations that were selected to represent the marsh area were chosen to access sediment quality in the middle portion and upper reaches of the marsh. Sufficient sediment data have been collected near the mouth of the marsh. Note that all sample locations were approved by EPA Region IV (refer to Final RI/FS Work Plan).

TABLE 2-7

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE WATER AND SEDIMENT INVESTIGATION
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Activity	QA/QC Sample (1)	Frequency of Collection	Analytical Parameters (3)
Surface Water	Trip Blanks (2)	One per Cooler	TCL Volatiles
	Field Blanks	One per Event (4)	TCL Organics/TAL Inorganics
	Equipment Rinsates (5)	One per Day	TCL Organics/TAL Inorganics
	Field Duplicates (6)	10% of Sample Frequency	TCL Organics/TAL Inorganics
Sediment	Trip Blanks	One per Cooler	TCL Volatiles
	Field Blanks	One Per Event	TCL Organics/TAL Inorganics
	Equipment Rinsates	One per Day	TCL Organics/TAL Inorganics
	Field Duplicates (7)	10% of Sample Frequency	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined on page 2-5 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to procedures outlined on Table 2-6.
(4) An event is defined as one 14 day period.
(5) Equipment rinsates collected from various sampling equipment (e.g., sediment corer).
(6) Field duplicate samples collected from Stations 48-NR5-SW (TCL organics and TAL inorganics) and 48-NR10-SW (TAL inorganics only).
(7) Field duplicate samples collected from Stations 48-NR10-SD (TAL inorganics only) and 48-NR-SD (TCL organics and TAL inorganics).

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48-MA7-SW/SD
48-NR9-SW/SD
48-MA8-SW/SD
HIGH TIDE MARK
LOW TIDE MARK
48-IT3-SW/SD
48NRSD1
48NRSD2
48NRSD3
48-IT2-SW/SD
48-NR4-SW/SD
48NRSD4
48NRSD5
48NRSD6
48NRSD7
NEW RIVER
CURTIS STREET
AS872
10
5
ASPHALT
AS804
ABOVE GROUND TANK
AS805
AS 807
TRANSF PAD-9
LONGSTAFF STREET
PARKING LOT
5
48-NR5-SW/SD
48-NR10-SW/SD
APPROXIMATE SITE BOUNDARY
10
AS811
48-NR6-SW/SD
48-IT1-SW/SD
AS810

Baker
Baker Environmental, Inc.

LEGEND

SEDIMENT SAMPLING STATION

SURFACE WATER/SEDIMENT SAMPLING LOCATION

SOURCE: LANTDIV, FEB. 1992

120 0 60 120 240

1 inch = 120 ft.

FIGURE 2-5
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

00187W06Z

2.6.1.2 Sampling Procedures

At each station, water samples were collected from the approximate mid-vertical depth point by dipping the sample bottles directly into the water. The designated depth was determined by slowly lowering a weighted line into the water and recording the depth to the sediments. Samples were not collected at the sediment/water interface (as stated in the Final RI/FS Work Plan), because the water was less than three feet deep at all the stations.

Care was taken when collecting samples for analysis of volatile organics compounds (VOCs) to avoid excessive agitation that could result in loss of VOCs. In addition, samples for the VOC analysis were collected prior to collecting samples for analysis of the other parameters.

The samples were collected in clean containers provided by the laboratory. Sampling personnel wore clean PVC gloves at each sampling station. For those sample bottles already containing preservative (e.g., sulfuric acid), the surface water first was collected in a clean glass container, and then slowly poured into the sample bottle. All sample containers not containing preservative were rinsed at least once with the surface water prior to final sample collection.

The downstream water samples were collected first, with subsequent samples taken while moving upstream. Any sediment or biological samples were collected after the water samples to minimize sediment resuspension that might contaminate the water samples.

The sampling locations were marked by placing a wooden stake and bright colored flagging at the nearest bank or shore. The sample number was marked on the stake with indelible ink. Photographs were taken to document the physical and biological characteristics of the sampling location.

2.6.1.3 Analytical Requirements

Five surface water samples were collected in the New River. All five samples were analyzed for TAL inorganics and three samples were analyzed for TCL organics. Three surface water samples were obtained in the intermittent tributary that drains into the New River. All three samples were analyzed for TAL inorganics. Two surface water samples, were collected in the marsh area north of the site that drains into the New River. All two samples were analyzed for TAL inorganics. Table 2-6 summarizes the analytical parameters.

2.6.2 Sediments

2.6.2.1 Sample Locations

Thirty-five (35) sediment samples were collected at Site 48; 23 of the samples were located in the New River, six of the stations were located in the intermittent tributary and four of the stations were located in the marsh area (Figure 2-5). Table 2-6 provides a summary of the sample locations, sample designations, and analytical methods for the sediment samples.

2.6.2.2 Sampling Procedures

At each station, sediment samples were collected at the surface (0-6 inches), and at depth (6-12 inches) using a decontaminated stainless-steel hand-held coring instrument. A disposable clear plastic liner tube, fitted with an eggshell catcher to prevent sample loss, was used at each station.

The coring device was pushed into the sediments to a minimum depth of fifteen inches, or until refusal. The liner was removed from the sampler and the sediments were extruded into the appropriate sample jars using a decontaminated extruder.

At some stations, the sediments were too wet to remain in the liner when the corer was removed from the water. Therefore, at those stations, the top six inches of sediment were collected using a decontaminated stainless steel spoon. Sediment from six to twelve inches were not collected at these stations.

In addition, at some stations the corer was pushed more than 12 inches into the sediments, however, less than twelve inches of sediments remained in the liner when it was removed from the water and there appeared to be some mixing of the sediments in the liner. Therefore, it was unknown which portion of the sediments were from the top six inches and which portion were from 6 to 12 inches. The sediments at these stations were separated into the appropriate jars using best professional judgment. Notations were recorded in the field log book when this occurred.

2.6.2.3 Analytical Requirements

Twenty-three samples were collected from the sediments of the New River. Six of the samples were analyzed for TAL inorganics and TCL organics. The 17 remaining samples were analyzed only for TAL inorganics. Six sediment samples were collected and analyzed for TAL inorganics in the intermittent tributary and four sediment samples were collected and analyzed for TAL inorganics from the marsh area.

2.7 Aquatic and Ecological Survey

The ecological investigation at Site 48 was conducted from August 30 through September 13, 1993 to determine if contamination attributed to Site 48 adversely impacts the ecological integrity of the New River or tributaries draining directly to the New River. The investigation included the collection of fish and benthic macroinvertebrates for population statistics and fish and shellfish for "body burden" analysis. The following sections summarize the results of this investigation. A summary of the Aquatic and Ecologic Sampling Program is shown on Table 2-8.

Biological samples collected at the stations consisted of fish and benthic macroinvertebrates (benthics) including shellfish. The sampling locations are shown on Figure 2-6. Prior to initiating the sampling event, the following information describing the area was recorded in the field log book at each station:

- Average width, depth and velocity of the water body
- Description of substrate
- Descriptions of "abiotic" characteristics of the reach such as pools, riffles, runs, channel shape, degree of bank erosion, and shade/sun exposure
- Description of "biotic" characteristics of the reach including aquatic and riparian vegetation and wetlands

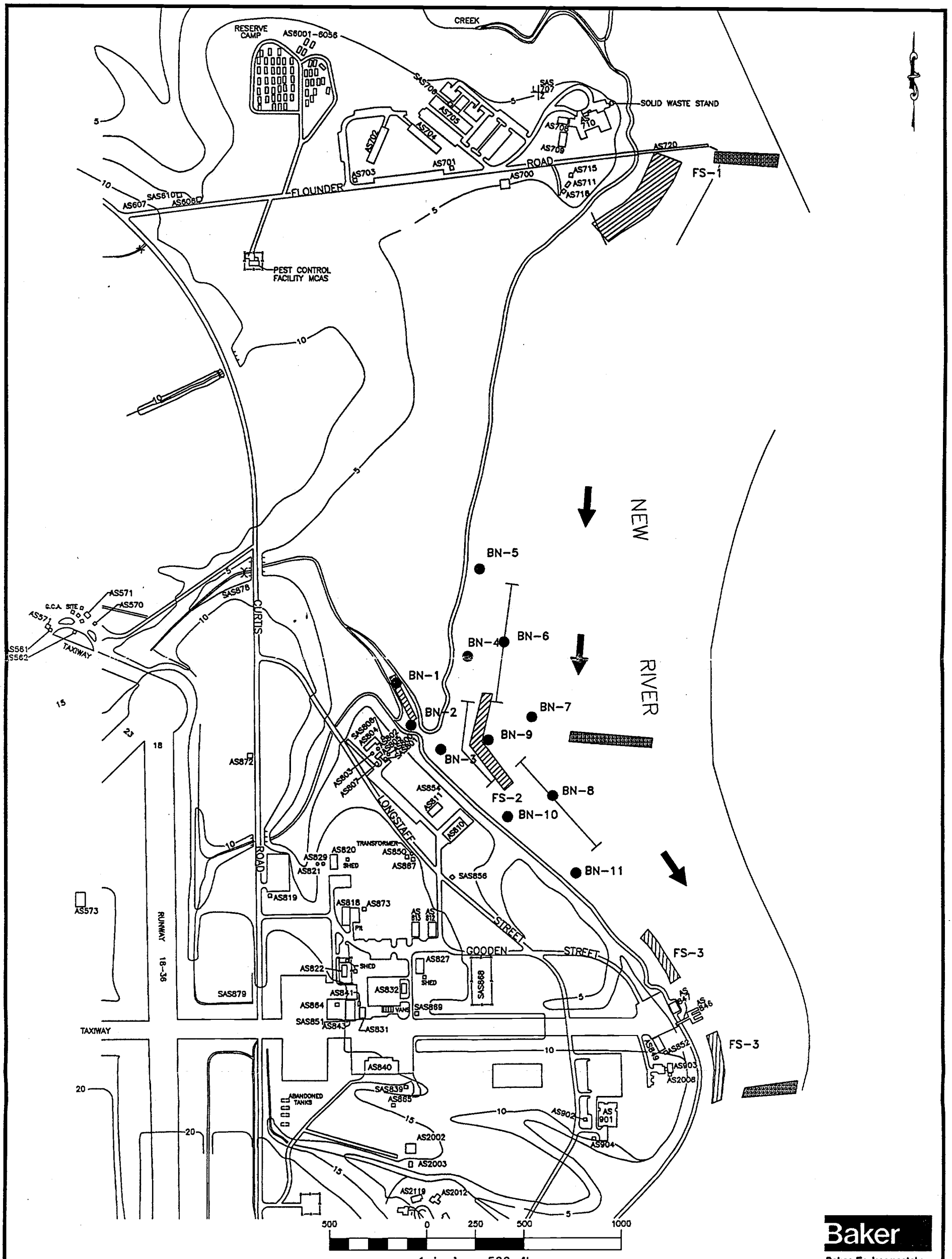
The on-site water quality measurements consisted of temperature, pH, specific conductance, salinity and dissolved oxygen. These measurements were collected immediately following sample collection. Water quality measurements were not collected at a few of the biological

TABLE 2-8

SUMMARY OF AQUATIC AND ECOLOGICAL SURVEY SAMPLING PROGRAM
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sampling Location	Sample Designation	Sample Type
New River - Upstream	48-NR1-FS	Fish
Marsh Area	48-NR1-BN 48-NR2-BN	Benthic Macroinvertebrates Benthic Macroinvertebrates
New River - Near Site	48-NR2-FS 48-NR3-NR11-BN Not Applicable (1)	Fish Benthic Macroinvertebrates Shellfish
New River - Downstream	48-NR3-FS	Fish

Notes: (1) Several attempts were made to collect shellfish, however, none were collected.



LEGEND

- ELECTROSHOCKING FISH COLLECTION AREA
- FISH COLLECTION AREA-GILL NETS
- BENTHIC COLLECTION STATION
- ATTEMPTED SHELLFISH COLLECTION AREAS
- SURFACE WATER FLOW DIRECTION

SOURCE: LANTDIV, OCT. 1991

FIGURE 2-6
BENTHIC AND FISH
SAMPLING LOCATIONS

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

00187W072

sampling stations because of their close proximity to other stations where measurements were recorded. The pH meters at the site were not working properly, therefore, pH in the water was measured using pH paper.

2.7.1 Benthic Macroinvertebrates

Benthics are defined as organisms that are large enough to be seen by the unaided eye, and are retained by a U.S. Standard No. 30 sieve (28 meshes per inch, 0.595 mm openings). They live at least part of their life cycles within or upon available substrates in a body of water or water transport systems (USEPA, 1990). Benthics were chosen as target organisms in the Ecological Risk Assessment (ERA) for the reasons discussed in the following paragraphs.

Benthics are important organisms in the trophic food web. They are a primary food source for many fish species, and some terrestrial and bird species. Therefore, a decrease in numbers of benthics could lead to decreased populations of fish and other species. Also, constituents that tend to bioaccumulate in organisms, could be biomagnified in species that ingest benthics.

2.7.1.1 Station Locations

Eleven benthic samples were collected at Site 48 as shown on Figure 2-6. Two of the samples were collected in the marsh area while nine were collected in the New River. Three replicates were collected at each station for a total of 33 benthic samples.

2.7.1.2 Sampling Procedures

Benthics were collected using a standard Ponar grab. The sampling area of the Ponar is 23 x 23 cm (9 x 9 inches) for an area of 529 cm^2 or 0.0529 m^2 (81 $inches^2$). Three replicate grabs were collected at each location. The position of the boat was different for each replicate to prevent the Ponar from resampling the same area.

After retrieving the Ponar with a sediment sample, it was opened into a clean tub and the sediments were removed with a decontaminated teflon spatula. The sediments were transferred to a 0.5 mm pore size sieve which was agitated in a tub half-full of water to remove the small particles. The remaining contents in the sieve were transferred into 16-ounce plastic sample jars. No more than half the jar was filled with sediments, while buffered formalin solution (10 percent by weight) was added to the remainder of the jar to preserve the

benthics contained in the sediments. A 100 percent cotton paper label, marked in pencil with the sample number, was placed inside the jar. The outside of jar was labeled with the sample number using a black permanent marker to identify the sample containers.

After all the sediment sampling was completed, the sample jars were transported to the laboratory for processing. The processing included washing each sample through a 0.5 mm sieve; transferring the washed sample back into the jar; and adding 70 percent isopropyl alcohol, as a preservative, to the washed sample in the jar. A small amount of rose bengal was added to each jar, using the end of a paper clip, to stain the benthics a pink-red color to aid in the sorting process. The rose bengal stains the tissue cells of the organisms, which helped to distinguish them from plant and other materials in the sediments.

After the benthics were stained for at least 24 hours, a half-teaspoon of the prepared sediment sample was placed onto a clear petri dish to begin the sorting process. The dish was then placed under a dissecting microscope and the benthics were removed from the sediments using a pair of forceps and placed into glass vials containing 70 percent isopropyl alcohol. After all the benthics in a given sample were sorted, a 100 percent cotton paper label marked in pencil with the sample number was placed inside each vial.

The vials were sealed with cotton, and placed into a jar containing 70 percent isopropyl alcohol. The date, sorting time, approximate number of benthics collected and the name of the person who sorted the sample, were recorded on a log sheet.

The samples then went through through QA/QC. A second environmental scientist followed the same procedures outlined above for sorting the samples as a QA/QC measure. Any additional species identified during QA/QC were placed into their respective containers. The number of additional benthics collected was recorded. In most cases, 100 percent of the sample was resorted. However, less than 100 percent of the sample was sorted when zero benthics were collected in more than half the sample.

The date, sorting time, number and type of additional organism found and percent of sample that underwent QA/QC were recorded on a log sheet. The vials containing the benthics were then sent to a laboratory for taxonomic identification.

2.7.2 Fish Survey

Fish were collected at Site 48 for use in the ERA. The ERA Report contains a detailed discussion of the fish sampling program.

Fish are integrators of community response to aquatic environmental quality conditions; they are the end products of most aquatic food webs, thus the total biomass of fishes is highly dependent on the gross primary and secondary productivity of lower organism groups (including benthic macroinvertebrates). In addition, fish constitute a conspicuous part of the aquatic biota and are recognized by the public for their sport, commercial and endangered status. They also represent the end product of protection for most water pollution abatement programs. Fish have a relatively high sensitivity to a variety of substances and physical conditions. Both acute toxicity (missing taxa) and stress effects (depressed growth and reproductive success) can be evaluated. Finally, fish have a high capacity for bioaccumulating large amounts of chemicals (i.e., mercury) which can be measured.

2.7.2.1 Station Locations

Fish were collected from three stations at Site 48 using a haul seine and gill nets. One station was located adjacent to the site, while the other two stations were located upstream and downstream of the site (Figure 2-6). The stations from upstream to downstream were designated as 48-NR1-FS, 48-NR2-FS, and 48-NR3-FS, respectively.

Fish were not collected from the proposed station in the unnamed tributary because the water was too shallow. However, a gill net was placed in front of the tributary and the fish captured in that net were combined with the fish collected at Station 48-NR2-FS.

2.7.2.2 Sampling Procedures

Fish were collected at the stations using gill nets and a haul seine. The gill nets were six feet deep by 50 feet long with 2-inch square mesh. The approximate twine break strength was 29 pounds and lead weights were tied along the bottom of the nets. The haul seine was six feet deep by 150 feet long with half-inch square mesh with 6- x 6- x 6-foot bag in the middle of the seine. The seine was treated with Netcoat to increase collection efficiency and the approximate twine break strength was 126 pounds. Lead weights were tied along the bottom of the seine while floats were attached along the top of the seine.

At each station, a minimum of two haul seines were conducted. The haul seine was deployed with one person securing the seine on the shore and another person walking out in a loop. The bottom of the net was kept in contact with sediment to prevent fish from swimming under the net. Other field personnel aided in removing snags from the net and keeping fish from jumping over the net.

When the person deploying the net arrived back at shore, the net was pulled in, making sure the bottom of the net remained in the sediment. When the bag in the middle of the seine reached the shore, the bag was lifted and the fish were carefully transferred into plastic tubs filled with water. Aerators were placed into the tubs, and water in the tubs was replaced periodically to minimize the mortality rate.

Fish also were collected using gill nets which were deployed approximately at the locations shown on Figure 2-6. Weights were attached to the nets to secure them on the bottom of the river. In addition, yellow buoys marked with "Baker Environmental" were attached to the nets. The nets were deployed either in the evening or the morning. They were checked for fish within twelve hours after being deployed.

The collected fish were separated into different species, and then measured and counted. The small fish (less than 20 mm) were weighed in groups of 10 or 20 because of their size. After four or five group were weighed, the remaining fish in that species were only counted (not weighed or measured). The larger fish were weighed individually. Because no shellfish were collected (discussed below), blue crabs that were captured in the nets were sent to the laboratory for chemical analysis. The proportion of individuals as hybrids and the proportion of individuals with disease, tumors, fin damage, and skeletal anomalies was recorded. Table 2-9 summarizes the number of haul seines and gill nets collected at each station.

Most of the the fish species were processed in the field and returned to the stream alive. Some specimens that presented taxonomic difficulties were preserved in 10 percent formalin, and transported to the Baker Ecological Services Laboratory for taxonomic work.

At a minimum, one representative fish from each species was preserved in 10 percent formalin as a voucher specimen. The station location, date sampled, and species name was recorded on the label.

TABLE 2-9

SUMMARY OF GILL NETS AND HAUL SEINES COLLECTED
SITE 48 AND WHITE OAK RIVER
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Date	No. of Gill Nets Collected	No. of Haul Seines Pulled
NR1	09/01/92	1	2
	09/02/92	2	
	09/13/92		1
NR2	08/30/92		1
	08/31/92		1
	09/01/92	1	2
	09/02/92	2	
	09/11/92		1
NR3	09/01/92		2
	09/02/92	2	
	09/11/92		2
	09/13/92		1
WO1	09/15/92	0	1
WO2	09/15/92	0	1

Three different species were collected at each station for the whole-body analysis. An attempt was made to collect ten individuals from three different species for the tissue analysis, however this was not possible at all the stations. Approximately 200-400 grams of the smaller fish were placed into clean zip-loc bags and stored on ice for whole-body analysis. The larger fish were placed into clean zip-loc or plastic garbage bags and stored on ice for tissue analysis. The blue crabs were placed into clean zip-loc bags and stored on ice for whole-body analysis. The bags were labeled with the date and station location.

A minimum of ten fish, where available, from each species were composited and analyzed for whole body burdens of chemicals. In addition, filets of at least ten fish, where available, from each species were analyzed for chemical constituents. The fish were frozen prior to being shipped to Ceimic, Inc. for chemical analysis.

2.7.3 Shellfish

The following sections discuss the sample locations and sampling procedures for the collection of shellfish.

2.7.3.1 Station Locations

The proposed shellfish sampling stations are shown on Figure 2-6. Several attempts were made to collect shellfish at the proposed shellfish sampling station adjacent to Site 48, however, no shellfish were collected after several attempts. Therefore, attempts were not made to collect shellfish at the other stations.

2.7.3.2 Sampling Procedures

The shellfish "attempts" were conducted from a boat using a bottom, scrape type, dredge. The overall frame dimension of the dredge is 18" x 18" x 10" high, and includes a 35" long nylon net (Mesh No. 1) and protective net shroud (Nylon sail cloth).

The dredge was slowly dragged along the bottom of the station, maintaining approximately a 15:1 ratio of rope length to depth of water until the desired distance was sampled. The dredge was slowly raised out of the water and emptied into a clean plastic tub. After several sampling attempts did not yield any shellfish, the field team leader decided that no more attempts should be made.

2.7.4 Aquatic and Ecologic Sampling Reference Location

The White Oak watershed is slightly smaller than the New River watershed. It begins in the Hoffman Forest and flows approximately 48 miles and empties into the Atlantic Ocean. Approximately 77 percent of the watershed is within the Hoffman Forest and the Croatan National Forest. This watershed has very little development, with Swansboro being the largest town. Because there is little development in this watershed, it was chosen as a reference station.

2.7.4.1 Station Location

Fish were collected from two stations in the White Oak River (WO1-FS and WO2-FS), while benthics only were collected at Station WO2-FS. WO1-FS was located near Pettiford Creek, while WO2 was located upstream of Swansboro, near Hadnot Creek. Although the salinity at WO1 was about 26 ppt (compared to 5 ppt to 15 ppt at Site 48), fish were collected at this location as a second comparison station because they are mobile and probably move into lower salinity waters. Benthic macroinvertebrates, however, were not collected at this station since they are not very mobile, and they would not be comparable to the benthics collected at Site 48.

The water salinity was measured every half-mile from Station WO2-FS to Station WO2-FS. The salinity appeared to level off at 15 ppt (slightly higher than Site 48), therefore fish and benthics were collected from this station.

2.7.4.2 Sampling Procedures

Fish and benthic macroinvertebrates for population statistics were collected at this station. Fish were not collected at these stations for tissue analysis. In addition, no surface water or sediment samples were collected at these stations.

2.8 Decontamination Procedures

Decontamination procedures performed in the field were initiated in accordance with EPA Region IV guidelines. In general, sampling and drilling equipment were divided into two decontamination groups: heavy equipment and routine sample collection equipment. Heavy

equipment included: the drill rig, hollow-stem augers, and drill rods; routine sample collection equipment included: split-spoons, stainless-steel spoons, bailers, bailer wire, and sediment corer.

For heavy equipment, the following procedures were implemented:

- Removal of caked-on soil with brush;
- Steam clean with high-pressure steam; and
- Air dry

For routine sample collection equipment, the following procedures were implemented:

- Clean with potable water and laboratory phosphate-free detergent (Alconox soap solution);
- Rinse thoroughly with potable water;
- Rinse thoroughly with deionized water;
- Rinse twice with 10 percent nitric acid;
- Rinse thoroughly with deionized water;
- Rinse twice with pesticide-grade isopropanol alcohol;
- Air dry; and
- Wrap in aluminum foil

Temporary decontamination pads, constructed of wood and plastic, were constructed for both procedures to minimize spillage onto the ground surface. Decontamination fluids generated during the field program were containerized and handled according to the procedures outlined in Section 2.9.

2.9 Investigative Derived Waste (IDW) Handling

A large volume of solids (approximately 10 cubic yards) and liquids (approximately 2,000 gallons) were generated during the field program at Site 48. Solids included soil cuttings and excess split-spoon samples; liquids included well development and purge water, and decontamination fluids (i.e., water, Alconox soap solution, isopropanol alcohol, and 10 percent nitric acid).

Containerization and handling of solids were performed in two phases. At the completion of drilling activities, soils were temporarily stockpiled on plastics sheeting and covered. Afterwards, the soils were transported and emptied into a roll-off box for final containerization. Composite samples were then collected from the roll-off box for disposal purposes. The analyses performed were full TCLP and RCRA hazardous waste characteristics.

Liquid generated the field program were also containerized and handled in two phases. Liquids were initially contained in 55-gallon steel drums, then pumped into a tanker for final containerization. Decontamination fluids, however, remained in drums because of the isopropanol alcohol and nitric acid content. Samples of the generated fluids were also collected and analyzed for disposal purposes. These analyses included TCL volatiles and TAL metals (total only). The IDW characterization results and recommended disposal options are provided in Appendix F. These options were implemented at MCB Camp Lejeune the week of February 21, 1993.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section contains a discussion of the physical characteristics of Site 48 including: surface features, meteorology, hydrology, geology, soils, hydrogeology, land use, ecology, and supply well inventories. This information was obtained from the RI field activities and available literature pertaining to MCB Camp Lejeune.

3.1 Surface Features

The topography of MCB Camp Lejeune is relatively flat with ground surface elevations ranging from mean sea level (msl) to 72 feet above msl. Most of MCB Camp Lejeune lies between 20 and 40 feet msl. The terrain of Camp Lejeune is typical of North Carolina coastal plains. Drainage at Camp Lejeune is generally to the New River and the Atlantic Ocean via the Intracoastal Waterway.

Site 48 is a predominantly flat area at approximately 5 feet above msl. The site elevations drop off sharply at the bank of the New River east of the site and at the intermittent tributary north of the site. The terrain of the area around Site 48 indicates that drainage would be toward the New River.

3.2 Meteorology

MCB Camp Lejeune is located within the Coastal Plain physiographic division of North Carolina. Coastal Plain elevations range from 200 feet above msl at the western boundary to generally 30 feet or less in areas of tidal influence to the east. The tidal portion of the Coastal Plain, where Camp Lejeune is situated, is generally flat and swampy.

Although coastal North Carolina lacks distinct wet and dry seasons, there is some seasonal variation in average precipitation. July tends to have larger amounts of precipitation and rainfall amounts during summer are generally the greatest. Daily showers during the summer are not uncommon, nor are periods of one or two weeks without rain. Convective showers and thunderstorms contribute to the variability of precipitation during the summer months. October tends to be the driest month. The least amount of precipitation, on average, occurs during the fall. Throughout the winter and spring months precipitation occurs primarily in the form of migratory low pressure storms. Camp Lejeune's average yearly rainfall is approximately 52 inches.

Coastal Plain temperatures are moderated by the proximity of the Atlantic Ocean. The ocean effectively reduces the average daily fluctuation of temperature. Lying 50 miles offshore at its nearest point, the Gulf Stream tends to have little direct effect on coastal temperatures. The southern reaches of the cold Labrador Current offsets any warming effect the Gulf Stream might provide.

Camp Lejeune experiences hot and humid summers, however, ocean breezes frequently produce a cooling effect. The winter months tend to be mild, with occasional brief cold spells. Average daily temperatures range from 58° F to 38° F in January and 86° F to 72° F in July. The average relative humidity, between 75 and 80 percent, does not vary greatly from season to season. Observed percentages of relative humidity range from 100 down to 10 or lower.

Observations of sky conditions indicate yearly averages of approximately 112 days clear, 105 partly cloudy, and 148 cloudy. Measurable amounts of rainfall occurs 120 days per year, on the average. Prevailing winds are generally from the south-southwest 10 months of the year, and from the north-northwest during September and October. The average wind speed for coastal observation points in North Carolina is 12 m.p.h.

3.3 Surface Water Hydrology

The terrain of MCB Camp Lejeune is generally a flat plain that gently slopes toward the New River or the Atlantic Ocean via the Intercoastal Waterway. Numerous creeks and streams act as tributaries conveying surface water runoff into the New River.

Site 48 lies on the west bank of the New River. It is approximately 17 miles north of the New River's outlet into the Atlantic Ocean. A marsh area exists north of Site 48 and drains into the New River. Marshy areas also exist along the northwestern, northern, and eastern boundaries of the site where the surface waters cut through the land. Surface water runoff at Site 48 tends to drain to the New River and to an intermittent tributary that borders the site on the north. The intermittent tributary also flows into the New River. Some surface water runoff is collected in the storm water sewers located along Longstaff Road and Curtis Street.

The 100-year flood elevation for this area of MCB Camp Lejeune is three feet above msl. Site 48 lies between elevations 5 and 10 above msl, therefore, all of Site 48 is above the 100-year flood plain.

The surface waters surrounding Site 48 are tidally influenced. The distribution of contaminants in the surface waters may vary depending on the tides, and precipitation events. Concentrations of contaminants in the surface water are expected to decrease with higher tides and precipitation events because of the decreased dilution. High tide and low tide data was obtained from the National Oceanic and Atmospheric Administration (NOAA) for the New River at Jacksonville, North Carolina. The tide at Jacksonville was obtained by applying a correction factor to data collected from a NOAA tide station in Hampton Roads, Virginia. Table 3-1 contains the low tide and high tide feet and time from August 1 through September 18, 1992. During the surface water sampling activities (August 30 and September 2, 1992) at Site 48, the average high tide was 1.60 mean lower level water (MLLW) and the average low tide was 0.95 MLLW.

North Carolina classifies water bodies in the state according to its designated use. The New River, adjacent to and downstream of Site 48 is designated as Class SC which are saltwaters protected for secondary recreation, fishing and aquatic life including propagation and survival; all saltwaters are classified to protect these uses at a minimum (N.C. DEHNR 1992). This section of the New River also is classified as a Nutrient Sensitive Water which are waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs (N.C. DEHNR, 1992).

Upstream of Site 48, the New River, north of a line beginning at a point on Mumford Point 34° 43' 15" - 77° 25' 00" W; running 2710(M) through Beacon No. 53 to a point on the west shore 34° 43' 14" N - 77° 25' 49" W is designated as Class SC, High Quality Water (HWQ) (N.C. DEHNR 1992, N.C. MFC 1992). HQW are waters that are rated as excellent based on biological and physical/chemical characteristics through division monitoring or special studies, native and special trout waters (and their tributaries) designated by the Wildlife Resources Commission, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Wildlife Resources Commission, critical habitat designated by the Wildlife Resources Commission or the Department of Agriculture, all water supply watersheds which are classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II have been received from the appropriate local government and accepted by the Division of Environmental Management and all Class SA waters (N.C. DEHNR, 1992). This section of the New River is classified as a primary nursery area, but it is not a water supply.

TABLE 3-1

TIDE DATA FOR THE NEW RIVER IN JACKSONVILLE, NORTH CAROLINA
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Date	High Tide		Low Tide	
	Time	Height (feet)	Time	Height (feet)
08/01/92	13.1	1.74	7.9	0.88
	25.5	1.62	20.3	0.92
08/02/92	14.1	1.62	8.8	0.84
	26.5	1.55	21.2	0.90
08/03/92	NA(1)	NA	9.5	0.93
	15.0	1.64	22.2	0.92
08/04/92	3.3	1.52	10.1	0.95
	16.5	1.67	22.6	1.05
08/05/92	4.5	1.54	11.4	1.05
	16.9	1.62	24.4	1.02
08/06/92	5.4	1.47	12.4	1.03
	18.1	1.59	25.3	1.04
08/07/92	6.3	1.49	13.3	1.04
	19.0	1.59	26.0	1.08
08/08/92	7.3	1.47	14.4	1.02
	20.1	1.58	NA	NA
08/09/92	8.6	1.44	NA	1.02
	20.8	1.55	3.4	1.03
08/10/92	9.6	1.50	4.1	1.02
	21.8	1.59	16.2	1.01
08/11/92	10.2	1.52	4.9	1.03
	24.3	1.72	16.9	1.02
08/12/92	11.1	1.57	5.7	0.99
	22.8	1.59	17.6	0.96
08/13/92	11.4	1.59	6.1	1.02
	24.4	1.81	18.0	1.06
08/14/92	11.9	1.76	6.4	1.19
	24.4	1.84	19.0	1.21
08/15/92	12.6	1.79	8.0	1.27
	25.0	1.76	19.7	1.20
08/16/92	13.0	1.73	7.7	1.22
	25.4	1.67	19.9	1.16
08/17/92	13.7	1.66	8.2	1.11
	25.9	1.62	20.4	1.14
08/18/92	14.5	1.65	8.6	1.09
	NA	NA	21.4	1.12
08/19/92	2.7	1.55	9.3	1.05
	15.2	1.64	22.2	1.13
08/20/92	3.7	1.54	10.0	1.12
	15.4	1.66	23.3	1.17
08/21/92	4.2	1.55	11.2	1.13
	16.6	1.64	24.2	1.14
08/22/92	5.0	1.51	12.0	1.06
	17.6	1.58	24.9	1.07
08/23/92	6.1	1.48	13.1	1.02
	18.7	1.60	26.0	1.05
08/24/92	7.3	1.52	14.2	1.01
	20.0	1.64	27.1	1.02
08/25/92	8.4	1.56	15.1	0.95
	21.0	1.65	NA	NA
08/26/92	9.2	1.59	4.0	0.95
	21.8	1.71	16.2	0.90
08/27/92	10.3	1.71	5.0	0.97
	22.5	1.74	17.3	0.95
08/28/92	11.2	1.73	6.0	0.95
	24.5	1.64	18.5	0.89
08/29/92	12.5	1.81	6.9	0.97
	24.9	1.74	19.5	0.96
08/30/92	12.9	1.75	7.7	0.96
	25.4	1.57	20.2	0.93
08/31/92	14.1	1.61	8.5	0.84
	26.5	1.56	21.0	0.91
09/01/92	NA	NA	9.2	0.96
	14.8	1.65	21.9	1.00
09/02/92	3.1	1.52	10.4	0.94
	15.6	1.59	22.8	0.98
09/03/92	4.1	1.45	11.0	0.95
	16.7	1.55	24.2	1.02
09/04/92	4.8	1.39	12.0	0.99
	17.7	1.53	24.7	1.02
09/05/92	6.2	1.44	13.2	1.04
	18.8	1.58	25.7	1.15
09/06/92	7.2	1.60	14.1	1.15
	19.9	1.68	26.7	1.23
09/07/92	8.1	1.62	14.9	1.17
	20.4	1.66	NA	NA
09/08/92	8.8	1.55	3.4	1.12
	21.1	1.59	15.7	1.08
09/09/92	9.6	1.55	4.0	1.04
	21.9	1.57	16.5	1.04
09/10/92	10.4	1.54	4.8	0.99
	22.5	1.55	17.2	1.02
09/11/92	10.8	1.66	4.8	1.05
	23.3	1.66	18.1	1.12
09/12/92	11.4	1.71	6.1	1.14
	23.7	1.64	18.5	1.12
09/13/92	12.1	1.69	6.7	1.09
	24.3	1.64	18.9	1.10
09/14/92	12.7	1.70	7.0	1.08
	24.9	1.61	19.8	1.11
09/15/92	13.1	1.69	7.6	1.07
	25.4	1.58	20.2	1.11
09/16/92	13.9	1.62	8.1	1.05
	26.2	1.50	21.0	1.04
09/17/92	NA	NA	9.1	1.00
	14.6	1.57	21.8	1.02
09/18/92	2.9	1.43	9.8	0.96
	15.4	1.56	22.8	1.03

Notes: (1) NA = Not Available
Source: NOAA Tide Station in Hampton Roads, Virginia
All data expressed in mean lower level water (MLLW) above zero reference level.

3.4 Geology

The following sections contain the regional geology of MCB Camp Lejeune and the site-specific geology of Site 48.

3.4.1 Regional Geology

MCB Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The sediments of the Atlantic Coastal Plain consist of interbedded sands, clays, calcareous clays, shell beds, sandstone, and limestone. These sediments are layered in interfingering beds and lenses that gently dip and thicken to the southeast. Regionally, they comprise 10 aquifers and nine confining units which overlie igneous and metamorphic basement rocks of pre-Cretaceous age. These sediments were deposited in marine or near-marine environments and range in age from early Cretaceous to Quatenary time. Table 3-2 presents a generalized stratigraphic column for this area (Harned et al., 1989).

United State Geological Survey (USGS) studies at MCB Camp Lejeune indicate that the Base is underlain by seven sand and limestone aquifers separated by confining units of silt and clay. These include the water table (surficial), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The combined thickness of these sediments is approximately 1,500 feet. Less permeable clay and silt beds function as confining units or semiconfining units which separate the aquifers and impede the flow of groundwater between aquifers. A generalized hydrogeologic cross-section of this area is presented in Figure 3-1. This cross-section illustrates the relationship between the aquifers in this area (Harned et al., 1989).

3.4.2 Site Geology

Ten soil borings were advanced in the surficial soils (depth less than 25 feet bgs.) within the vicinity of Site 48 to collect soil samples for laboratory analysis and classification purposes. In general, the site is underlain by unconsolidated deposits of silty clay, silty sand, and silt with clay and sand being the predominant soils. These soils represent the Quatenary "undifferentiated" formation which characterize the surficial aquifer. The silty clays encountered were generally stiff (based on results of standard penetration tests commonly referred to as "blow counts," ASTM 1586), plastic to slightly plastic, and contained trace to little amounts of silt. Tests performed on the Shelby Tube sample collected within a silty clay

TABLE 3-2

GEOLOGIC AND HYDROGEOLOGIC UNITS IN
THE COASTAL PLAIN OF NORTH CAROLINA
SITE 48
REMEDIAL INVESTIGATION CTO-0133
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 confining unit
		Pungo River Formation(1)	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)
	Paleocene	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: Harned et al., 1989

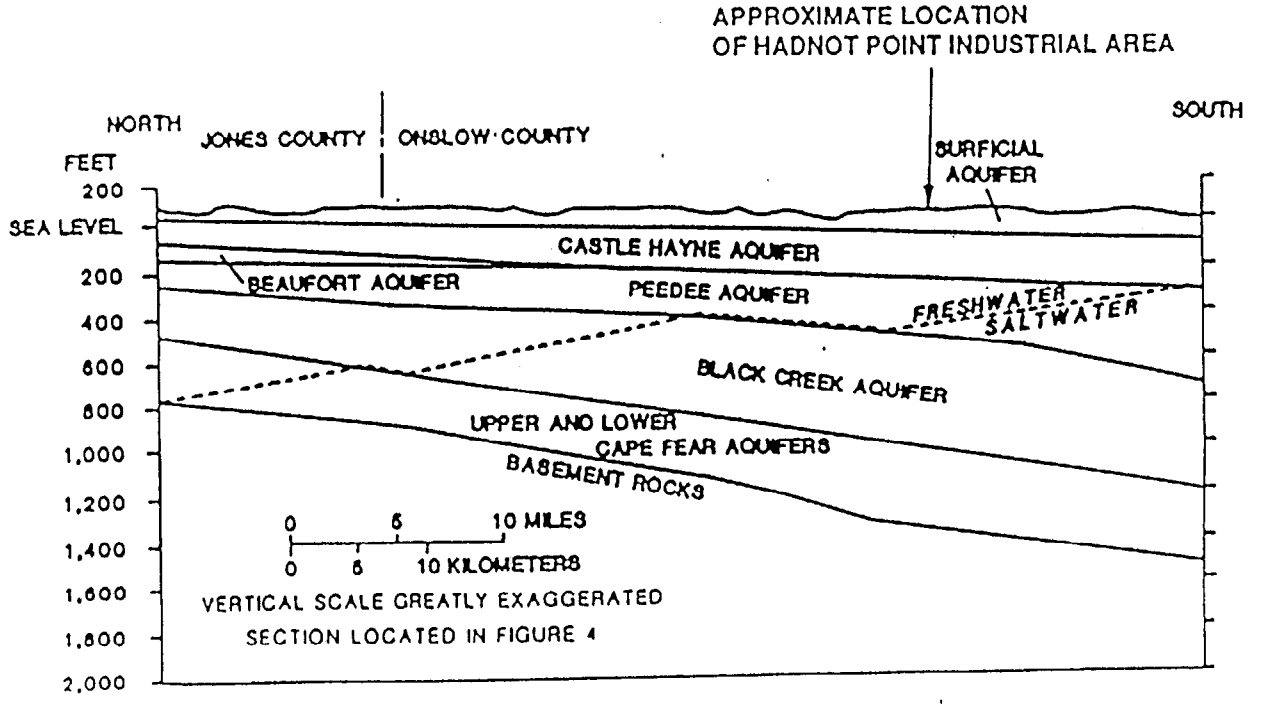


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FIGURE 3-1
GENERALIZED HYDROGEOLOGIC CROSS-SECTION
JONES AND ONSLOW COUNTIES, NORTH CAROLINA

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

SOURCE: HARNED, et. al., 1989

layer (soil boring SB6 from 4 - 6 feet) classified the clays as CH or fat clays (relatively high plasticity clay) according to the USCS. Moreover, the silty clays were generally encountered underlying the silts within the first 10 feet of drilling. Sands were generally fine to medium-grained, contained trace to little amounts of silt (silty sands), and were typically encountered underlying the silty clays. Grain size analysis performed on a sand collected from 8 to 20 feet (soil boring SB6) classified the sands as SM (or silty sand) according to the USCS.

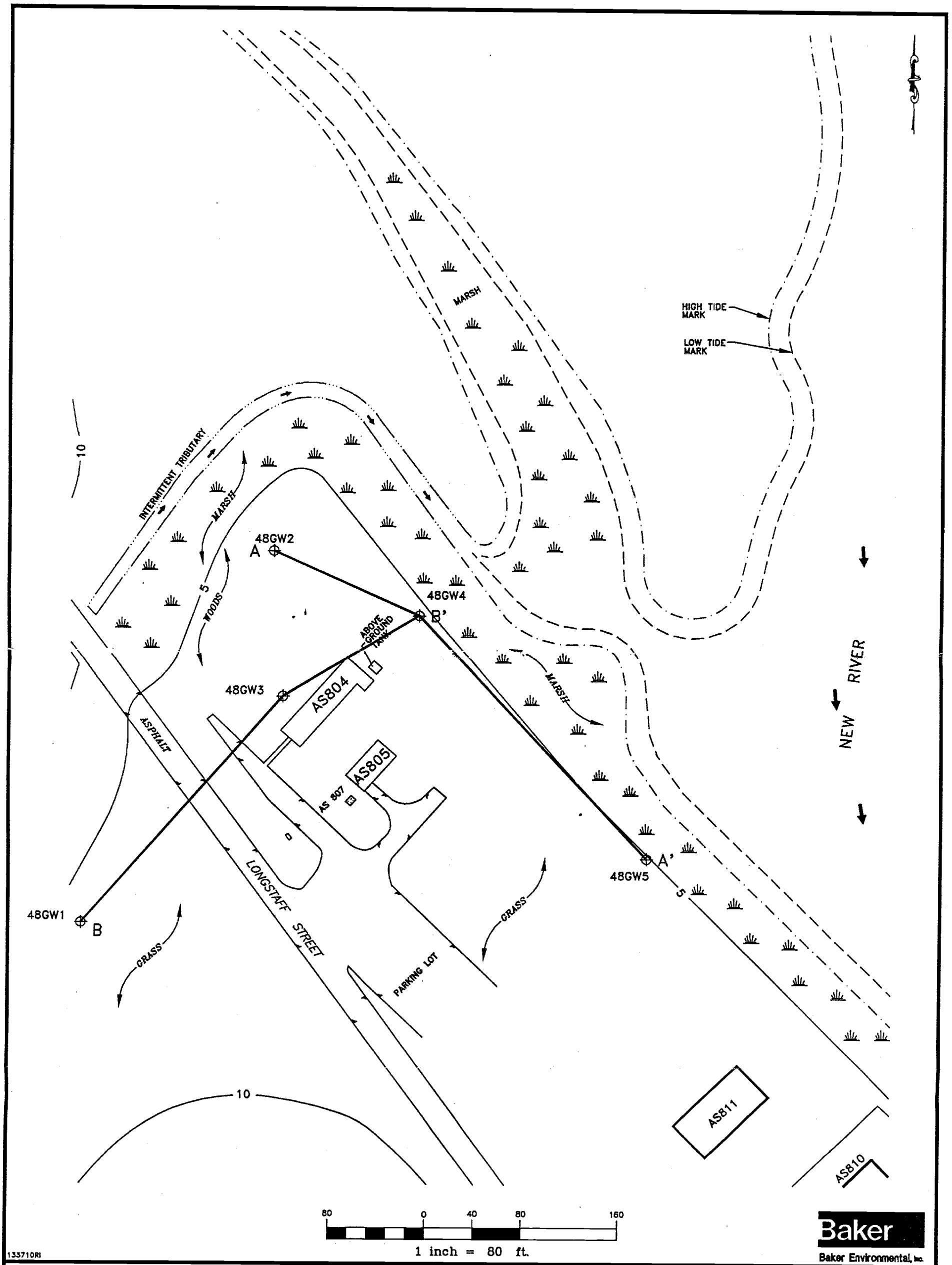
Hydrogeologic cross-sections depicting lithologic conditions underlying the site were developed based on information obtained during the drilling program. As shown on Figure 3-2, two cross-sections at the site were traversed. In general, cross-section A to A' traverses northwest to southeast (soil borings 48GW2 to 48GW5) while cross-section B to B' traverses southwest to northeast (soil borings 48GW1 to 48GW4).

Cross-section A to A' depicts the lithologic characteristics along the northwestern and southeastern boundaries of the site. As illustrated on Figure 3-3, this area is underlain by deposits of silt, silty clay, and silty sand. The deposits of silty clay, which underlie the surficial silts (one to three feet deep), increases in thickness from five feet along the northwestern portion of the site to 15 feet along the southeastern portion. In contrast, the silty sands (which underlie the silty clay) decrease in thickness from the northwestern portion of the site to the southeastern portion. The silty sands were encountered until a depth of approximately 25 feet where the borings were terminated.

Lithologic characteristics from the southwestern to the northeastern boundaries of the site are depicted on Figure 3-4. As illustrated on Figure 3-4, similar soil conditions as cross-section A to A' are encountered along traverse B to B' as deposits of silt, silty clay, and silty sand were observed. In general, the deposits of silt and silty clay decrease in thickness in the vicinity of soil boring 48GW3. In contrast, deposits of silty sand increase in thickness in the vicinity of soil boring 48GW3. The silty sands were also encountered along this traverse until a depth of approximately 25 feet where the borings were terminated.

3.5 Soils

Information regarding site soil conditions was obtained from a soil survey publication prepared by the U.S. Department of Agriculture Soil Conservation Service (SCS) for Camp Lejeune, North Carolina (SCS, 1984). It should be noted, however, that because sections of



LEGEND

48GW1 ⊕ SHALLOW GROUND WATER MONITORING WELL

A—A' CROSS-SECTION TRAVERSE

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-2
CROSS-SECTION LOCATION MAP
A-A' AND B-B'

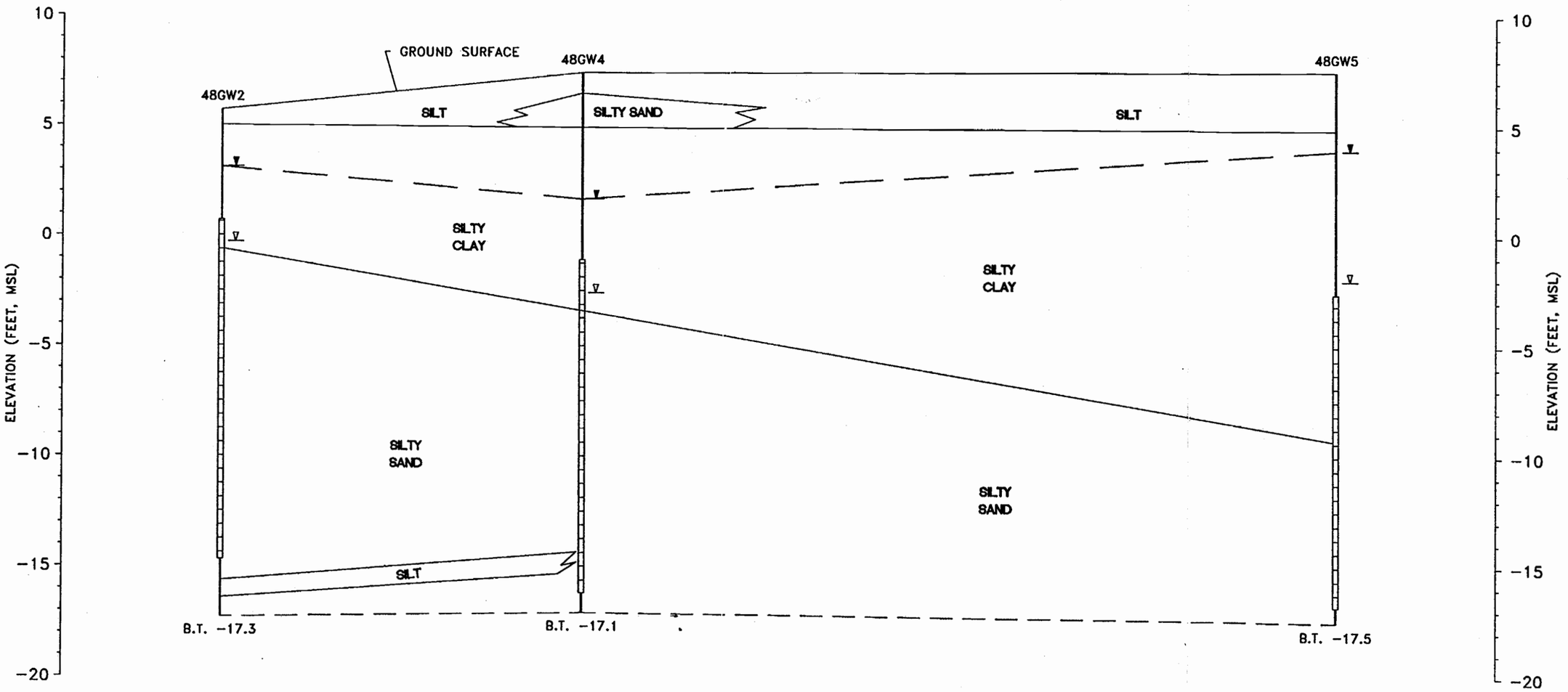
MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

00187WB2Z

133712RI

A
NORTHWEST

A'
SOUTHEAST



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LEGEND

- GROUNDWATER ELEVATION, 10/8/92 (ABOVE MSL)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. −17.3' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- GROUNDWATER GRADIENT
- PROJECTED
- ESTIMATED

40 0 20 40 80
Horizontal Scale: 1 inch = 40 ft.

5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

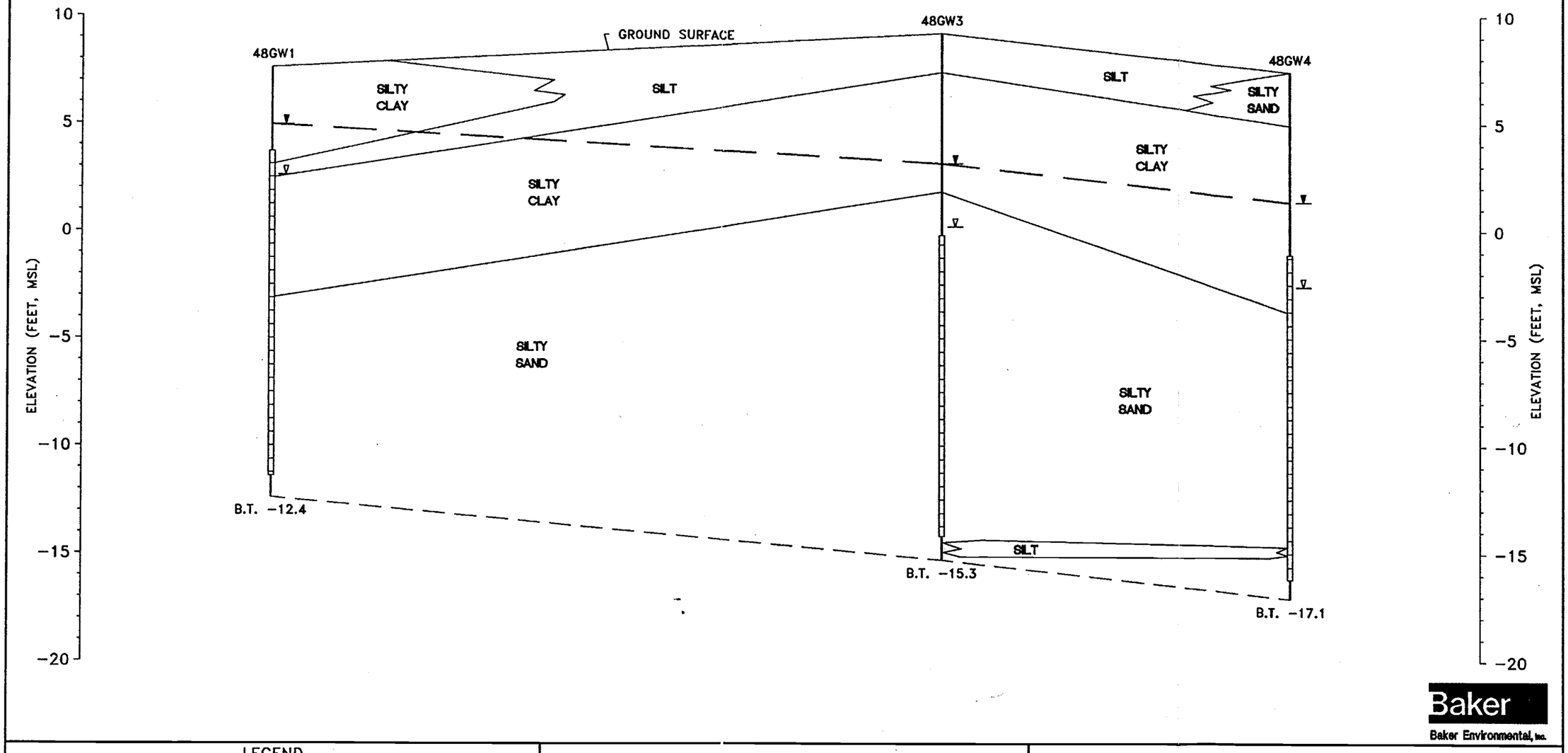
FIGURE 3−3
HYDROGEOLOGIC CROSS−SECTION A−A'

MAIRINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

133713RI

B
SOUTHWEST

B'
NORTHEAST



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LEGEND

- GROUNDWATER ELEVATION 10/8/92 (ABOVE MSL)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. −12.4' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- GROUNDWATER GRADIENT
- PROJECTED
- ESTIMATED

40 0 20 40 80
Horizontal Scale: 1 inch = 40 ft.

5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3−4
HYDROGEOLOGIC CROSS−SECTION B−B'

MARINE CORPS BASE CAMP LEJEUE
JACKSONVILLE, NORTH CAROLINA

Site 48 have been excavated and backfilled, the soils described in the publication may not be currently present at the site.

According to the SCS soil survey information, Site 48 is underlain by Bohicket (BO) silty clay loam. It is described as nearly level, very poorly drained soil commonly associated with tidal flats. Internal drainage is very slow and shrink-swell potential is high. The soil ranges from slightly acid to moderately alkaline throughout its profile. The soils generally are classified as CH or MH (elastic silt) [according to USCS], and have a permeability ranging from 1.4×10^{-4} cm/s to 4.2×10^{-5} cm/s, an average bulk density of 1.30 g/cc, and a pH ranging from 6.1 to 8.4 S.I. These permeability and bulk density values are consistent with test results from samples collected during the field investigation as shown on Table 3-3.

3.6 Hydrogeology

The following sections discuss the regional and site-specific hydrogeologic conditions. The information presented on the regional hydrogeology is from literature and site-specific hydrogeology information presented is from data collected during the field investigation.

3.6.1 Regional Hydrogeology

The surficial aquifer is a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This unit is not used for water supply at the air station.

The principal water supply aquifer for the Base is the series of sand and limestone beds that occur between 50 and 300 feet below land surface. This series of sediments generally is known as the Castle Hayne aquifer. The Castle Hayne aquifer is about 150 to 350 feet thick in the area and is the most productive aquifer in North Carolina. Estimated transmissivity (T) and hydraulic conductivity (k) values for the Castle Hayne aquifer range from 4,300 to 24,500 ft^2/day and 14 to 82 ft/day, respectively (Harned et al., 1989).

Onslow County and Camp Lejeune lie in an area where the Castle Hayne aquifer contains freshwater, although the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals from the aquifer. Overpumping of the deeper parts of the aquifer could cause upcoming of saltwater to occur. The aquifer contains water having less than 250 milligrams per liter (mg/L) chloride throughout the area of the Base (Harned et al., 1989).

TABLE 3-3

SUMMARY OF SOIL PHYSICAL PROPERTIES
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample I.D.	Atterberg Limits (%)			Permeability (cm/s)	Bulk Density (g/cc)	Soil Classification (USCS)	Sample Depth (feet)
	Liquid Limit	Plastic Limit	Plastic Index				
48-SB8	73	28	45	1.6×10^{-5}	1.31	CH[2]	4-6
48-GS2-00	NA[1]	NA	NA	NA	NA	SM[3]	8-20

Notes: (1) NA = Not Applicable - parameters not tested
(2) CH = Fat Clay (relatively high plasticity clay)
(3) SM = Silty Sand

The aquifers that lie below the Castle Hayne consist of a thick sequence of sand and clay. Although some of these aquifers are used for water supply elsewhere in the Coastal Plain, they contain saltwater in the Camp Lejeune area (Harned et al., 1989).

Rainfall that occurs in the Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the water table, which is the top of the saturated zone. In the saturated zone, ground water flows in the direction of lower hydraulic head, moving through the system to discharge areas like the New River and its tributaries or the ocean (Harned et al., 1989).

Water levels in wells tapping the surficial aquifer vary seasonally. 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 water table generally is highest in the winter months and lowest in summer or early fall (Harned et al., 1989).

In semi-confined aquifers, water is under hydraulic pressure (head) and the level to which it rises in a tightly cased well is called the potentiometric surface. The hydraulic head in a semi-confined aquifer, such as the Castle Hayne, shows a different pattern of variation over time than that in an unconfined aquifer. Some seasonal variation also is common in the water levels of the Castle Hayne aquifer, but the changes tend to be slower and over a smaller range than for water table wells (Harned et al., 1989).

3.6.2 Site Hydrogeology

As described in Section 3.4, the site is underlain by unconsolidated deposits of silty clay, silty sand, and silt which characterize the surficial aquifer. These conditions are consistent with the regional hydrogeologic framework described in USGS publications. The surficial aquifer, which is characterized by unconfined conditions (i.e., water table aquifer), was encountered at the site to a depth of 25 feet. Drilling was terminated at 25 feet, therefore, the actual extent of the surficial aquifer has not been completely evaluated. Based on published information (Harned et al., 1989), the surficial aquifer extends to an average depth of 45 feet deep at Camp Lejeune. The main water supply aquifer underlying the site, the Castle Hayne, was not encountered during the drilling program.

Groundwater conditions at the site were evaluated by installing five shallow monitoring wells (less than 25 feet). During the drilling program, groundwater was encountered from approximately five feet bgs (well 48GW1) to 10 feet bgs (48GW4) and was typically encountered within the sands. Three rounds of groundwater level measurements were obtained during the investigation as shown on Table 3-4. In general, water levels fluctuated between 0.5 and 1 foot over a one month period. Water level data collected over a 22-hour period from monitoring well 48GW2 suggests that the groundwater underlying the site is slightly influenced by tidal changes at the New River (Table 3-5). A water level change of 0.11 feet was observed over a 22-hour period.

Contour maps depicting groundwater flow patterns within the surficial aquifer near the site are presented on Figures 3-5, 3-6, and 3-7 for three dates (September 30, 1992, October 8, 1992, and October 26, 1992, respectively). As shown on Figures 3-5 and 3-6, groundwater flow across the site on September 30 and October 8 is toward the northeast in the general direction of the New River. On October 26, however, a mounding of groundwater occurs in the vicinity of 48GW3. As shown on Figure 3-7, groundwater appears to flow radially away from the 48GW3 area which is located on the north side of Building 804. It is unclear why this mounding of groundwater occurred on this date and not the other dates. It should be noted that if the groundwater elevation at well 48GW3 is omitted from this map, the groundwater flow direction across the site is the same as on September 30 and October 5. Accordingly, the water level obtained from 48GW3 appears to be anamolous.

The average groundwater gradient across the site was calculated based on the September 30 and October 8 groundwater level data. Based on these measurements, the average groundwater gradient across the site is 4×10^{-3} feet/feet, which is relatively low. The low groundwater gradient indicates a relatively flat water table. The groundwater gradient appears to gradually slope in the direction of the New River.

Hydrogeologic aquifer characteristics (i.e., hydraulic conductivity, transmissivity, and storativity) for the surficial aquifer were not evaluated during this investigation. However, recent hydrogeologic investigations conducted by Baker (December 1992) at the New River Air Station (less than one mile from Site 48) have generated estimates of the hydrogeologic conditions within the surficial aquifer. Hydraulic conductivity (k) testing within the clays has indicated k values ranging from 10^{-2} to 10^{-3} feet/day (10^{-6} to 10^{-7} cm/s). Aquifer pump test results obtained from the deeper silty-sands (25 to 30 feet bgs.) indicated an average

TABLE 3-4

SUMMARY OF WATER LEVEL MEASUREMENTS
SEPTEMBER 30, 1992 AND OCTOBER 8 AND 26, 1992
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of Casing Elevation (feet, above msl)(1)	Depth to Groundwater (feet, below top of casing) (9/30/92)	Depth to Groundwater (feet, below top of casing) (10/8/92)	Depth to Groundwater (feet, below top of casing) (10/26/92)	Groundwater Elevation (feet, above msl) (9/30/92)	Groundwater Elevation (feet, above msl) (10/8/92)	Groundwater Elevation (feet, above msl) (10/26/92)
48GW1	9.87	6.33	4.91	6.39	3.54	4.96	3.48
48GW2	8.16	5.36	4.91	5.31	2.80	3.25	2.85
48GW3	12.11	9.25	8.66	8.12	2.86	3.45	3.99
48GW4	9.98	7.20	8.66	7.09	2.78	1.32	2.89
48GW5	10.10	7.45	6.96	7.27	2.65	3.14	2.83

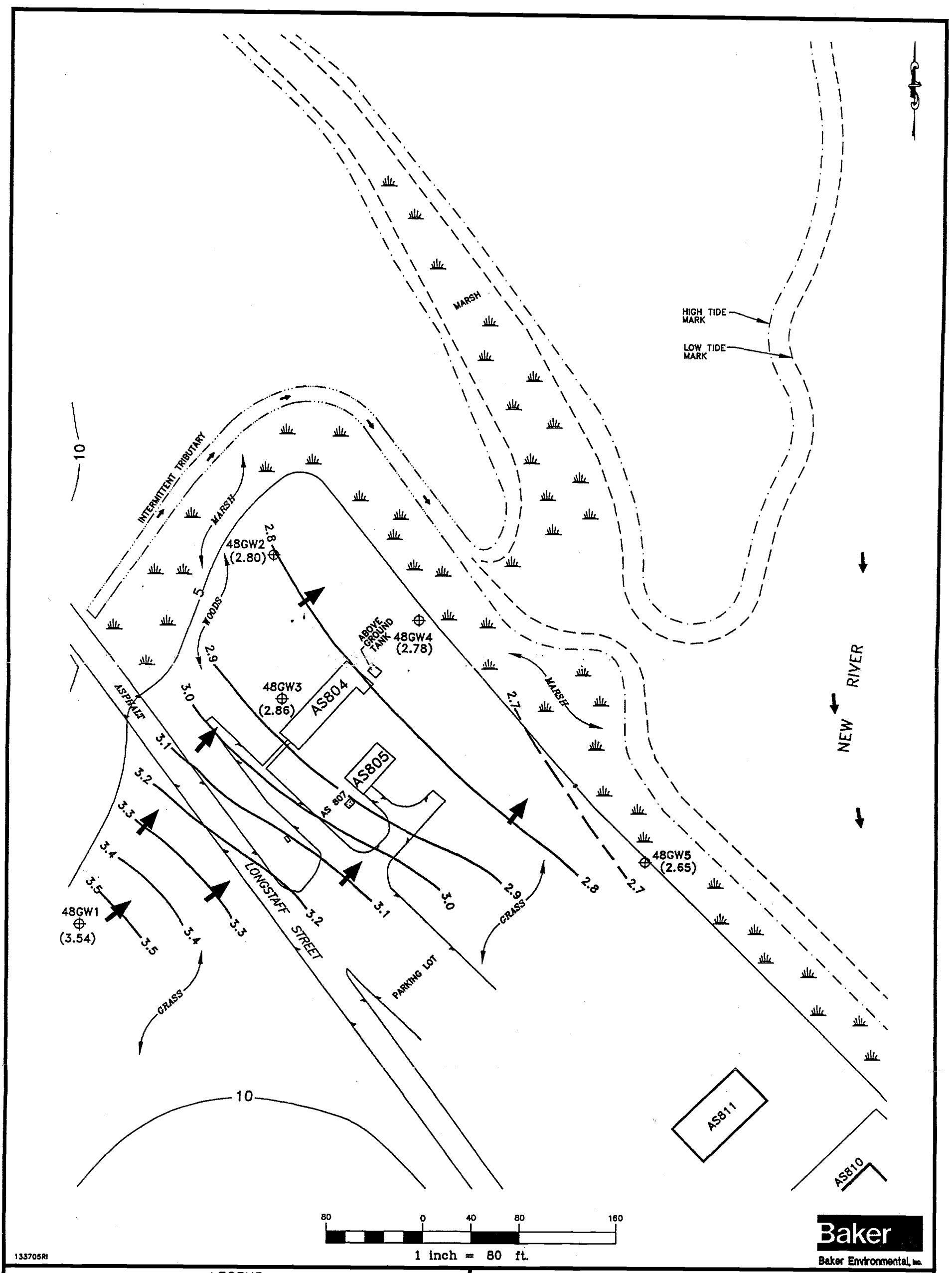
Notes: (1) msl - mean sea level

TABLE 3-5

SUMMARY OF WATER LEVEL MEASUREMENTS
OVER A 22-HOUR PERIOD AT MONITORING WELL 48GW2
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Time From Start (Min)	Depth to Water (Feet, bgs.)	Time From Start (Min)	Depth to Water (Feet, bgs.)	Time From Start (Min)	Depth to Water (Feet, bgs.)
0.000	5.594	440.000	5.610	870.000	5.563
10.000	5.625	450.000	5.625	880.000	5.563
20.000	5.610	460.000	5.625	890.000	5.563
30.000	5.610	470.000	5.625	900.000	5.578
40.000	5.610	480.000	5.625	910.000	5.578
50.000	5.610	490.000	5.625	920.000	5.578
60.000	5.610	500.000	5.641	930.000	5.578
70.000	5.610	510.000	5.625	940.000	5.578
80.000	5.594	520.000	5.641	950.000	5.594
90.000	5.594	530.000	5.641	960.000	5.594
100.000	5.594	540.000	5.641	970.000	5.594
110.000	5.578	550.000	5.641	980.000	5.594
120.000	5.578	560.000	5.641	990.000	5.610
130.000	5.578	570.000	5.656	1000.000	5.594
140.000	5.563(1)	580.000	5.641	1010.000	5.594
150.000	5.563	590.000	5.656	1020.000	5.594
160.000	5.563	600.000	5.656	1030.000	5.610
170.000	5.563	610.000	5.641	1040.000	5.594
180.000	5.563	620.000	5.656	1050.000	5.610
190.000	5.563	630.000	5.641	1060.000	5.610
200.000	5.563	640.000	5.641	1070.000	5.625
210.000	5.563	650.000	5.641	1080.000	5.610
220.000	5.563	660.000	5.641	1090.000	5.610
230.000	5.563	670.000	5.625	1100.000	5.610
240.000	5.578	680.000	5.625	1110.000	5.625
250.000	5.578	690.000	5.625	1120.000	5.625
260.000	5.578	700.000	5.610	1130.000	5.625
270.000	5.578	710.000	5.610	1140.000	5.641
280.000	5.594	720.000	5.610	1150.000	5.625
290.000	5.594	730.000	5.594	1160.000	5.641
300.000	5.594	740.000	5.594	1170.000	5.641
310.000	5.594	750.000	5.594	1180.000	5.656
320.000	5.594	760.000	5.578	1190.000	5.656
330.000	5.594	770.000	5.578	1200.000	5.656
340.000	5.610	780.000	5.578	1210.000	5.656
350.000	5.594	790.000	5.578	1220.000	5.656
360.000	5.610	800.000	5.578	1230.000	5.656
370.000	5.610	810.000	5.563	1240.000	5.656
380.000	5.610	820.000	5.563	1250.000	5.672(2)
390.000	5.610	830.000	5.563	1260.000	5.656
400.000	5.610	840.000	5.563	1270.000	5.672
410.000	5.610	850.000	5.563	1280.000	5.672
420.000	5.610	860.000	5.563	1290.000	5.672
430.000	5.610			1300.000	5.672

NOTES: (1) Minimum Water Level Recorded
(2) Maximum Water Level Recorded



LEGEND

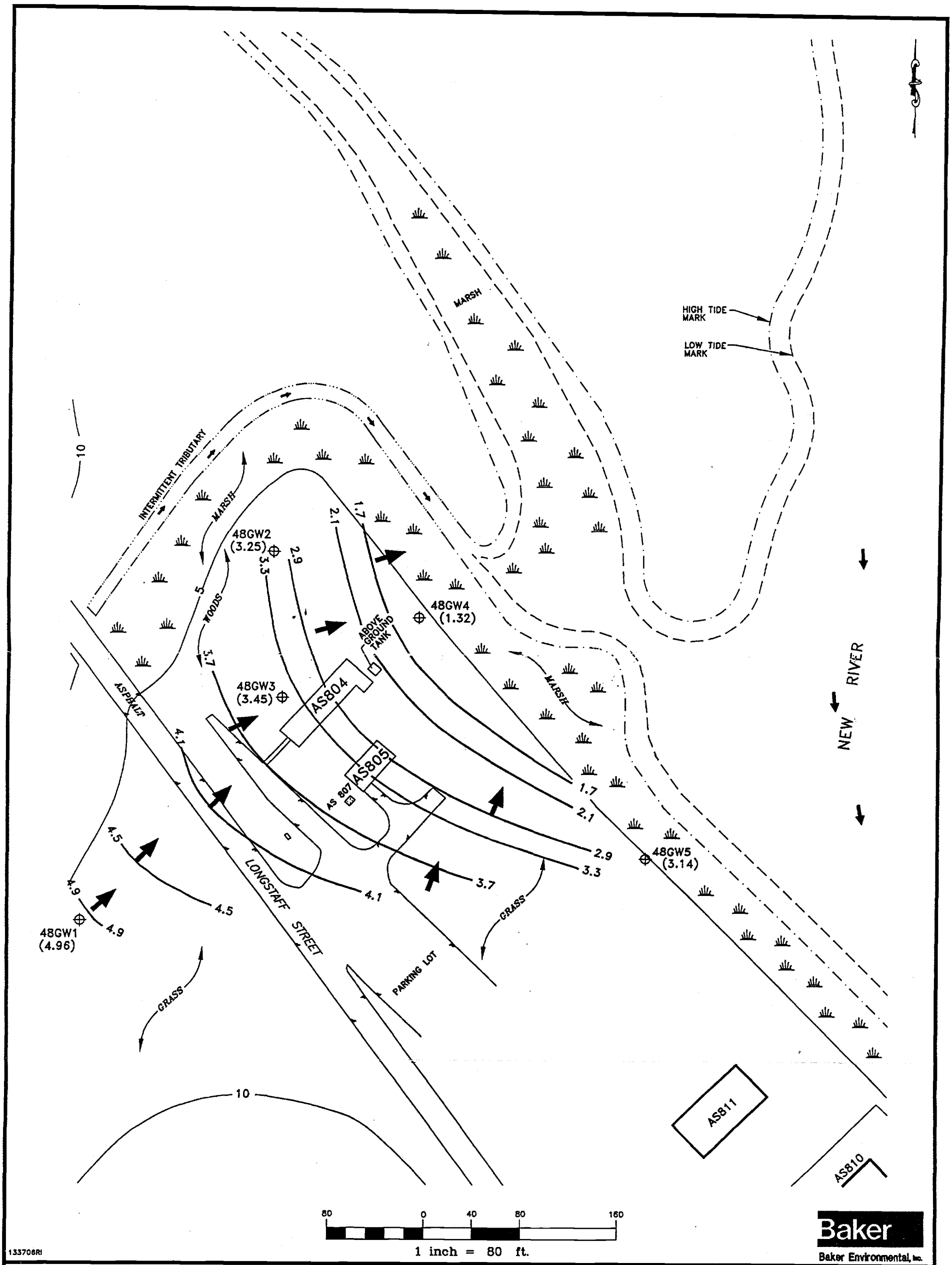
- 48GW1 ⊕ SHALLOW GROUNDWATER MONITORING WELL
- 3.1—— GROUNDWATER CONTOUR LINE (ft.,MSL)
- 2.7– – – ESTIMATED GROUNDWATER CONTOUR LINE (ft.,MSL)
- (3.54) GROUNDWATER ELEVATION (ft., MSL)
- ➡ ESTIMATED GROUNDWATER FLOW DIRECTION

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-5
GROUNDWATER CONTOUR MAP
SEPTEMBER 30, 1992

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

00187WB3Z



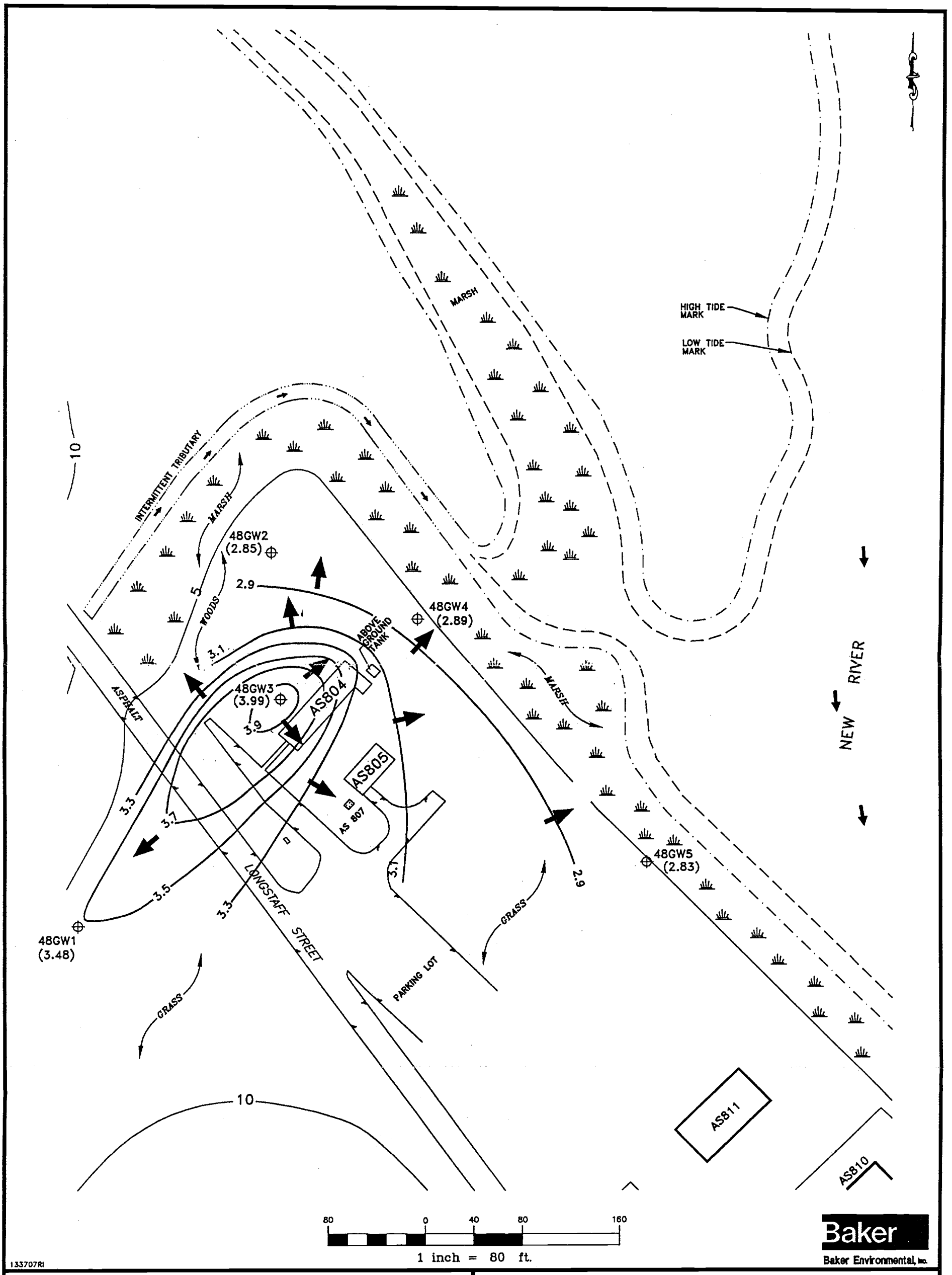
LEGEND

- 48GW1 ⊕ SHALLOW GROUNDWATER MONITORING WELL
- 3.7 —— GROUNDWATER CONTOUR LINE (ft.,MSL)
- (3.45) GROUNDWATER ELEVATION (ft., MSL)
- ➡ ESTIMATED GROUNDWATER FLOW DIRECTION

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-6
GROUNDWATER CONTOUR MAP
OCTOBER 8, 1992

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA



LEGEND

- 48GW1 ⊕ SHALLOW GROUNDWATER MONITORING WELL
- 3.7 —— GROUNDWATER CONTOUR LINE (ft.,MSL)
- (3.48) GROUNDWATER ELEVATION (ft., MSL)
- ➡ ESTIMATED GROUNDWATER FLOW DIRECTION

SOURCE: LANTDIV, FEB. 1992

FIGURE 3-7
GROUNDWATER CONTOUR MAP
OCTOBER 26, 1992

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

transmissivity of 70 gallons/day/feet, an average k of 6.3 feet/day, and an average storativity of 1.4×10^{-2}.

3.7 Land Use and Demography

MCB Camp Lejeune encompasses an area of approximately 170 square miles (108,800 acres), and is comprised of several distinct areas of development including Hadnot Point, MCAS/Camp Geiger, French Creek, and Courthouse Bay. The installation border is approximately 70 miles in length, which includes 17 miles of ocean front and Intracoastal Waterway.

Land use within Camp Lejeune is influenced by the topography of the land itself, by established environmental policy, and by base operational requirements. Soil drainage is the most critical factor which determines the suitability of a site for development. Much of the land area found within the facility consists of freshwater swamps that are wooded and largely unsuitable for development. In addition, approximately 3,000 acres of sensitive estuary and other areas set aside for the protection of threatened and endangered species are to remain undeveloped. Operational restrictions and regulations, such as explosive quantity safety distances, impact-weighted noise thresholds, and aircraft landing and clearance zones, may also greatly constrain and influence development (Master Plan, Camp Lejeune Complex, North Carolina, 1988).

The vast majority of Camp Lejeune is comprised of training ranges and maneuver areas. Although interspersed throughout the installation, these areas are generally concentrated between Sneads Ferry Road and the eastern border of the base.

The combined military and civilian population of the Camp Lejeune/Jacksonville area is approximately 60,000. At the present time nearly 90 percent of the surrounding population resides within urbanized areas. As evidenced by the rapid population growth of Jacksonville and adjacent communities, particularly during the period from 1940 to 1960, Camp Lejeune continues to have a direct effect on regional population growth and development.

There are no housing areas within the borders of Site 48. Buildings in Site 48 are currently used for military operations. Building 804 is used as a training facility.

The New River, which bisects the installation, provides both a commercial and recreational source of fish and shellfish for human consumption. The N.C. DEHNR reports that during the years 1989 through 1990 over 2.7 million pounds of fish and shellfish were caught commercially in the New River.

3.8 Ecology

MCB Camp Lejeune is located on 17 miles of Atlantic coastline containing tidal marshes and alluvial deposits that are protected by a barrier of sand dunes along the coast. The New River inlet divides MCB Camp Lejeune and provides an environment for a variety of species. Onslow county maintains two forest preserves near MCB Camp Lejeune. These forest preserves, as well as other large areas of undeveloped land near the base, contribute to maintaining an environment favorable to the species that inhabit this area.

MCB Camp Lejeune is approximately 108,800 acres, with 84 percent of the area covered by forests.

Vegetation at MCB Camp Lejeune includes pure pine stands consisting of loblolly and longleaf pine (found on the drier upland soils), pure pond pine stands in high organic wet soils, pine-hardwood and pure hardwood stands in streamside zones and in more productive soils, and bottomland hardwoods found on the floodplains of the major creeks (USMC, 1987). Wildlife on the base includes white-tailed deer, wild turkey, black bear, along with numerous small game species (e.g., bobwhite quail, morning dove, rabbit) (USMC, 1987).

The N.C. DEHNR, Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (N.C. DEHNR, 1992c). In addition, certain activities impacting wetlands also are regulated by the U.S. Corps of Engineers (COE).

The U.S. Fish and Wildlife Service (FWS) prepares National Wetland Inventory (NWI) maps. The NWI map for the Jacksonville South quadrangle was prepared primarily by stereoscopic analysis of high altitude aerial photographs. The wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with classification of Wetland and Deep-Water Habitats of the United States (An Operational Draft), Cowardin, et al., 1977 (USDI, 1982). NWI maps are intended for a cursory identification of wetland areas. They cannot be substituted for an actual wetland delineation that may be required by Federal, State and Local regulatory agencies.

Three classifications of wetlands have been identified around Site 48 from the NWI maps. These wetland areas include: PSS711B (Pallustrian, scrub-shrub, evergreen, broad-leaved deciduous, hyperhaline, saturated); PFO1A (Palustrine, forested, Broad-leaved deciduous, temporarily flooded); and E2EM1P (Estuarine, intertidal, emergent, persistent, irregularly flooded). PSS711B wetlands are primarily mixed shrub assemblages or broadleaf evergreens and pines, sometimes mixed with cedars. PFO1A wetlands in coastal plains occur in soils that have a high base saturation and is usually silty or clayey. Trees in these areas include: river birch, sweetgum, red maple, yellow poplar, sycamore, American elm, sugarberry, bitternut hickory, swamp chestnut oak, box elder, and loblolly pine. Finally, E2EM1P wetlands are saltmarshes dominated by needle rush (N.C. DNRCD, 1988).

Certain species have been granted protection by the United States Fish and Wildlife Service under the Federal Endangered Species Act (16 U.S.C. 1531-1543), and/or the North Carolina Wildlife Resources Commission, under the Endangered Species Act (G.S. 113-331 to 113-337). The protected species fall into one of the following status classifications: Federal or state endangered, threatened or candidate species, state special concern, state significantly rate, or state watch list. While only the Federal or state threatened or endangered, or state special concern species are protected from certain actions, the other classified species have the potential for protection in the future.

Many protected species have been sited near and on MCB Camp Lejeune. Table 3-6 contains a list of these protected species (either endangered, threatened, or special concern) that have been identified within the boundaries of MCB Camp Lejeune. (MCB Camp Lejeune, 1991), (LeBlond, 1991), (Fussell, 1991), and (Walters, 1991).

Around and within Site 48 various species were identified. Black skimmers and Piping plovers were observed near the New River Inlet (Fussell, 1991). The Black skimmers and Piping plovers primarily inhabit shore line areas and therefore are not expected to be found at Site 48. A peregrine falcon was spotted approximately ten miles southeast of Site 48. Peregrine falcons may inhabit or feed in areas surrounding Site 48. In addition, Bachmans sparrows and Red-cockaded woodpeckers were observed at numerous locations throughout southern Camp Lejeune (Fussell, 1991) (Walters, 1991).

During the field study conducted in August and September 1992, a representative of the MCB Camp Lejeune Fish and Wildlife Division stated that the American alligator is known to

TABLE 3-6

PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
American alligator (Alligator mississippienis)	T(f), T(s)
Bachmans sparrow (Aimophilia aestivalis)	SC
Black skimmer (Rhynochops niger)	SC
Green (Atlantic) turtle (Chelonia m. mydas)	T(f), T(s)
Loggerhead turtle (Caretta caretta)	T(f), T(s)
Piping plover (Charadrius melodus)	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)	E(f), E(s)
Rough-leaf loosestrife (Lysimachia asperulifolia)	E(f), E(s)

Legend: SC = State Special Concern
E(f) = Federal Endangered
E(s) = State Endangered
T(f) = Federal Threatened
T(s) = State Threatened

inhabit the waters surrounding Site 48. There are no documented sitings that other protected species inhabit Site 48. A protected floral species and special-interest community survey was conducted at Camp Lejeune (LeBlond, 1991). From this list, the rough-leaf loosestrife was the only Federally threatened or endangered plant species found on the marine base. Several state endangered or threatened, and Federal and state candidate species were found on the marine base, however, none of these species were located on or immediately adjacent to Site 48.

In addition to wetlands and protected species, the presence of other sensitive environments, particularly those listed in 40 CFR Part 300, were evaluated. No sensitive environments were identified within the boundaries of Site 48.

3.9 Identification of Water Supply Wells

Water supply wells within a one-mile radius of Site 48 were identified as shown on Figure 3-8. Supply well information was obtained in "U.S.G.S. Water Resources Investigation Report 89-4096." (Harned, et al., 1989). As shown on Table 3-7 two wells were identified within a one-mile radius, well numbers MCAS-131 and MCAS-203. Well MCAS-131 is 200 feet deep and located 4,540 feet northwest of the site; Well MCAS-203 is 173 feet deep and located 5,270 feet northwest of the site. Screen interval information on these two wells was unavailable in the referenced document. Both wells identified are located in the upgradient groundwater flow direction. Given the distance of these wells in relationship to Site 48, and local geological/hydrogeological conditions, it is unlikely that contaminants, (if present) at Site 48 would migrate to these supply wells and impact the drinking water.

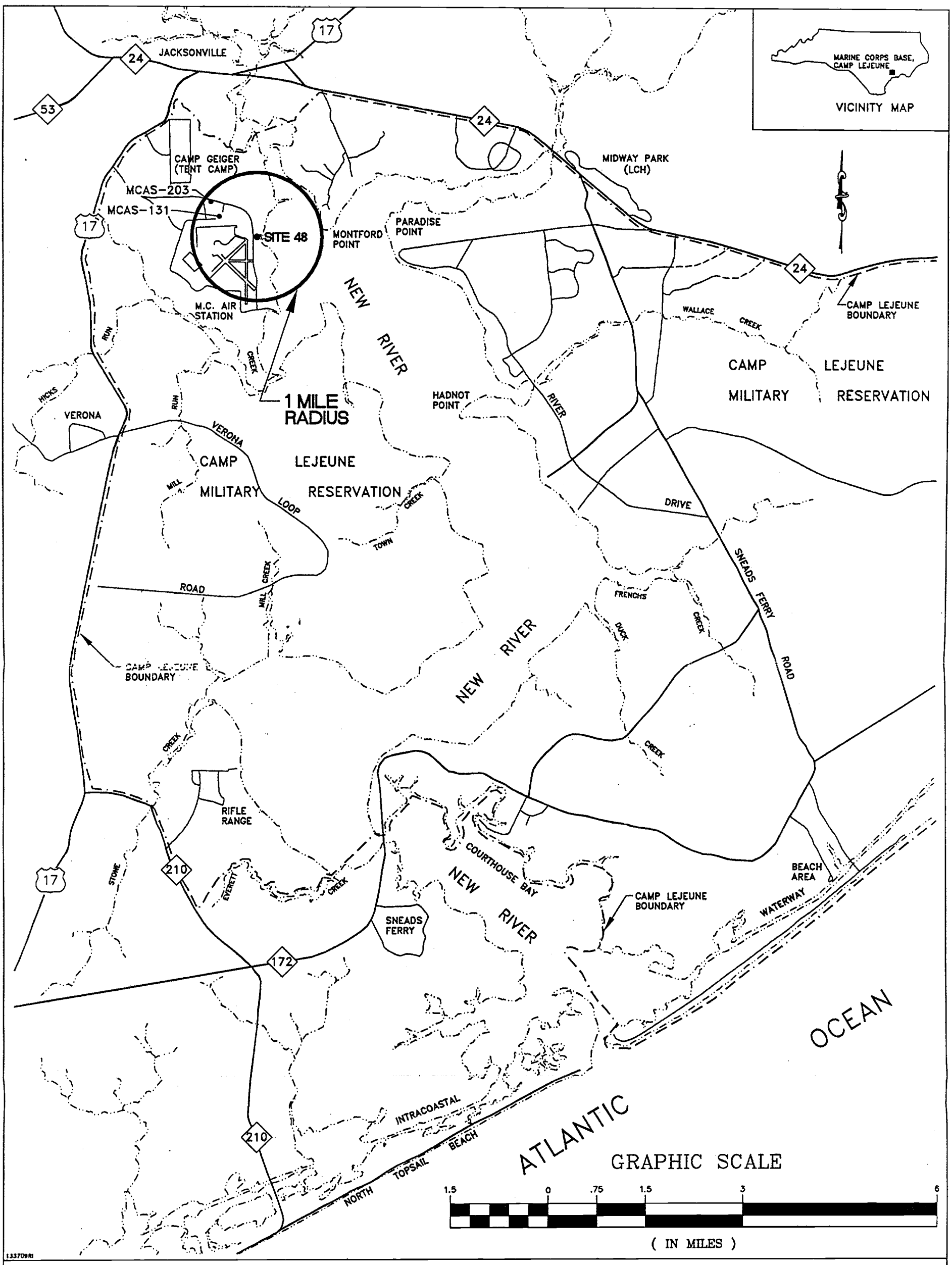


FIGURE 3-8
WATER SUPPLY WELLS
IN SITE 48 VICINITY

SOURCE: U.S.G.S. WATER-RESOURCES INVESTIGATIONS REPORT 89-4096, HARNED et. al., 1989

MARINE CORPS BASE CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

00187W082

TABLE 3-7

SUMMARY OF WATER SUPPLY WELLS WITHIN A ONE-MILE RADIUS(1)
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	USGS Identification Number	Total Depth (feet)	Screen Interval (feet)	Approximate Distance/Direction from Site (Feet)
MCAS-131	3443090772648.1	200	-- (2)	4,540/NW
MCAS-203	3443230772653.1	173	--	5,270/NW

Notes: (1) Information obtained from "Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina," (Harned, et al., 1989).
(2) Information Not Available

4.0 NATURE AND EXTENT OF CONTAMINATION

The results of the remedial investigation are presented in this section. The primary objective of the remedial investigation is to determine the nature and extent of contamination such that the decisions can be made as to the level of risk presented by the site and the appropriate remedial response. Data collected as part of the Soil Investigation, Groundwater Investigation, and Surface Water and Sediment Investigation are presented herein. Information gathered during these investigations will help determine source areas and extent of contaminant migration.

4.1 Soil Investigation

The Soil Investigation focused on three areas of concern that were identified via historical photographs. These areas, as well as the sampling program, were discussed previously in Section 2.4 and are depicted on Figure 2-1.

Organic analyses performed on surface soil and subsurface soil revealed only limited contamination. Organic contaminants detected in surface and subsurface soils are presented on Tables 4-1 and 4-2, respectively. A summary of all surface and subsurface soil analyses, range of concentrations, and frequency of positive detections, are presented in Appendix G.

Low levels of the pesticides 4,4'-DDE (12 µg/kg), 4,4'-DDD (3.6 µg/kg), and 4,4'-DDT (7.4J µg/kg) were detected in one surface soil sample collected from test boring SB3C (see Figure 2-3). Two of the surface soil samples and all of the subsurface soil samples exhibited acetone ranging from 6 µg/kg to 220 µg/kg. The presence of acetone in these samples is most likely due to the use of pesticide-grade isopropanol during decontamination. (The pesticide-grade isopropanol was analyzed and found to contain approximately 1.3 percent acetone.) Although the final step in the decontamination procedures states that sampling the equipment will be air dried, it is possible that sampling equipment was not completely dry before it was used. Acetone was not present in groundwater samples, which supports the belief that the presence of acetone in soil is not related to waste disposal but rather to decontamination techniques. In addition, the acetone was detected in subsurface soil samples collected offsite at soil boring 48MW5.

Target Analyte Inorganics (TAL) inorganics were detected in surface soil samples with the exception of cyanide, antimony, beryllium, mercury, selenium, silver, and thallium (i.e., no

TABLE 4-1
SITE 48 SURFACE SOIL
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
ORGANICS

	Sample No:	48-A4-00	48-B3-00
	Depth:	0-6"	0-6"
	Date Sampled:	8/26/92	8/26/92
	Lab Id:	00547-05	00547-07
Parameter	Units		
4,4'-DDE	UG/KG		12
4,4'-DDD	UG/KG		3.6
4,4'-DDT	UG/KG		7.4 J
ACETONE	UG/KG	6 J	9 J

N/A - Not applicable
UG/L - microgram per liter
J - value is estimated

TABLE 4-2
SITE 48 SUBSURFACE SOIL
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
ORGANICS

	Sample No:	48-A3-02	48-A4-01	48-B3-03	48-B3-05	48-C3-03	48-GW1A-01	48-GW2A-01
	Depth:	3-15	1-3	7-9	9-11	5-7	4-5	0-2
	Date Sampled:	8/26/92	8/26/92	8/26/92	8/26/92	8/26/92	8/29/92	8/27/92
	Lab Id:	00547-04	00547-06	00547-08	00547-10	00547-12	00551-01	00547-13
Parameter	Units							
ACETONE	UG/KG	27 J	10 J	67 J	23 J	220 J	22	180 J

N/A - Not applicable
UG/L - microgram per liter
J - value is estimated

TABLE 4-2 (CONTINUED)
SITE 48 SUBSURFACE SOIL
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
ORGANICS

	Sample No:	48-GW2B-03	48-GW4A-04	48-GW4B-05	48-GW5A-03	48-GW5B-05	48-GWB-02
	Depth:	6-8	6-8	8-10	4-6	8-10	5-6
	Date Sampled:	8/27/92	8/27/92	8/27/92	8/28/92	8/28/92	8/29/92
	Lab Id:	00547-14	00547-15	00547-17	00551-03	00551-04	00551-02
Parameter	Units						
ACETONE	UG/KG	25 J	26 J	15 J	13 J	31	170

N/A - Not applicable
UG/L - microgram per liter
J - value is estimated

positive detections of cyanide). The inorganics that were detected in surface soil, along with the concentration, are presented on Table 4-3. A complete listing of all inorganic analyses, range of concentrations, and frequency of positive detections is presented in Appendix G.

Based on the review of inorganics in surface soil, a significant number of samples analyzed exhibited inorganic levels above base-specific background levels. The base-specific background samples were collected from two soil borings (4 samples) located just east of Piney Green Road, approximately 900 feet north of supply well HP-636. Base-specific concentrations for inorganics in the surface and subsurface soils are presented on Table 4-4. All four areas of concern exhibited higher than background levels of inorganics. However, mercury was not detected above sample quantitation limits in any of the surface soil samples.

Target Analyte Inorganics (TAL) inorganics were detected in subsurface surface soil samples with the exception of cyanide, mercury, selenium, silver, and thallium (i.e., no positive detections). The inorganics that were detected in subsurface surface soil, along with the concentration, are presented in Table 4-5. A complete listing of all inorganic analyses, range of concentrations, and frequency of positive detections is presented in Appendix G.

Subsurface soil exhibited similar characteristics to surface soil. The majority of subsurface soil inorganic levels exceeded base-specific background values. As with the surface soils, no mercury was detected above the sample quantitation limit. In addition, subsurface soil samples collected offsite (test boring location 48GW5) also exhibited inorganic levels above base-specific background values.

Soil samples collected for purposes of determining whether soils from Site 48 are hazardous characteristically were collected for full TCLP, reactivity, corrosivity, and ignitability. The results, which are presented on Table 4-6, indicate that the soil at Site 48 is not hazardous. Soil samples collected for engineering analysis (grain size, etc.) are discussed in Section 2.4. Analytical summary forms are presented in Appendix K.

In summary, surface and subsurface soil at Site 48 do not indicate any impacts associated with mercury disposal activities. The one sample with low levels of pesticides is not believed to be related to waste disposal or handling activities. Historical usage of pesticides at the base for pest control has been documented. Elevated inorganic levels detected in surface and subsurface soil were observed at all four areas of concern, and offsite locations. Soil results

TABLE 4-3
SITE 48 SURFACE SOIL
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-A3-00	48-A4-00	48-B3-00	48-C3-00
Depth:		0-6"	0-6"	0-6"	0-6"
Date Sampled:		9/27/92	9/27/92	9/26/92	9/26/92
Lab Id:		00547-03	00547-05	00547-07	00547-11
Parameter	Units				
ALUMINUM	MG/KG	8900	28000	3560	6830
ARSENIC	MG/KG	3.4 J	0.97 BJ	0.63 JB	2.5 J
BARIUM	MG/KG	15.6 B	25.7 B	11.9 B	13.3 B
CADMIUM	MG/KG	0.48 JB	3.6 J	1.1 J	1.6 J
CALCIUM	MG/KG	309 JB	352 JB	26800 J	1190 J
CHROMIUM	MG/KG	10.4	37.3	7.3	11.3
COBALT	MG/KG	1.1 JB	2.2 JB	0.59 JB	0.87 JB
COPPER	MG/KG	2.7 B	5.6 J	3.5 JB	3.2 JB
IRON	MG/KG	6320	24200	2320	10500
LEAD	MG/KG	9.2 J	8.7 J	23.7 J	16.1 J
MAGNESIUM	MG/KG	290 B	1200	549 B	276 B
MANGANESE	MG/KG	5.4 J	14.9 J	11.5 J	6.9 J
NICKEL	MG/KG	2 JB	4.6 JB		1.8 JB
POTASSIUM	MG/KG	311 B	1240	136 B	322 B
SODIUM	MG/KG		49.4 JB	59.5 JB	
VANADIUM	MG/KG	18.8 J	53.9 J	7 JB	22.2 J
ZINC	MG/KG	9.8	12.8	24.8	

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-4

SUMMARY OF BACKGROUND INORGANIC CONCENTRATIONS IN SURFACE AND SUBSURFACE SOILS AT MCB CAMP LEJEUNE
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Surface Soils (1)	Subsurface Soils (2)
Aluminum	<90.5 - 1120	672 - 3600
Antimony	<2.6 - 9.6	2.5 - <9.7
Arsenic	<0.56 - 0.91	<0.61 - <0.65
Barium	3.5 - 16.5	<4.0 - 7.6
Beryllium	<0.06 - <0.2	<0.05 - <0.2
Cadmium	<0.35 - <0.59	<0.34 - <0.59
Calcium	108 - 10700	<10.7 - 4410
Chromium	<0.66 - <3.2	<3.2 - 6.0
Cobalt	<0.37 - <1.8	<0.35 - <1.8
Copper	<1.1 - 3.1	0.65 - 1.2
Iron	160 - 684	126 - 833
Lead	2.0 - 3.0	1.2 - 1.6
Magnesium	<20.2 - 200	<25.4 - 133
Manganese	<2.0 - 16	<0.79 - 7.5
Mercury	<0.02 - <0.12	<0.02 - <0.08
Nickel	<1.5 - <3.3	<1.4 - <3.4
Potassium	54.5 - 75	<81.6 - 187
Selenium	<0.93 - <1.0	<1.0
Silver	<0.37 - <2.0	<0.35 - <2
Sodium	<9.4 - <39.3	<14.5 - <26.5
Thallium	<0.37 - <0.41	<0.40 - <0.44
Vanadium	<2.1 - 2.8	<1.5 - 4.7
Zinc	<1.1 - 23.1	<0.79 - 11.6

Notes: (1) Surface soils considered as soils collected from ground surface to one foot bgs.
(2) Subsurface soils considered as soils collected below one foot bgs. All concentrations expressed in milligrams per kilograms (mg/kg).

TABLE 4-5
SITE 48 SUBSURFACE SOIL
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-A3-02	48-A4-01	48-B3-03	48-B3-05	48-C3-03	48-GW1A-01	48-GW2A-01
Depth:		3-5	1-3	7-9	9-11	5-7	4-5	0-2
Date Sampled:		9/27/92	9/26/92	9/26/92	9/26/92	9/26/92	9/29/92	9/27/92
Lab Id:		00547-04	00547-06	00547-08	00547-10	00547-12	00551-01	00547-13
Parameter	Units							
ALUMINUM	MG/KG	15100	24400	14100	730	11700	12000	11400
ANTIMONY	MG/KG							
ARSENIC	MG/KG	0.64 JB	4.6 J	2.4 J		0.77 JB	1.3 B	2.2 J
BARIUM	MG/KG	22 B	25.8 B	17.6 B	2.5 JB	15 B	21.1 B	16.3 B
BERYLLIUM	MG/KG						0.2 B	
CADMIUM	MG/KG	1.1 J	2.1 J	1.3 J		1.8 J	1.4 J	0.79 JB
CALCIUM	MG/KG		299 JB	112 JB				
CHROMIUM	MG/KG	21.1	32.8	20.9	1.1 B	18.6	18.2	14.8
COBALT	MG/KG	1.2 JB	1.7 JB	0.71 JB		1.1 JB	0.55 B	1.2 JB
COPPER	MG/KG	3.9 JB	4.8 JB	3.8 JB		3.8 JB	3.5 JB	2.8 JB
IRON	MG/KG	3750	11000	9420	371	11800	4140	4140
LEAD	MG/KG	13.5 J	12.9 J	13.5 J	2.9 J	14.3 J	32.3	13.9 J
MAGNESIUM	MG/KG	508 B	1080 B	501 B	25.5 B	362 B	411 B	361 B
MANGANESE	MG/KG	7.9 J	13.3 J	5.9 J	0.94 JB	7 J	5.7 J	9.2 J
NICKEL	MG/KG		3.2 JB			1.9 JB	2.2 JB	1.5 JB
POTASSIUM	MG/KG	586 B	1140 B	577 B	33.6 B	533 B	510 B	463 B
SODIUM	MG/KG	39.3 JB	50.6 JB	71.8 BJ		62.5 JB		
VANADIUM	MG/KG	23 J	44.3 J	24.6 J	1.5 JB	20.8 J	28.3	15.4 J
ZINC	MG/KG							

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-5 (CONTINUED)
SITE 48 SUBSURFACE SOIL
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-GW2B-03	48-GW4A-04	48-GW4B-05	48-GW5A-03	48-GW5B-05	48-GW1B-02
Depth:		6-8	6-8	8-10	4-6	8-10	5-6
Date Sampled:		9/27/92	9/27/92	9/27/92	9/28/92	9/28/92	9/29/92
Lab Id:		00547-14	00547-15	00547-17	00551-03	00551-04	00551-02
Parameter	Units						
ALUMINUM	MG/KG	1320	14400 J	14200	14900	12800	2880
ANTIMONY	MG/KG				4.1 JB		
ARSENIC	MG/KG		0.94 BJ	0.67 JB	1.7 B	1.3 B	0.82 B
BARIUM	MG/KG	3 JB	16.9 B	19.2 B	21.2 B	19.5 B	9.9 B
BERYLLIUM	MG/KG				0.17 B	0.22 B	
CADMIUM	MG/KG		4.4 J	1.4 J	1.7 J	2.2 J	0.61 JB
CALCIUM	MG/KG	873 JB	124 JB	150 JB	80.9 B	236 B	
CHROMIUM	MG/KG	3.3	17.8	25.8	15.3	20.7	3.2
COBALT	MG/KG	1.1 JB	1.4 JB	1.3 JB	0.52 B	0.54 B	
COPPER	MG/KG	31.5	5.4 JB	4.1 JB	3 JB	3.3 JB	0.75 JB
IRON	MG/KG	1850	37400 J	9620	6060	8600	1460
LEAD	MG/KG	2.7 J	11.4 J	10.6 J	15.6	6.6	3.1
MAGNESIUM	MG/KG	569 B	566 B	886 B	519 B	725 B	94.7 B
MANGANESE	MG/KG	6.4 J	10.2 J	13.1 J	6.8 J	15.6 J	1.5 JB
NICKEL	MG/KG				2.1 JB	3.3 JB	
POTASSIUM	MG/KG	78.9 B	444 B	653 B	446 B	735 B	94.1 B
SODIUM	MG/KG		55.9 JB	71.5 JB	64.3 J	75.6 J	
VANADIUM	MG/KG	2.6 JB	42.5 J	22.4 J	16.7	20.3	5.7 B
ZINC	MG/KG				5.6	7.7	

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-6
SITE 48 SOIL DATA SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TCLP AND RCRA

Sample No:		48-B7-00	48-B7-00D	48-B7-03
Parameter	Units			
Volatiles				
Vinyl Chloride	UG/L	10 U	10 U	10 U
1,1-DCE	UG/L	10 U	10 U	10 U
Chloroform	UG/L	10 U	10 U	10 U
1,2-DCA	UG/L	10 U	10 U	10 U
2-Butanone	UG/L	10 U	10 U	10 U
Carbon Tetrachloride	UG/L	10 U	10 U	10 U
Trichloroethene	UG/L	10 U	10 U	10 U
Benzene	UG/L	10 U	10 U	10 U
Tetrachloroethane	UG/L	10 U	10 U	10 U
Chlorobenzene	UG/L	10 U	10 U	10 U
Semivolatiles				
Pyridine	UG/L	33 U	33 U	33 U
2,4-Dinitrotoluene	UG/L	33 U	33 U	33 U
Hexachlorobenzene	UG/L	33 U	33 U	33 U
Nitrobenzene	UG/L	33 U	33 U	33 U
1,4-Dichlorobenzene	UG/L	33 U	33 U	33 U
Methylphenols (total)	UG/L	33 U	33 U	33 U
Pentachlorophenol	UG/L	83 U	83 U	83 U
2,4,5-Trichlorophenol	UG/L	83 U	83 U	83 U
2,4,6-Trichlorophenol	UG/L	33 U	33 U	33 U
Pesticides				
Gamma-BHC	UG/L	0.17 U	0.17 U	0.17 U
Heptachlor	UG/L	0.17 U	0.17 U	0.17 U
Heptachlor Epoxide	UG/L	0.17 U	0.17 U	0.17 U
Endrin	UG/L	0.33 U	0.33 U	0.33 U
Methoxychlor	UG/L	1.7 U	1.7 U	1.7 U
Alpha-Chlordane	UG/L	0.17 U	0.17 U	0.17 U
Gamma-Chlordane	UG/L	0.17 U	0.17 U	0.17 U
Toxaphene	UG/L	17 U	17 U	17 U
Metals				
Arsenic	UG/L	40.00 U	40.00 U	40.00 U
Barium	UG/L	404.00	224.00	1850.00 U
Cadmium	UG/L	8.40 B	6.40 B	2.00 U
Chromium	UG/L	3.60 U	63.90	3.60 U
Lead	UG/L	22.00 U	36.00 B	68.50 U
Mercury	UG/L	0.04 U	0.04 U	0.04 U
Selenium	UG/L	248.00	187.00 B	50.00 U
Silver	UG/L	2.00 U	2.00 U	2.00 U
Herbicides				
2,4-D	UG/L	30 U	30 U	30 U
2,4,5-TP (Silvex)	UG/L	10 U	10 U	10 U
Inorganics				
Alkalinity	MG/KG	232	NA	20 U
Chloride	MG/KG	20 U	NA	20 U
Flashpoint	F	>200	NA	>200
Fluoride	MG/KG	4	NA	2 U
pH	S.U.	7.95	NA	4.5
Total Nitrogen	MG/KG	510	NA	132
TOC	MG/KG	12000	NA	1300

NOTES:
U - not detected above the Contract Required Quantitation Limit (CRQL)
B - reported value is less than the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL).
NA - not analyzed
UG/L - microgram per liter
MG/KG - milligram per kilogram

from previous investigations (see Section 1.3) exhibited similar levels of mercury and other inorganics. Inorganics may be naturally elevated at this section of the base.

4.2 Groundwater Investigation

The Groundwater Investigation focused on three areas of concern that were identified via historical photographs. These areas, as well as the sampling program, were discussed previously in Section 2.5.

Organics detected in monitoring wells above the sample quantitation limit are presented on Table 4-7. A summary of the complete groundwater database for organic analysis, including the concentration range of contaminants and frequency of occurrence, is provided in Appendix G.

As shown on Table 4-7, low levels of trichloroethene (TCE) (1 µg/l, maximum), and phenol (3 µg/l maximum) were detected in monitoring wells 48GW3 and 48GW5 (see Figure 2-3). Monitoring well 48GW3 is located near an area that was documented as a suspected disposal area in the EPA EPIC report. Monitoring well 48GW5 is located southeast of Building AS804. Well 48GW5 was established as a downgradient well. The horizontal extent of this contamination is limited because other wells north (48GW2 and 48GW4) and southwest (48GW1) of the suspected disposal area do not exhibit TCE or phenol. Well 48GW3 also exhibited methylene chloride (12 µg/l) and bis(2-ethylhexyl)phthalate (2 µg/l), which are common laboratory contaminants. Note that methylene chloride (5 µg/l maximum) was detected in trip blanks and field blanks, and that bis (2-ethylhexyl) phthalate (2 µg/l) was detected in field blanks. These levels further suggest that the presence of methylene chloride and bis (2-ethylhexyl) phthalate in groundwater samples are due to laboratory contamination.

Acenaphthalene (2 µg/l) and bis(2-ethylhexyl)phthlate (1 µg/l) were detected in monitoring well 48GW4, which was established to monitor groundwater quality at the suspected disposal area north of Building AS804 (see Figures 2-1 and 2-3). The bis(2ethylhexyl)phthalate is believed to be associated with laboratory contamination. The acenaphthalene was detected at very low levels and in only one monitoring well. The extent of this contamination is limited to the area around well 48GW4.

None of the organic contaminants detected in groundwater were observed in soil. None of the organic soil contaminants (e.g., pesticides) were detected in groundwater.

TABLE 4-7
SITE 48 GROUNDWATER
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
ORGANICS

	Sample No:	48-GW3-1	48-GW4-1	48-GW5-1
	Depth:	N/A	N/A	N/A
	Date Sampled:	10/9/92	10/8/92	10/8/92
	Lab Id:	00567-05	00567-09	00567-11
Parameter	Units			
METHYLENE CHLORIDE	UG/L	12 J		
TRICHLOROETHENE	UG/L	1.0		1.0
PHENOL	UG/L	1 J		3 J
ACENAPHTHENE	UG/L		2 J	
BIS(2-ETHYLHEXYL)PHTHALATE	UG/L	2 J	1 J	

N/A - Not applicable
UG/L - microgram per liter
J - value is estimated

Inorganics detected in monitoring wells above the sample quantitation limit are presented on Table 4-8 for total metals analysis and Table 4-9 for dissolved metals analysis. A summary of the complete groundwater database for inorganic analysis, including the concentration range of contaminants and frequency of occurrence, is provided in Appendix G. Dissolved metals were generally detected at slightly lower concentrations than total metals.

Manganese was the only inorganic contaminant detected above the State of North Carolina Water Quality Standards (WQS) of 50 µg/l in three of the five monitoring wells (wells 48GW1, -2, and -3). Monitoring wells GW1 and GW3 are located at suspected disposal areas. Monitoring well GW2 is located north of the disposal area between Building AS804 and the intermittent tributary to the New River. The well locations are shown on Figure 2-3. Soil samples collected from the monitoring well test borings and other test borings did not exhibit elevated levels of manganese. The levels of manganese in surface soil were below base-specific background levels. Subsurface manganese levels were either slightly above or below base-specific background levels. The source of elevated manganese levels in groundwater does not appear to be site-related.

With respect to manganese contamination, it has been reported that manganese has consistently been detected above State standards in potable supply wells throughout the base along with aluminum and iron (Greenhorne & O'Mara, Inc, 1992). Concentrations of manganese in base potable supply wells ranged from 50 µg/l to 120 µg/l. The presence of manganese in groundwater is not believed to be a result of former disposal activities at Site 48 since manganese is naturally present in the environment. Further, there is no source at Site 48 associated with elevated manganese levels in groundwater.

Many other inorganic constituents were detected in shallow groundwater at Site 48. None of these constituents were detected above State or Federal groundwater standards. Mercury was not detected above Contract Required Detection Limits (CRDLs) in any of the five monitoring wells.

A groundwater sample was also collected from monitoring well 48GW3 and analyzed for chemical engineering parameters for evaluation of potential treatment options. Reported COD, TDS, and TTS values were 20 milligrams per liter (mg/L), 840 mg/L, and 503 mg/L, respectively. The TSS in the groundwater slightly exceeded the Federal Secondary MCL of

TABLE 4-8
SITE 48 GROUNDWATER
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-GW1-1	48-GW2-1	48-GW3-1	48-GW4-1	48-GW5-1
Depth:		N/A	N/A	N/A	N/A	N/A
Date Sampled:		10/8/92	10/8/92	10/9/92	10/8/92	10/8/92
Lab Id:		00567-01	00567-03	00567-05	00567-09	00567-11
Parameter	Units					
ALUMINUM	UG/L	1750 J	1680 J	6830 J	382 J	
BARIUM	UG/L	29.4 JB	30.4 JB	51.3 B	18 JB	27 JB
CADMIUM	UG/L	2.5 JB	3.3 JB	2.5 JB	2.2 JB	2.2 JB
CALCIUM	UG/L	46300	77000	115000	30600	69300
CHROMIUM	UG/L		5.8 B	17.5		
COBALT	UG/L		2.8 JB	4.2 JB		
COPPER	UG/L		13.5 JB	4.2 JB		3.1 JB
IRON	UG/L	5190	9520	11900	4430	1900
MAGNESIUM	UG/L	1460 B	1950 B	3300 B	1340 B	2160 B
MANGANESE	UG/L	70.6 J	272	585	38.1 J	42 J
MERCURY	UG/L	0.09 B	0.09 B	0.09 B	0.04 B	
POTASSIUM	UG/L	970 B	1230 B	1800 B	837 B	859 B
SODIUM	UG/L	5750	8760	7860	6470	7960
VANADIUM	UG/L	3.4 JB	4 JB	12.8 JB		
ZINC	UG/L			30.3		

N/A - Not applicable
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-9
SITE 48 GROUNDWATER
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
DISSOLVED METALS

	Sample No:	48-GW1D-1	48-GW2D-1	48-GW3D-1	48-GW4D-1	48-GW5D-1
	Depth:	N/A	N/A	N/A	N/A	N/A
	Date Sampled:	10/8/92	10/8/92	10/9/92	10/8/92	10/8/92
	Lab Id:	00567-02	00567-04	00567-06	00567-10	00567-12
Parameter	Units					
BARIUM	UG/L	17.5 JB	20.7 JB	23.6 JB	16.8 JB	27.6 JB
CADMIUM	UG/L		3.1 JB			
CALCIUM	UG/L	49800	68200	72600	32400	80700
COBALT	UG/L			2.2 JB		2.2 JB
COPPER	UG/L	5 JB	2.6 JB		7.6 JB	6.7 JB
IRON	UG/L	3180		380 J	4080	1760
MAGNESIUM	UG/L	1530 B	1640 B	2220 B	1460 B	2480 B
MANGANESE	UG/L	72.2 J	241	539	39.7 J	47.4 J
MERCURY	UG/L	0.09 B		0.05 B	0.06 B	0.07 B
POTASSIUM	UG/L	1050 B	912 B	1100 B	948 B	1050 B
SODIUM	UG/L	6430	8510	7910	7060	8920

N/A - Not applicable
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

500 mg/L. BOD and TVS levels were not detected above method reporting limits. Results of the chemical engineering parameters are presented in Appendix K.

Field measurements including pH, temperature, and specific conductance were obtained during the groundwater sampling investigation. Results of the field measurements and well purging volumes are provided on Table 4-10. Specific conductance, pH, and temperature values from the five wells ranged from 194 to 489 micromhos/cm, to 6.22 to 7.02 Standard Units (slightly acidic to slightly alkaline), and 20.7 to 20.0°C, respectively. These ranges are consistent with typical values of natural waters (Pagenkopt, 1978).

In summary, groundwater contamination at Site 48 is primarily limited to trace levels of TCE, phenol, and acenaphthalene, and manganese. The extent of groundwater contamination is limited based on the levels detected in the wells. The source of groundwater contamination is not believed to be site related, based on the review of soil analyses. Mercury was not detected above the CRDL, or above State or Federal groundwater standards.

4.3 Surface Water and Sediment

Surface water and sediment samples were collected from the intermittent tributary, the marsh area, and the New River. Section 2.6 of this report discusses the sampling locations and analytical program. The sampling locations are depicted on Figure 2-5. The following subsections discuss the nature and extent of contamination for each area.

4.3.1 Intermittent Tributary

The following sections discuss the nature and extent of surface water and sediment contamination in the intermittent tributary.

4.3.1.1 Surface Water

Various inorganic constituents were detected in surface water at all three sampling stations (see Table 4-11). The most downstream sampling location (Station 48-IT3), which is located near the point where the intermittent tributary discharges into the marsh, exhibited slightly higher inorganic concentrations than either upstream location. However, there is no "order of magnitude" difference between the inorganic concentrations between the three stations that would indicate that the higher levels at Station 48-IT3 is due to previous disposal activities at

TABLE 4-10

SUMMARY OF GROUNDWATER FIELD PARAMETERS
SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No. / Date of Measurement	Depth of Well (ft) (1)	Purge Volume (gals)	Field Parameters			
			Well Volume	Specific Conductance at 25C (cm/µmhos)	Temperature (C)	pH (S.U.)
48GW1			1	350	21.7	6.75
			2	299	20.9	6.73
10/08/92	19.4	50.5	3	300	21.0	6.74
			4	313	20.9	6.67
			5	312	21.0	6.67
48GW2			1	429	21.1	6.96
			2	398	21.1	6.93
10/08/92	20.7	57	3	409	21.2	6.93
			4	392	21.1	6.88
			5	358	21.1	6.97
48GW3			1	489	21.8	7.02
			2	474	22.0	6.94
10/09/92	24.0	60	3	444	22.0	6.99
			4	411	22.0	6.91
			5	391	22.0	6.97
48GW4			1	322	21.4	6.51
			2	235	21.3	6.38
10/08/92	24.0	66	3	216	21.3	6.29
			4	203	21.3	6.28
			5	194	21.1	6.22
48GW5			1	411	21.3	6.72
			2	379	20.8	6.67
10/08/92	24.7	65	3	361	20.7	6.64
			4	365	20.7	6.73
			5	353	20.8	6.70

Notes: (1) Well depth taken from below ground surface (bgs).

TABLE 4-11
SITE 48 INTERMITTENT TRIBUTARY SURFACE WATER
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No.:		48-IT1-SW-06	48-IT2-SW-06	48-IT3-SW-06
Depth:		N/A	N/A	N/A
Date Sampled:		8/30/92	8/30/92	9/2/92
Lab Id:		00464-05	00464-06	00488-03
Parameter	Units			
ALUMINUM	UG/L	1360		854 J
BARIUM	UG/L	29 B	64.2 B	18 JB
CALCIUM	UG/L	40900	51200	56900 J
CHROMIUM	UG/L			7 B
COPPER	UG/L			4 JB
IRON	UG/L	3650	798	932 J
LEAD	UG/L	1.4 JB		2.4 JB
MAGNESIUM	UG/L	55800	115000	140000 J
MANGANESE	UG/L	38.5 J	27.7 J	20 J
MERCURY	UG/L	0.04 B		0.04 B
POTASSIUM	UG/L	19300	41400	52400
SODIUM	UG/L	485000	904110 J	1410000 J
VANADIUM	UG/L	3.5 JB		4 JB

N/A - Not applicable
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

Site 48. For some constituents, upstream surface water sampling locations exhibited higher inorganic levels than downstream sampling locations. Because of tidal influence, this in not uncommon.

Mercury was detected at low levels (0.04 mg/kg) at two sampling stations, 48-IT1 and 48-IT3. Station 48-IT1 is located approximately 500 feet upstream of the site. The level of mercury is below the CRDL, but above the laboratory instrument detection level (IDL). The level of mercury exceeds both State and Federal water quality standards for the protection of aquatic life (0.025 µg/l).

4.3.1.2 Sediment

Inorganic constituents were detected at all three sample locations. Table 4-12 summarizes the positive detections of inorganics. A complete summary of inorganic constituents for intermittent tributary sediment is presented in Appendix G.

With the exception of lead and zinc, sample stations adjacent to the Site 48 (i.e., Stations IT2 and IT3) exhibited higher levels of inorganics than the upstream location. Subsurface sediment samples (collected from a depth of approximately 6 to 12 inches) exhibited similar levels of inorganics compared to surface sediment samples. Station IT3 subsurface sediment inorganic levels were slightly higher than the corresponding surface sediment sample. Mercury was detected at Station IT3 in both the surface sediment (0.06 mg/kg) and subsurface sediment (0.17 mg/kg) sample. The source of the mercury at this location may be associated with offsite migration of mercury from the site, or from other sources upstream from the site.

4.3.1.3 Summary of Surface Water and Sediment Results (Intermittent Tributary)

Mercury levels slightly exceeded State and Federal water quality standards in the intermittent tributary upstream and adjacent to Site 48 (refer to Section 6.4.2 for media-specific contaminant values with ARARs). The source of mercury in surface water could either be associated with other sources (since upstream levels also exceeded surface water standards), sediment contamination, or from groundwater discharge. Groundwater discharge, as the source of surface water contamination, is unlikely given that relatively low mercury levels (mercury was present at a maximum level of 0.09 µg/l) in groundwater would not be expected to impact surface water quality.

TABLE 4-12
SITE 48 INTERMITTENT TRIBUTARY SEDIMENT
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No.:		48-IT1-SD-06	48-IT1-SD-612	48-IT2-SD-06	48-IT2-SD-612	48-IT3-SD-06	48-IT3-SD-612
Depth:		0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
Date Sampled:		8/30/92	8/30/92	8/30/92	8/30/92	9/2/92	9/2/92
Lab Id:		00464-01	00464-02	00464-03	00464-04	00488-01	00488-02
Parameter	Units						
ALUMINUM	MG/KG	2600	1700	5700	4110	5520	13600
ARSENIC	MG/KG	2.5 B	1.1 B	1 B		4	5.5 B
BARIUM	MG/KG	12.6 B	4.2 JB	7.3 B	9.4 B	7.3 B	20.8 B
BERYLLIUM	MG/KG	0.08 B	0.06 B	0.21 B	0.14 B	0.33 B	0.69 B
CADMIUM	MG/KG	1.7 J	0.84 JB	1.1 JB	0.59 JB	2 J	4.2 J
CALCIUM	MG/KG	1120 B	1340	1520	2060	1160 B	6210
CHROMIUM	MG/KG					7.8	11.8
COBALT	MG/KG	0.65 JB			0.6 JB	0.98 JB	1.4 JB
COPPER	MG/KG	5.1 JB	5.9 J	2.6 JB		8.8 J	4.2 JB
IRON	MG/KG	7190	4890	4580	2350	8580	24700
LEAD	MG/KG	34.1	12.6	7.9	6.4	13.6	11.6
MAGNESIUM	MG/KG	338 B	297 B	1110 B	142 B	1160 B	4330
MANGANESE	MG/KG	4.9 J	6.3 J	5.7 J	6.8 J	16 J	69.4
MERCURY	MG/KG					0.06 JB	0.17 JB
POTASSIUM	MG/KG	144 B	100 B	352 B	119 B	418 B	1230 B
SODIUM	MG/KG	248 JB		731 JB		1560 B	7390
VANADIUM	MG/KG	9.8 B	5.5 B	6.8 B	6 B	18.3	18.8 B
ZINC	MG/KG	38.8	18.2	6.8			

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

Site 48 is not likely acting as a continual source of mercury contamination in the intermittent stream based on the results of the soil and groundwater investigations.

4.3.2 Marsh Area

The following sections discuss the nature and extent of surface water and sediment contamination at the marsh located near Site 48.

4.3.2.1 Surface Water

Inorganic levels detected in the marsh are similar to those levels detected in the intermittent stream and to concentration levels from previous site investigations (see Section 1.3). Mercury was detected in both surface water samples at 0.05 µg/l, which is above State and Federal water quality standards. The levels of mercury in the marsh are also similar to the levels detected in the intermittent tributary. The source of mercury in surface water may be due to previous disposal activities at the site, sediment contamination (see Section 4.3.2.2), or other sources along the New River or the intermittent tributary (the area is tidally influenced). Table 4-13 summarizes the positive detections of inorganics. Soil and groundwater data collected from the site do not indicate significant levels of mercury contamination that could be correlated with an existing source of mercury contamination in the marsh.

4.3.2.2 Sediment

Sediment samples were collected from the same locations where surface water samples were collected. Section 2.6 summarized the sampling and analytical program. The sampling locations are depicted on Figure 2-5.

Inorganic constituents were detected in surface and subsurface sediments at both sampling locations. The inorganic levels detected in the marsh area are comparable to the intermittent tributary. The positively detected inorganics are presented on Table 4-14. Station MA7 represents the northern portion of the marsh and Station MA8 represents the middle portion of the marsh. Neither area exhibited a significant difference in inorganic contaminant levels. Surface and subsurface sediment quality was relatively comparable given the limited database (i.e., no order of magnitude difference in inorganic levels).

TABLE 4-13
SITE 48 MARSH AREA SURFACE WATER
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

	Sample No.:	48-MA7-SW-06	48-MA8-SW-06
	Depth:	N/A	N/A
	Date Sampled:	9/2/92	9/2/92
	Lab Id:	00488-06	00488-09
Parameter	Units		
ALUMINUM	UG/L	631 J	919 J
BARIUM	UG/L	19.1 JB	17.5 JB
CALCIUM	UG/L	40000 J	47100 J
COPPER	UG/L	3 JB	6 JB
IRON	UG/L	1560 J	1430 J
LEAD	UG/L	2 B	1.6 JB
MAGNESIUM	UG/L	62600 J	100000 J
MANGANESE	UG/L	48 J	31 J
MERCURY	UG/L	0.05 B	0.05 B
POTASSIUM	UG/L	22500	36700
SODIUM	UG/L	604000 J	1020000 J
VANADIUM	UG/L		2 JB

N/A - Not applicable
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-14
SITE 48 MARSH AREA SEDIMENT
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No.:		48-MA7-SD-06	48-MA7-SD-612	48-MA8-SD-06	48-MA8-SD-612
Depth:		0-6"	6-12"	0-6"	6-12"
Date Sampled:		9/2/92	9/2/92	9/2/92	9/2/92
Lab Id:		00488-04	00488-05	00488-07	00488-08
Parameter	Units				
ALUMINUM	MG/KG	4480	7100	11500	26300
ARSENIC	MG/KG	3.6 B	1.8 JB	3.1	7.4
BARIUM	MG/KG	12.6 B	13.6 B	11.4 B	32 B
BERYLLIUM	MG/KG	0.43 B	0.4 B	0.24 B	0.84 B
CADMIUM	MG/KG	1.7 JB	1.2 JB	2.2 J	2.9 J
CALCIUM	MG/KG	1480 B	1920 B	475 B	2510
CHROMIUM	MG/KG	7.3	8.1	12.5	29.9
COBALT	MG/KG	1.3 JB	1.2 JB	1.4 JB	2.9 B
COPPER	MG/KG	3.5 JB	2 JB	1.9 JB	6.7 JB
IRON	MG/KG	9380	7230	8710	20100
LEAD	MG/KG	11.8	9.3	10.8	19.5
MAGNESIUM	MG/KG	1190 B	983 B	1140 B	3690
MANGANESE	MG/KG	14.2 J	30.7	12.8 J	30.3
MERCURY	MG/KG	0.08 JB	0.07 JB	0.05 JB	0.1 JB
NICKEL	MG/KG		3.6 JB	2.1 JB	6.3 JB
POTASSIUM	MG/KG	418 B	468 B	773 B	2010 B
SODIUM	MG/KG	1680 B	839 B	1210	4200
VANADIUM	MG/KG	14.2 B	14.2 B	22.4	47.2

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

Mercury was detected in the surface and subsurface sediments at both locations ranging from 0.07 mg/kg to 0.10 mg/kg. Similar levels of mercury were detected during previous site investigations (see Section 1.3).

4.3.2.3 Summary of Surface Water and Sediment Contamination (Marsh)

Surface water and sediment quality in the marsh does not appear to have been impacted by previous mercury disposal activities at Site 48. Surface water quality for mercury just exceeds State and Federal water quality standards. Based on the current groundwater quality at Site 48, and the levels of mercury in soil at Site 48, it is unlikely that Site 48 is the source of mercury contamination in the marsh area.

4.3.3 New River

The following sections discuss the nature and extent of surface water and sediment contamination in the New River.

4.3.3.1 Surface Water

Surface water samples were collected adjacent to Site 48 (Stations 48NR4 and -5), upstream of the site (Station 48NR9), offshore of the site (48NR10), downstream of the site (Station 48NR6) as shown on Figure 2-5. The sampling procedures and analytical program are discussed in Section 2.6.

Table 4-15 summarizes only the positive detections of organics for samples collected from the New River. A complete summary of all surface water analyses is provided in Appendix G.

Organic contamination in the New River is limited to low levels of toluene (3 µg/l maximum) and total xylenes (2 - 4 µg/l) at Stations NR4 and NR9. Station NR4 is located adjacent to Site 48 and Station NR9 is located approximately 400 feet upstream of the site. The source of this contamination is unknown, but most likely not from Site 48 since neither groundwater or soil were contaminated with these contaminants. The concentrations of these contaminants do not exceed either State or Federal water quality standards.

Inorganic constituents detected in the New River are summarized on Table 4-16. A complete summary of all inorganic analyses is provided in Appendix G. Surface water sample stations

TABLE 4-15
SITE 48 NEW RIVER SURFACE WATER
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
ORGANICS

Sample No.:		48-NR4-SW-06	48-NR9-SW-06
Depth:		0-6"	0-6"
Date Sampled:		9/2/92	9/2/92
Lab Id:		00488-14	00488-21
Parameter	Units		
TOLUENE	UG/L	3 J	3 J
TOTAL XYLENES	UG/L	2 J	4 J

N/A - Not applicable
UG/L - microgram per liter
J - value is estimated

TABLE 4-16
SITE 48 NEW RIVER SURFACE WATER
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No.:		48-NR10-SW-06	48-NR4-SW-06	48-NR5-SW-06	48-NR6-SW-06	48-NR9-SW-06
Depth:		N/A	N/A	N/A	N/A	N/A
Date Sampled:		9/2/92	9/2/92	9/2/92	9/2/92	9/2/92
Lab Id:		00483-09	00488-14	00488-18	00483-05	00488-21
Parameter	Units					
ALUMINUM	UG/L		1410 J	1260 J	365	2070 J
ANTIMONY	UG/L					
ARSENIC	UG/L					
BARIUM	UG/L	14.9 JB	20.5 JB	19.4 JB	16.1 JB	19.7 JB
CALCIUM	UG/L	55700	69700 J	66900 J	58500	64200 J
CHROMIUM	UG/L					4 B
COPPER	UG/L		3 JB	4 JB		3 JB
IRON	UG/L	298	1390 J	1290 J	525	1670 J
LEAD	UG/L		1.5 JB	2.6 JB		3 J
MAGNESIUM	UG/L	138000	173000 J	167000 J	144000	160000 J
MANGANESE	UG/L	15.5 J	21 J	20 J	17.1 J	20 J
MERCURY	UG/L					
POTASSIUM	UG/L	51300	66000	62700	53800	59900
SODIUM	UG/L	1280000	1720000 J	1730000 J	1340000	1480000 J
VANADIUM	UG/L		2 JB	3 JB		3 JB

N/A - Not applicable
UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

NR4, NR5, and NR10, which are closest to the site, do not exhibit significantly higher levels of inorganic contamination when compared to upgradient station NR9. In most cases, the variance between these stations and the upgradient station is less than 10 percent. None of the five sampling stations exhibited mercury.

4.3.3.2 Sediment

Sediment samples were collected from the surface and subsurface at 12 locations. Five of these locations correspond to the surface water sampling stations. The other nine stations represent the immediate shoreline near the site as shown on Figure 2-5. Only sediment samples were collected from these locations for purposes of determining the potential migration of mercury from Site 48 via surface runoff.

Tables 4-17 and 4-18 summarize the positive detections of organics and inorganics in New River sediments. A complete summary of analyses is provided in Appendix G.

Pesticides were detected in surface and subsurface sediment samples collected from Stations NR4 and NR5. Both stations are located along the shoreline near Site 48. The pesticides included 4,4'-DDE (4.7 to 149 µg/kg), 4,4'-DDD (17 to 32 µg/kg), and 4,4'-DDT (8.3 µg/kg). The presence of pesticides in subsurface sediment samples may be indicative of historical use in this area.

Polynuclear aromatic hydrocarbons (PAHs) were also detected at low levels at both Stations NR4 and NR5. Station NR4 exhibited low levels of PAHs in the subsurface sediment soil sample while Station NR5 exhibited contamination in only the surface sediment sample.

Other stations along the New River did not exhibit pesticides or PAHs in sediment. The pesticide and PAH contamination is limited to the study area. Because no organic analyses were performed on sediment samples collected from the marsh or intermittent tributary, it is unknown whether more widespread pesticide or PAH contamination exists. The source of the pesticides is likely from pest control activities as opposed to disposal activities. Only one soil sample collected from the surface at location SB3 revealed pesticide contamination at low levels. The source of PAH contamination is unknown. Surface soil and subsurface soil did not exhibit PAH contamination.

TABLE 4-17
SITE 48 NEW RIVER SEDIMENT
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
ORGANICS

	Sample No.:	48-NR4-SD-06	48-NR4-SD-612	48-NR5-SD-06	48-NR5-SD-612
	Depth:	0-6"	6-12"	0-6"	6-12"
	Date Sampled:	9/2/92	9/2/92	9/2/92	9/2/92
	Lab Id:	00488-12	00488-13	00488-15	00488-16
Parameter	Units				
4,4'-DDE	UG/KG	4.7 J	149	65 J	18 J
4,4'-DDD	UG/KG	17 J	32	32 J	23 J
4,4'-DDT	UG/KG			8.3 J	
CARBON DISULFIDE	UG/KG		3 J		
PHENANTHRENE	UG/KG			100 J	
FLUORANTHENE	UG/KG		57 J	160 J	
PYRENE	UG/KG		56 J	120 J	
BENZO(A)ANTHRACENE	UG/KG			72 J	
CHRYSENE	UG/KG			62 J	
BENZO(B)FLUORANTHENE	UG/KG			73 J	
BENZO(A)PYRENE	UG/KG		180 J	65 J	
INDENO(1,2,3-CD) PYRENE	UG/KG			44 J	
BENZO(G,H,I)PERYLENE	UG/KG			46 J	

N/A - Not applicable
UG/L - microgram per liter
J - value is estimated

TABLE 4-18
SITE 48 NEW RIVER SEDIMENT
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-NR10-SD-06	48-NR10-SD-612	48-NR4-SD-06	48-NR4-SD-612	48-NR5-SD-06	48-NR5-SD-612	48-NR6-SD-06
Depth:		0-6	6-12	0-6	6-12	0-6	6-12	0-6
Date Sampled:		9/2/92	9/2/92	9/2/92	9/2/92	9/2/92	9/2/92	9/2/92
Lab Id:		00483-06	00483-08	00488-12	00488-13	00488-15	00488-16	00483-04
Parameter	Units							
ALUMINUM	MG/KG	502 J	917 J	6740	17200	5160	4740	7700 J
ANTIMONY	MG/KG					3.4 JB		
ARSENIC	MG/KG		0.86 B	4.2	4.4	5.2	10.7	1.3 B
BARIUM	MG/KG	2.9 JB	3.2 JB	8.5 B	21.4 B	4.9 JB	5.7 JB	7 B
BERYLLIUM	MG/KG			0.24 B	0.59 B	0.23 B	0.23 B	0.19 B
CADMIUM	MG/KG		0.55 JB	1.9 J	2.6 J	1.4 J	1.4 J	1.2 JB
CALCIUM	MG/KG		182 JB	819 B	1060 B	486 B	371 B	581 JB
CHROMIUM	MG/KG	1.1 B	1.5 B	12.6	22.9	9.1	11.8	11.4
COBALT	MG/KG			0.71 JB	2.1 JB	1.6 JB	0.91 JB	0.57 JB
COPPER	MG/KG			5.7 JB	6.2 JB	5.9 J	2 JB	12.6 J
IRON	MG/KG	801	1540	14700	14400	10400	15000	6380
LEAD	MG/KG		6.2	17.9	22.5	7.5	6.8	10
MAGNESIUM	MG/KG	157 JB	252 JB	1350	2150	3510	414 B	929 JB
MANGANESE	MG/KG	2.7 JB	4 J	10.4 J	26.7	10.3 J	10.7 J	9.3 J
MERCURY	MG/KG			0.05 JB	0.07 JB	0.04 JB	0.03 JB	
NICKEL	MG/KG				3.5 JB			
POTASSIUM	MG/KG		98 B	741 B	1350 B	386 B	304 B	579 B
SODIUM	MG/KG	518 JB	602 JB	1930	2450	621 JB	410 JB	1070 B
VANADIUM	MG/KG	1.8 JB	3.5 JB	38.2	37.9	23.9	35.2	19
ZINC	MG/KG							13.4

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-18 (CONTINUED)
SITE 48 NEW RIVER SEDIMENT
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-NR9-SD-06	48-NR9-SD-612	48-NRSD1-SD-06	48-NRSD1-SD-612	48-NRSD2-SD-06	48-NRSD2-SD-612	48-NRSD3-SD-06
Depth:		0-6	6-12	0-6	6-12	0-6	6-12	0-6
Date Sampled:		9/2/92	9/2/92	8/30/92	8/30/92	8/30/92	8/30/92	8/30/92
Lab Id:		00488-19	00488-20	00464-07	00464-08	00464-09	00464-10	00464-11
Parameter	Units							
ALUMINUM	MG/KG	897	2900	9360	7130	13000	2750	4460
ANTIMONY	MG/KG		4.9 JB					
ARSENIC	MG/KG	0.76 B	0.83 JB	4 B	2.9 B	5.9	2.4 B	3.4 B
BARIUM	MG/KG	3.2 JB	6 JB	12.7 B	10.6 B	15.7 B	4.1 JB	7 JB
BERYLLIUM	MG/KG		0.32 B	0.23 B	0.16 B	0.29 B	0.1 B	0.13 B
CADMIUM	MG/KG		0.96 JB	3.8 J	2.1 J	3.2 J	1.2 JB	1.5 JB
CALCIUM	MG/KG	190 B	862 B	2360 B	1210 B	1480 B	523 B	1200 B
CHROMIUM	MG/KG	1.8 B	6.1		10.1 J	17.1		
COBALT	MG/KG		0.96 JB	1.7 JB	0.81 JB	1.4 JB		1 JB
COPPER	MG/KG	1.5 JB	1.6 JB	17.4 J	8.5 JB	7.4 JB		12.6 J
IRON	MG/KG	1180	3570	16900	11800	16800	7600	11100
LEAD	MG/KG	3	2.2	28.9	37.4	30.8	6.3	24.4
MAGNESIUM	MG/KG	247 B	979 B	2580 B	1420 B	1920	580 B	1300 B
MANGANESE	MG/KG	3.1 JB	18.2	30.1 J	19.2 J	23 J	16.3 J	12.5 J
MERCURY	MG/KG	0.03 JB	0.04 JB					
NICKEL	MG/KG							
POTASSIUM	MG/KG	120 B	369 B	989 B	682 B	1000 B	288 B	471 B
SODIUM	MG/KG	698 JB	2560	6160	2760	2510	1230 B	2840
VANADIUM	MG/KG	2.4 JB	5.1 JB	26.8	20.1	38.5	15.4	20.7
ZINC	MG/KG			58.8	37.8	30	3.5 B	30.6

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-18 (CONTINUED)
SITE 48 NEW RIVER SEDIMENT
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-NRSD3-SD-612	48-NRSD4-SD-06	48-NRSD4-SD-612	48-NRSD5-SD-06	48-NRSD5-SD-612	48-NRSD6-SD-06	48-NRSD6-SD-612
Depth:		6-12	0-6	6-12	0-6	6-12	0-6	6-12
Date Sampled:		8/30/92	8/30/92	8/30/92	8/30/92	8/30/92	8/30/92	8/30/92
Lab Id:		00464-12	00464-13	00464-15	00464-16	00464-17	00464-18	00464-19
Parameter	Units							
ALUMINUM	MG/KG	6970	9660 J	12600	10600	15900	4130	9240
ANTIMONY	MG/KG							
ARSENIC	MG/KG	5.4	5.5 B	5.5	8.3	6.3	7.7	11.2
BARIUM	MG/KG	8.8 B	14.2 B	16.3 B	15.6 B	16.3 B	7.3 B	13.5 B
BERYLLIUM	MG/KG	0.23 B	0.19 B	0.23 B	0.39 B	0.32 B	0.47 B	0.35 B
CADMIUM	MG/KG	2.6 J	3.9 J	3 J	4.5 J	3.3 J	5.6 J	3.3 J
CALCIUM	MG/KG	1090 B	3150	1760	2690 B	2280	1320	2600
CHROMIUM	MG/KG	11.4		17.3	17.4 J	21.8	23.5	19.7
COBALT	MG/KG	0.72 JB	1.4 JB	1.2 JB	3.4 JB	0.91 JB	1.3 JB	4 B
COPPER	MG/KG	3.3 JB	29.2	7.6 JB	42.5	6.9 JB	11.7	26.7
IRON	MG/KG	13800	17500	15200	22200	17800	40100	19000
LEAD	MG/KG	12.7	36.5	28.4	43.9	27.2	23.6	86.2
MAGNESIUM	MG/KG	1470	2900 B	2000	3040 B	2060	1140	2530
MANGANESE	MG/KG	12.8 J	30.7 J	24.6 J	35.6 J	24.3 J	47.1	40.7
MERCURY	MG/KG							
NICKEL	MG/KG							
POTASSIUM	MG/KG	696 B	1030 B	1340 B	1190 B	1480 B	605 B	988 B
SODIUM	MG/KG	2220	5700	2450	5250	1460 B	681 JB	4600
VANADIUM	MG/KG	34.4	28.4 B	30.9	38.8	35.8	104	36.8
ZINC	MG/KG	18.5	68.2 J	30.6	72.3	31.1	45.7	73.2

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-18 (CONTINUED)
SITE 48 NEW RIVER SEDIMENT
POSITIVE DETECTION SUMMARY
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA
TOTAL METALS

Sample No:		48-NRSD7-SD-06	48-NRSD7-SD-612
Depth:		0-6	6-12
Date Sampled:		8/30/92	8/30/92
Lab Id:		00464-20	00464-21
Parameter	Units		
ALUMINUM	MG/KG	2870	3570
ANTIMONY	MG/KG		
ARSENIC	MG/KG	19.3	12 J
BARIUM	MG/KG	7.7 B	12.4 B
BERYLLIUM	MG/KG	0.39 B	0.38 B
CADMIUM	MG/KG	4.4 J	3.3 J
CALCIUM	MG/KG	960	7910
CHROMIUM	MG/KG	17 J	16.1 J
COBALT	MG/KG	1.8 B	0.77 JB
COPPER	MG/KG	8.7 J	10.8 J
IRON	MG/KG	31400 J	26700 J
LEAD	MG/KG	7.4 J	18 J
MAGNESIUM	MG/KG	1030	1060 B
MANGANESE	MG/KG	33.4	9.6 J
MERCURY	MG/KG		
NICKEL	MG/KG		
POTASSIUM	MG/KG	468 B	246 B
SODIUM	MG/KG	400 JB	1740 J
VANADIUM	MG/KG	89.7	69.4
ZINC	MG/KG	34.3	31.8

N/A - Not applicable
MG/KG - milligram per kilogram
B - reported value is less than Contract Required Detection Limit(CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

No inorganics detected in the sediment samples collected from the New River exceeded the NOAA sediment quality criteria (refer to Section 6.4.2 for comparisons of sediment values against EPA Region IV's sediment screening values). The levels of sediment detected in the sediment are believed to be consistent with base-background.

4.3.3.3 Summary of Surface Water and Sediment Contamination

Surface water quality in the New River does not appear to be impacted by previous activities at Site 48, primarily because no mercury was detected in surface water and only trace levels were detected in sediment. The low levels of toluene and xylene are not likely the result of previous disposal activities since one of the two locations where these constituents were detected is located approximately 400 feet upstream from Site 48.

Sediment quality has been impacted by pesticide spraying/control activities at the study area. The presence of pesticides and PAHs in sediment samples is not likely associated with previous disposal activities since site-related analytical data do not suggest a source area.

5.0 CONTAMINANT FATE AND TRANSPORT

This section contains a discussion on the various physical and chemical properties of contaminants detected at Site 48 that determine the behavior of the contaminants in the environment. The basis for the discussion of contaminant fate and transport is discussed in Section 4.0, Nature and Extent of Contamination. In addition, potential routes of migration are discussed.

The fate and transport analysis is not meant to result in a quantitative evaluation of the media-specific contaminant concentrations. Rather, the intent is to identify media that are receiving or may be receiving site-related contamination.

5.1 Chemical and Physical Properties

Empirically determined literature values which affect contaminant migration in environmental media such as specific gravity, vapor pressure, water solubility, octanol/water partition coefficients, organic carbon partition coefficients, and Henry's Law constants are not presented in this section. These values are only relevant to organic contaminants. The low frequency and low levels of detected organics are not attributable to the site. Inorganic contaminant fate and transport is affected primarily by the chemical and physical characteristics of the medium in which it results. Soil pH, redox potential (Eh), ion exchange capacity and soil particle size distribution effect the speciation of the inorganic contaminant. Similarly, groundwater pH and Eh directly affects dissolution and precipitation of reactions which affects the inherent mobility of an inorganic contaminant to migrate in the saturated subsurface.

5.2 Contaminant Persistence

This section discusses the transformation mechanisms that affect contamination persistence. In addition, this section discusses the physical and chemical properties which may determine the fate of contaminants detected at this site.

After an inorganic contaminant is released into the environment it may be impacted by any of the following transformation mechanisms:

- Transportation - convected downstream in water or on suspended sediment or through the atmosphere

- Physical transformation - volatilization or precipitation

- Chemical transformation - reduction, oxidation, speciation

- Biological transformation - biodegradation

- Accumulated in one or more media - soil, groundwater, surface water, sediment or air.

5.3 Potential Routes of Migration

This section identifies the potential release mechanisms and migration routes at Site 48. These mechanisms were identified through an evaluation of the analytical data base and known site characteristics.

The retention/release and transport of inorganic contaminants detected in site soil samples is affected by bulk density, particle-size distribution, pH, redox status (Eh), ion exchange capacity, and type and amount of organic matter. When the concentration of a metal exceeds the capacity of the soil to retain it, migration may take place as if the soil were an inert, porous medium. Surface soil samples collected at this site contain low levels of relatively immobile contaminants such as pesticides. The retention/release and transport of the organic contaminants is mainly affected by organic carbon partition coefficients and transportation.

Total and dissolved inorganics were also detected in groundwater samples. In contrast to most organic contaminants which are not initially present in the environment, metals occur naturally and cycle by biogeochemical processes throughout the environment. Consequently, the metals that are present in groundwater samples occur from natural sources. Low levels of trichloroethene were detected in groundwater samples. The low concentration and frequency of detection of this organic in groundwater samples leads to the conclusion that this contaminant is not site related.

Organic contaminants were detected in both surface water and sediment. Organochlorine pesticides and polynuclear aromatic hydrocarbons (PAHs) were detected in the sediment. Most organochlorine pesticides are persistent in the environment, and whether they are

sprayed, dusted, or applied directly to the soil, the soil is the ultimate sink. Detection of these contaminants in the sediment leads to the conclusion that these contaminants may be transported to the sediment via erosion of soil material. Sediments have naturally high organic matter contents and tend to bind higher molecular weight organic compounds such as organochlorine pesticides. Further transport of organochlorine pesticides in sediments would be limited to downstream adjective transport of sediment particles of which pesticides adhere. The presence of PAHs in the sediment are likely a result of atmospheric deposition and/or erosion of the soil material. PAHs are ubiquitous chemicals in environmental media and can be present as a result of natural and anthropogenic processes.

The volatile organics were detected in surface water samples, were not in the other media, which leads to the conclusion that these contaminants are not site related. Furthermore, the organic contaminants were detected at relatively low concentrations suggesting that their presence in surface water samples could be attributable to field or lab contamination, or other sources of contamination along the New River. The presence of inorganics may be due to sediment particles suspended in the surface water due to agitation of the surface water (e.g., wind, water current, etc.).

6.0 BASELINE RISK ASSESSMENT

6.1 Introduction

This section presents the baseline Risk Assessment (RA) for Operable Unit Number 3 (Site 48), Marine Corps Air Station (MCAS) Mercury Dump. The baseline RA evaluates the potential for chemicals to affect human health, both now and in the future, under a no action scenario. The environmental assessment for Site 48 was prepared under separate cover, therefore, potential ecological effects will not be discussed in this baseline RA.

The baseline RA identifies chemicals of concern and corresponding environmental concentrations at the site with respect to the physical characteristics of the study area. This information is used to estimate the extent of potential exposure to hypothetical receptors. Finally, theoretical chemical intakes are determined for each receptor and each potential exposure route and combined with the most recent toxicological data to inferentially estimate the potential human health effects.

The components of the baseline RA include:

- Identification of chemicals of concern;
- The exposure assessment;
- The toxicity assessment;
- Risk characterization; and
- Uncertainty analysis.

The baseline RA is divided into six sections including this introduction. Section 6.2 identifies chemicals of concern, which are the chemicals detected at the site having the greatest potential to affect human health. Section 6.3 presents the exposure assessment which employs a site conceptual model of potential exposure to identify current and future potential exposure pathways and receptors. Section 6.4 presents the toxicity assessment which contains the toxicological indices for chemicals of concern. Section 6.5 combines exposure pathways, receptors and toxicological indices to provide the quantitative risk characterization. Total site risk is also presented in this section. Finally, Section 6.6 discusses the sources of uncertainty inherent to the baseline RA.

6.2 Identification of Chemicals of Concern

Chemicals of Concern (COCs) are site related chemicals used to qualitatively or quantitatively estimate potential human exposures and associated health effects. Five environmental media were investigated at Site 48 during the RI. These are: groundwater, surface soils (0 to 2 feet), subsurface soils (2 feet and below), surface waters and sediments. This section presents the rationale for the selection of COCs and the COCs for each medium investigated at Site 48.

Site 48 history indicates that from 1956 to 1966, mercury was periodically drained from delay lines of radar units and disposed of behind building 804. Several other potential disposal areas were also identified from a review of historical aerial photographs. Building 804 is located in the center of Site 48 and was operated as a photography laboratory. An aboveground storage tank is located behind building 804 which replaced an underground storage tank that contained diesel fuel used for a generator. Chemicals associated with past disposal practices and property usage include:

- Mercury;
- benzene, toluene, ethylbenzene, xylenes; and
- Polynuclear Aromatic Hydrocarbons (PAHs).

In addition to site history, frequency of detection of a chemical in environmental media is a primary consideration in the selection or elimination of a chemical as a COC. The Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual, Part A (USEPA 1989) (RAGs) suggests that a frequency of occurrence of 5 percent (one positive detection per 20 samples) is sufficient for including a chemical as a COC. Using a frequency of 5 percent requires at least 20 samples per medium. Of the five sampled environmental media only sediments have more than 20 sampling points in their data set. Therefore, additional criteria must also be considered in the selection of COCs. Additional criteria include:

- Consideration of the concentration(s) at which chemicals were detected in environmental media;

- Comparison of analytical results with available Maximum Contaminant Levels (MCLs), Maximum Contaminant Level Goals (MCLGs) Federal Ambient Water Quality Criteria (AWQC), Health Advisories (HA) and State Water Quality Criteria (NCWQS); and

- Comparison of analytical results with literature background concentrations of appropriate chemicals.

Currently, the only enforceable Federal regulatory standards are the MCLs. However, MCLs have not been specified for many of the COCs at the facility. In some cases, NCWQS are available for chemicals not having MCLs. These values are considered enforceable by the State. When enforceable criteria are not available, other regulatory guidelines are used for comparative purposes to infer potential health risks and environmental impacts when necessary. Relevant regulatory guidelines include the AWQCs, MCLGs, and HAs. The regulatory guidelines evaluated in this assessment are defined below.

Maximum Contaminant Levels (MCLs) - MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs have been adopted as enforceable standards for public drinking water systems, and apply to drinking water supplies consumed by a minimum of 25 persons. They have been developed for the prevention of human health effects associated with lifetime exposure (70-year lifetime) of an average adult (70 Kg) consuming 2 liters of water per day. MCLs also consider the technical and economic feasibility of removing the constituent from a public water supply.

Maximum Contaminant Level Goals (MCLGs) - MCLGs are nonenforceable guidelines based entirely on the potential for human health effects. The MCLs have been set as close to the MCLGs as is considered technically and economically feasible. MCLGs are specified as zero for carcinogenic substances, based on the assumption of non-threshold toxicity, and do not consider the technical or economic feasibility of achieving these goals. In addition, MCLGs for noncarcinogens are set based upon chronic toxicity or other data.

Federal Ambient Water Quality Criteria (AWQC) - AWQC are nonenforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic organisms. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). The AWQCs for protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one

additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (i.e., the 10^{-7} to 10^{-5} range).

Health Advisories (HAs) - HAs are guidelines developed by the USEPA Office of Drinking Water for Non-Regulated Constituents in Drinking Water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight of 10 kg) who consume 1 liter of water per day or in adults (assumed body weight of 70 kg) who consume 2 liters of water per day. Health Advisories are generally available for acute (1 day), subchronic (10 days), and chronic (longer-term) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not acceptable levels of potential human carcinogens.

The following paragraphs present the analytical data for each medium of interest investigated at Site 48. The data was subjected to a third-party, independent data validation. Values qualified with "J" are considered to be estimated values. Refer to section 4.0 for a more detailed discussion of the analytical results.

North Carolina Water Quality Standards (NCWQS) - NCWQS are the maximum allowable concentrations resulting from any discharge of contaminants due to the land or waters of the state, which may be tolerated without creating a threat to human health or which otherwise render the groundwater unsuitable for its intended purpose. This standard is the concentration, that either alone or in combination with other wastes, in surface waters that will not render the groundwater or surface water unsuitable.

Sediment Screening Values (SSVs) - SSVs were developed by National Oceanic and Atmospheric Administration (NOAA) for screening chemicals detected in sediments. SSVs for aquatic (marine and freshwater) organisms, were developed for each contaminant having sufficient data available. Adverse effects on the biota are considered probable if the contaminant concentrations are above the Effects Range-Median (ER-M). If contaminant concentrations are between the Effects Range-Low (ER-L) and ER-M adverse effects are considered possible. Concentrations below the ER-L indicate that adverse effects are unlikely.

6.2.1 Groundwater

Five monitoring wells were installed and sampled at Site 48 during the RI. These wells were analyzed for target compound list organics and target analyte list inorganic constituents.

Five organic contaminants were detected at relatively low concentrations. Two of these contaminants, methylene chloride and bis(2-ethylhexyl)phthalate are common field and laboratory contaminants and could be present in groundwater samples for this reason. Methylene chloride was detected in a sample taken from Well GW3 at 12J µg/L. Bis (2-ethylhexyl) phthalate was detected in 2 of 5 samples (GW3 and GW4) at concentrations of 25 µg/L and 1J µg/L respectively. Phenol (1J µg/L) was also detected in a sample taken from well GW3. Duplicate sample analysis of GW3 contained 1 µg/L of methylene chloride and no detectable bis(2-ethylhexyl)phthalate or phenol. These chemicals were, therefore not retained as COCs in groundwater. Other organic chemicals detected in groundwater samples were trichloroethene (GW3 and GW5) at 1 µg/L and the PAH acenaphthene 2J µg/L. Trichloroethene and acenaphthene were retained for further evaluation in the baseline RA.

Naturally occurring inorganic chemicals were detected in samples taken from throughout the study area. These include aluminum, barium, cadmium, calcium, chromium, cobalt, copper, iron magnesium, manganese, potassium, sodium, vanadium and zinc. Sodium, potassium, calcium and magnesium are the principal cations detected in groundwaters (USEPA, 1986). These chemicals are also considered to be essential nutrients in the human diet, and are toxic only at extremely high concentrations. Because these chemicals are not historically associated with activities at Site 48 and given the concentrations at which these inorganic analytes were detected, they were not retained as COCs. The remaining inorganic chemicals detected in site groundwaters are presented in Table 6-1 and compared to available State and Federal criteria and standards. Manganese and iron exceeded the NCWQS value of 50 µg/L and 300 µg/L respectively. These criteria are based on Federal Secondary Maximum Contaminant Levels (SMCLs) which are not human health based. Iron is the fourth most abundant rock-forming element, comprising 5 percent of the earth's crust. The presence of iron in groundwaters samples at Site 48 is probably related to regional geology. Therefore, iron was not retained as a COC in groundwater. The presence of manganese in groundwater samples is also due to the mineral composition of study area. It has been suggested that the potential for significant manganese deposits exists in the Atlantic and Gulf coastal plains of the United States (USDI, 1985). Manganese was, therefore, not retained as a COC in groundwater for further evaluation in the baseline RA.

TABLE 6-1

COMPARISON OF SITE 48 GROUNDWATER ANALYTICAL RESULTS TO STATE AND FEDERAL CRITERIA AND ADVISORIES REMEDIAL INVESTIGATION CTO-0133 MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Contaminant Frequency/Range		Groundwater Criteria			Comparison Criteria		
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	North Carolina NCWQS (1)	Federal MCLs/MCLG (2)	Health Advisories (3)	No. of Positive Detects above NCWQS	No. above Federal MCLs/ MCLGs	No. above Health Advisories
Acenaphthene	1/5	2.0	NA	NA	NA	--	--	--
Aluminum	4/5	382 - 6,830	NA	NA	NA	--	--	--
Barium	5/5	18.0 - 51.3	1,000	2,000/2,000	N A	0	0	--
Cadmium	5/5	2.2 - 3.3	5.0	5.0/5.0	20.0	0	0	0
Chromium*	2/5	5.8 - 17.5	50.0	100.0/100.0	800.0	0	0	0
Cobalt	2/5	2.8 - 4.2	NA	NA	NA	--	--	--
Copper	3/5	3.1 - 13.5	1000	NA	NA	0	--	--
Iron	5/5	1,900 - 11,900	300	300 (4)	NA	5	--	--
Mercury	4/5	0.04 - 0.09	1.1	2.0/2.0	2.0	0	0	0
Manganese	5/5	38.1 - 585	50.0	50 (4)	NA	3	--	--
Trichloroethene	2/5	1.0	2.8	5.0	NA	0	0	0
Vanadium	3/5	3.4 - 12.8	NA	NA	20	--	--	--
Zinc	1/5	30.3	5,000	5,000 (4)	NA	0	0	--

All concentrations expressed in µg/L

Notes: (1) NCWQS - North Carolina Water Quality Standard for Groundwater
(2) MCL - Maximum Contaminant Level/Maximum Contaminant Level Goal
(3) Longer Term Health Advisories for 70 kg Adult
(4) SMCL - Secondary Maximum Contaminant Level
NA - Not Available
* Total Chromium Value

6.2.2 Soils (0 to 2 feet)

Four surface soil samples (0 to 2 feet) were collected at Site 48. The organic contaminants, 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT were detected at low levels in one of four sampling locations. These chemicals could have been applied at the site in the past for insect control purposes. Therefore, these chemicals are retained as COCs for further evaluation in the baseline RA. Acetone detected in the surface soil is most likely due to the use of pesticide-grade isopropanol used in the decontamination procedure. Analysis of the isopropanol determined that acetone is an artifact of this grade isopropanol. Therefore, acetone will not be retained as a contaminant of concern.

A total of thirteen subsurface samples (2 feet and below) were analyzed for target compound list organics and target analyte list inorganics. Acetone was the only organic chemical detected in subsurface soils. Acetone is a contaminant in pesticide-grade isopropanol which was used in the decontamination procedure. Furthermore, site history does not indicate that acetone was used or disposed of at Site 48. Consequently, acetone is not believed to be site-related and was not retained as a COC in soils.

Surface and subsurface soil results were compared to available site-specific values for inorganics to determine if inorganic concentrations in Site 48 soils are related to past disposal practices. Base-specific background values represent an average of four samples collected offsite on the main side area of the base, several miles from Site 48. These samples were collected from an area that is not believed to have been impacted from previous waste disposal activities.

Inorganic contaminants detected in the surface and subsurface soil are presented in Table 6-2.

Surface and subsurface soil results were compared to available literature values for inorganics to determine if inorganic concentrations in Site 48 soils are related to past disposal practices. Table 6-3 presents the native concentration ranges for select inorganics in soil. Literature values do not represent site specific background but provide a range of inorganic soil concentrations which could be as encountered as a result of site geology. Mercury was not detected in either surface or subsurface soil samples. All detected surface and subsurface inorganic results appear to be within literature values. Inorganic chemicals are not retained as COCs based on site history and the literature soil concentration comparison.

TABLE 6-2

SUMMARY OF SITE 48 SOIL ANALYTICAL DATA
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Soil (0-2 feet)			Subsurface Soil (2 feet and Below)		
	Base-Specific Background Concentration	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Base-Specific Background Concentration	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples
Aluminum	<90.5 - 1,120	3,560 - 28,000	4/4	672 - 3,600	730 - 24,400	13/13
Arsenic	<0.56 - 0.91	0.63 - 3.4	4/4	<0.61 - <0.65	0.64 - 4.6	11/13
Barium	3.5 - 16.5	11.9 - 25.7	4/4	<4.0 - 7.6	2.5 - 25.8	13/13
Beryllium	<0.06 - <0.2	ND	0/4	<0.05 - <0.02	0.17 - 0.22	3/13
Cadmium	<0.35 - <0.59	0.48 - 3.6	4/4	<0.34 - <0.59	0.61 - 4.4	11/13
Chromium	<0.06 - <3.2	7.3 - 37.3	4/4	<3.2 - 6.0	1.1 - 32.8	13/13
Cobalt	<0.37 - <1.8	0.59 - 2.2	4/4	<0.35 - <1.8	0.52 - 1.7	13/13
Copper	<1.1 - 3.1	2.7 - 5.6	4/4	0.65 - 1.2	0.75 - 31.5	12/13
Lead	2.0 - 3.0	8.7 - 23.7	4/4	1.2 - 1.6	2.7 - 32.3	13/13
Manganese	<2.0 - 3.0	5.4 - 14.9	4/4	1.2 - 1.6	0.94 - 15.6	13/13
Mercury	<0.02 - <0.12	ND	0/4	<0.02 - <0.08	ND	0/13
Nickel	<1.5 - <3.3	1.8 - 4.6	3/4	<1.4 - <3.4	1.5 - 3.2	6/13
Selenium	<0.93 - <1.0	ND	0/4	<1.0	ND	0/13
Thallium	<0.37 - <0.41	ND	0/4	<0.40 - <0.44	ND	0/13
Vanadium	<2.1 - 2.8	7.0 - 53.9	4/4	<1.5 - 4.7	1.5 - 44.3	13/13
Zinc	<1.1 - 23.1	9.8 - 24.8	3/4	<0.19 - 11.6	5.6 - 7.7	20/13

Notes: ND = Not Detected

TABLE 6-3

NATIVE CONCENTRATION RANGES FOR SELECT INORGANICS IN SOILS FROM LITERATURE
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent	Lindsay, 1979[1]	Tox. Profiles[2]	Tox. of Metals, 1986[3]	Dragun, 1988[4]	Modern Env. Tox. XI, 1987[5]	U.S. Geological Survey (Eastern Portion of U.S.)[6]
Aluminum	NA	NA	NA	10,000 - 300,000	NA	7,000 - >10,000
Arsenic	1.0 - 50	0.1 - 80	40	1 - 40	Trace - 40	<0.1 - 73
Beryllium	NA	0.01 - 40	NA	0.1 - 40	NA	<1.0 - 7.0
Cadmium	0.01 - 0.7	0.6 - 6.0	<1.0	0.01 - 7.0	<1.0 - 30	NA
Chromium	1 - 100	NA	Trace - 250	5.0 - 3,000	Trace - 250	1.0 - 1,000
Lead	2 - 200	10 - 30	2 - 200	2.0 - 200	10 - 700	<10 - 300
Mercury	0.01 - 0.3	NA	NA	0.01 - 0.08	0.01 - 0.3	<0.01 - 3.4
Nickel	NA	5.0 - 1,000	NA	5.0 - 1,000	NA	<5.0 - 700
Selenium	0.1 - 2.0	4.0 - 8.0	NA	0.1 - 2.0	0.1 - 10.0	<0.01 - 3.9
Zinc	NA	10 - 300	NA	<10 - 2,000	NA	<5.0 - 2,900

Notes:

NA - Not available

All values reported in mg/kg.

(1) Lindsay, W. L. 1979. Chemical Equilibria in Soils. John Wiley and Sons, New York.

(2) U.S. Environmental Protection Agency.
Draft Toxicological Profile for Arsenic, February 1992.
Draft Toxicological Profile for Beryllium, February 1992.
Draft Toxicological Profile for Lead, February 1992.
Draft Toxicological Profile for Nickel, February 1992.
Draft Toxicological Profile for Selenium, October 1987.
Draft Toxicological Profile for Zinc, December 1989.
Prepared for the Agency for Toxic Substances and Disease Registry (ATSDR).

(3) Friberg, L., Nordberg, G. F. and Vouk, V. B., editors. 1986. Handbook on the Toxicology of Metals, Volume II: Specific Metals. Elsevier Science Publishers, Amsterdam.

(4) Dragun, J. 1988. The Soil Chemistry of Hazardous Materials. The Hazardous Materials Control Research Institute, Silver Spring, Maryland.

(5) Mehlman, M. A. 1987. Series: Advances in Modern Environmental Toxicology, Volume XI, Genotoxic and Carcinogenic Metals: Environmental and Occupational Occurrence and Exposure. Princeton Scientific Publishing, Princeton, New Jersey.

(6) Schacklette, H. T. and Boerngen, J. G. 1984. "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States." U.S. Geological Survey Professional Paper 1270, U.S. Department of the Interior.

6.2.3 Surface Water

Ten surface water samples were taken throughout the study area. Of the ten surface water samples, five were taken from the New River, two from the Marsh Area, and three from the Intermittent Tributary.

Only surface water samples collected from the New River were analyzed for organic chemicals. Low levels of the volatile organics toluene and total xylenes were detected at an upstream location and at one location near Site 48. These contaminants were not detected in any other media. Because of the concentrations at which these chemicals were detected, and the upstream detection, they are not believed to be site related. Consequently, these low toxic contaminants were not retained as contaminants of concern in surface waters.

Samples from all three surface water bodies were analyzed for inorganics encountered. Inorganic compounds that were frequently detected include: barium, copper, chromium, lead, manganese and mercury. Tables 6-4 through 6-6 present the surface water analytical data for the New River, Marsh Area and Intermittent Tributary, respectively as well as State and Federal surface water quality criteria. These inorganics are believed to be naturally occurring, and not associated with the site. Inorganics are therefore not retained as COCs for further evaluation in the baseline RA.

6.2.4 Sediment

A total of thirty-three sediment samples were collected from the New River (23), Marsh Area (4) and Intermittent Tributary (6). Only sediments from the New River were analyzed for organics. The pesticides 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected in four New River sediment samples. These chemicals may or may not be site related. Pesticide contamination has been detected in sediment samples collected all over Camp Lejeune. They are, however, retained for further evaluation in the baseline RA, because they were not detected in upstream sediment sample NR9.

All sediment samples were analyzed for inorganic contaminants. Tables 6-7 through 6-9 present the sediment analytical data for the New River, Marsh Area and Intermittent Tributary, respectively. Sediment values were compared to National Oceanic and Atmospheric Administration (NOAA) sediment screening values for the selection of COCs. Lead exceeds its corresponding ER-L in 4 of 23 downstream locations in the New River. Lead

TABLE 6-4

COMPARISON OF NEW RIVER SURFACE WATER ANALYTICAL DATA TO STATE AND FEDERAL CRITERIA
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Surface Water Criteria		Comparison to Criteria	
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	North Carolina NCWQS(1)	Federal AWQCs (2)	No. of Positive Detects above NCWQS	No. of Positive Detects above AWQCs
Barium	5/5	14.9 - 20.5	NA	NA	--	--
Chromium	1/5	4.0 - 4.0	20	50	0	0
Copper	3/5	3.0 - 4.0	3	NA	3	--
Lead	3/5	1.5 - 3.0	25	8.5	0	0
Manganese	5/5	15.5 - 21.0	NA	NA	--	--

Notes: All concentrations expressed in µg/L
NA - Not Available
(1) NCWQS - North Carolina Water Quality Standard for Tidal Saltwater (Aquatic)
(2) AWQCs - Federal Ambient Water Quality Standards (Marine Chronic)

TABLE 6-5

COMPARISON OF MARSH AREA SURFACE WATER ANALYTICAL DATA TO STATE AND FEDERAL CRITERIA
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Surface Water Criteria		Comparison to Criteria	
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	North Carolina NCWQS (1)	Federal AWQCs (2)	No. of Positive Detects above NCWQS	No. of Positive Detects above AWQCs
Barium	2/2	17.5 - 19.1	NA	NA	--	--
Copper	2/2	3.0 - 6.0	3	NA	2	--
Lead	2/2	1.6 - 2.0	25	8.5	0	0
Manganese	2/2	31.0 - 48.0	NA	NA	--	--
Mercury	2/2	0.05	0.025	0.025	2	2

Notes: All concentrations expressed in µg/L
NA - Not Available
(1) NCWQS - North Carolina Water Quality Standard for Tidal Saltwater (Aquatic)
(2) AWQCs - Federal Ambient Water Quality Standards (Marine Chronic)

TABLE 6-6

COMPARISON OF INTERMITTENT TRIBUTARY SURFACE WATER ANALYTICAL DATA TO STATE AND FEDERAL CRITERIA REMEDIAL INVESTIGATION CTO-0133 MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Surface Water Criteria		Comparison to Criteria	
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	North Carolina NCWQS (1)	Federal AWQCs (2)	No. of Positive Detects above NCWQS	No. of Positive Detects above AWQCs
Barium	3/3	18.0 - 64.2	NA	NA	--	--
Chromium	1/3	7.0	20	50	0	0
Copper	1/3	4.0	3	NA	1	--
Lead	2/3	1.4 - 2.4	25	8.5	0	0
Manganese	3/3	20 - 38.5	NA	NA	--	--
Mercury	2/3	0.04	0.025	0.025	2	2

Notes: All concentrations expressed in µg/L
NA - Not Applicable
(1) NCWQS - North Carolina Water Quality Standard for Tidal Saltwater (Aquatic)
(2) AWQCs - Federal Ambient Water Quality Standards (Marine Chronic)

TABLE 6-7

COMPARISON OF NEW RIVER SEDIMENT DATA
TO NOAA SEDIMENT SCREENING VALUES
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Sediment Screening Values (SSV)		Comparison to Screening Values	
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	ER-L[1]	ER-M[2]	No. of Positive Detects above ER-L	No. of Positive Detects above ER-M
Arsenic	21/23	0.76 - 19.3	33	85	0	0
Barium	23/23	2.9 - 21.4	NA	NA	--	--
Beryllium	20/23	0.1 - 0.59	NA	NA	--	--
Cadmium	21/23	0.55 - 5.6	5	9	0	0
Chromium	19/23	1.1 - 23.5	80	145	0	0
Copper	20/23	1.5 - 42.5	70	390	0	0
Lead	21/23	2.2 - 86.2	35	110	4	0
Manganese	23/23	2.7 - 47.1	NA	NA	--	--
Mercury	6/23	0.03 - 0.07	0.15	1.3	0	0
Zinc	15/23	3.5 - 73.2	120	270	0	0

Notes: All concentrations expressed in mg/kg
NA - Not Available
(1) ER-L - Effects Range - Low
(2) ER-M - Effects Range - Median

TABLE 6-8

COMPARISON OF MARSH AREA SEDIMENT DATA TO
NOAA SEDIMENT SCREENING VALUES
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Sediment Screening Values (SSV)		Comparison to Screening Values	
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	ER-L(1)	ER-M(2)	No. of Positive Detects above ER-L	No. of Positive Detects above ER-M
Arsenic	4/4	1.8 - 7.4	33	85	0	0
Barium	4/4	11.4 - 32.0	NA	NA	--	--
Beryllium	4/4	0.24 - 0.84	NA	NA	--	--
Cadmium	4/4	1.2 - 2.9	5	9	0	0
Chromium	4/4	7.3 - 29.9	80	145	0	0
Copper	4/4	1.9 - 6.7	70	390	0	0
Lead	4/4	9.3 - 19.5	35	110	0	0
Manganese	4/4	12.8 - 30.7	NA	NA	--	--
Mercury	4/4	0.05 - 0.1	0.15	1.3	0	0
Nickel	3/4	2.1 - 6.3	30	50	0	0

Notes: All concentrations expressed in mg/kg
NA - Not Available
(1) ER-L - Effects Range - Low
(2) ER-M - Effects Range - Median

TABLE 6-9

COMPARISON OF INTERMITTENT TRIBUTARY SEDIMENT DATA TO
NOAA SEDIMENT SCREENING VALUES
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Contaminant Frequency/Range		Sediment Screening Values (SSV)		Comparison to Screening Values	
	No. of Positive Detects/ No. of Samples	Range of Positive Detections	ER-L(1)	ER-M(2)	No. of Positive Detects above ER-L	No. of Positive Detects above ER-M
Arsenic	5/6	1.0 - 5.5	33	85	0	0
Barium	6/6	4.2 - 20.8	NA	NA	--	--
Beryllium	6/6	0.06 - 0.69	NA	NA	--	--
Cadmium	6/6	0.59 - 4.2	5	9	0	0
Chromium	2/6	7.8 - 11.8	80	145	0	0
Copper	5/6	2.6 - 8.8	70	390	0	0
Lead	6/6	6.4 - 34.1	35	110	0	0
Manganese	6/6	4.9 - 69.4	NA	NA	--	--
Mercury	2/6	0.06 - 0.17	0.15	1.3	1	0
Zinc	3/6	6.8 - 38.8	120	270	0	0

Notes: All concentrations expressed in mg/kg
NA - Not Applicable
(1) ER-L - Effects Range - Low
(2) ER-M - Effects Range - Median

could potentially be site related and was, therefore, retained as a COC. Lead does not exceed the ER-M value at any sampled location in the New River. Mercury also exceeds its ER-L value at one location in the Marsh Area, but does not exceed the corresponding ER-M value. Because of site history and the exceedance of its ER-L value, mercury was retained as a COC.

6.2.5 Aquatic Biota

Biota samples were analyzed for organics as part of the Ecological Risk Assessment conducted at Site 48. Biota samples exhibited the presence of 4,4'-DDD and 4,4'-DDE. These contaminants may or may not be site related. They were, however, retained for further evaluation in the baseline RA.

Inorganic contaminants were also detected in biota samples. Inorganics, are considered to be essential nutrients in the human diet, and are toxic only at extremely high doses. Consequently, these inorganics are not retained as COCs.

Table 6-10 presents a summary of the COCs.

6.3 Exposure Assessment

The purpose of the exposure assessment is to evaluate the potential for human exposure to hazardous chemicals in the environmental media at this site. This section characterizes the exposed populations and identifies actual or potential exposure routes, by developing a site conceptual model of potential exposure. The nature and extent of contamination upon which the exposure is based is presented in Section 4.0.

To determine whether there is the potential for exposure at this site, the most likely pathways of contaminant release and transport as well as human environmental activity patterns at the site must be considered. A complete exposure pathway has three components: (1) a source of contaminants that can be released to the environment; (2) a route of transport through the environmental medium; and (3) an exposure or contact point for a human or environmental receptor. These components of the exposure pathways are addressed in the following subsections.

TABLE 6-10

SUMMARY OF POTENTIAL CONTAMINANTS OF CONCERN
IN ENVIRONMENTAL MEDIA OF INTEREST
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater	Surface Soils	Sediments	Biota
Trichloroethene	X			
Acenaphthene	X			
4,4'-DDD		X	X	X
4,4'-DDE		X	X	X
4,4'-DDT		X	X	X
Lead			X	
Mercury			X	

6.3.1 Site Conceptual Model of Potential Exposure

A site conceptual model of potential sources, migration pathways and human receptors was developed which encompasses all potential routes of exposure both now and in the future. The site conceptual model is derived by considering current site demographic information and the future residential development of the property. Figure 6-1 presents the diagram of the conceptual site model for Operable Unit No. 3. Future potential exposure to contaminants is also addressed in Figure 6-1 under a no remedial action scenario.

Furthermore, available analytical data and meteorological data were considered in the site conceptual model. From this information, the following list of potential receptors was developed for inclusion in the quantitative health risk analysis:

- Onsite base personnel;
- Recreational users (adolescent) of New River;
- Adult fisher persons; and
- Future onsite residents (child and adult).

6.3.2 Identification of Potential Exposure Pathways

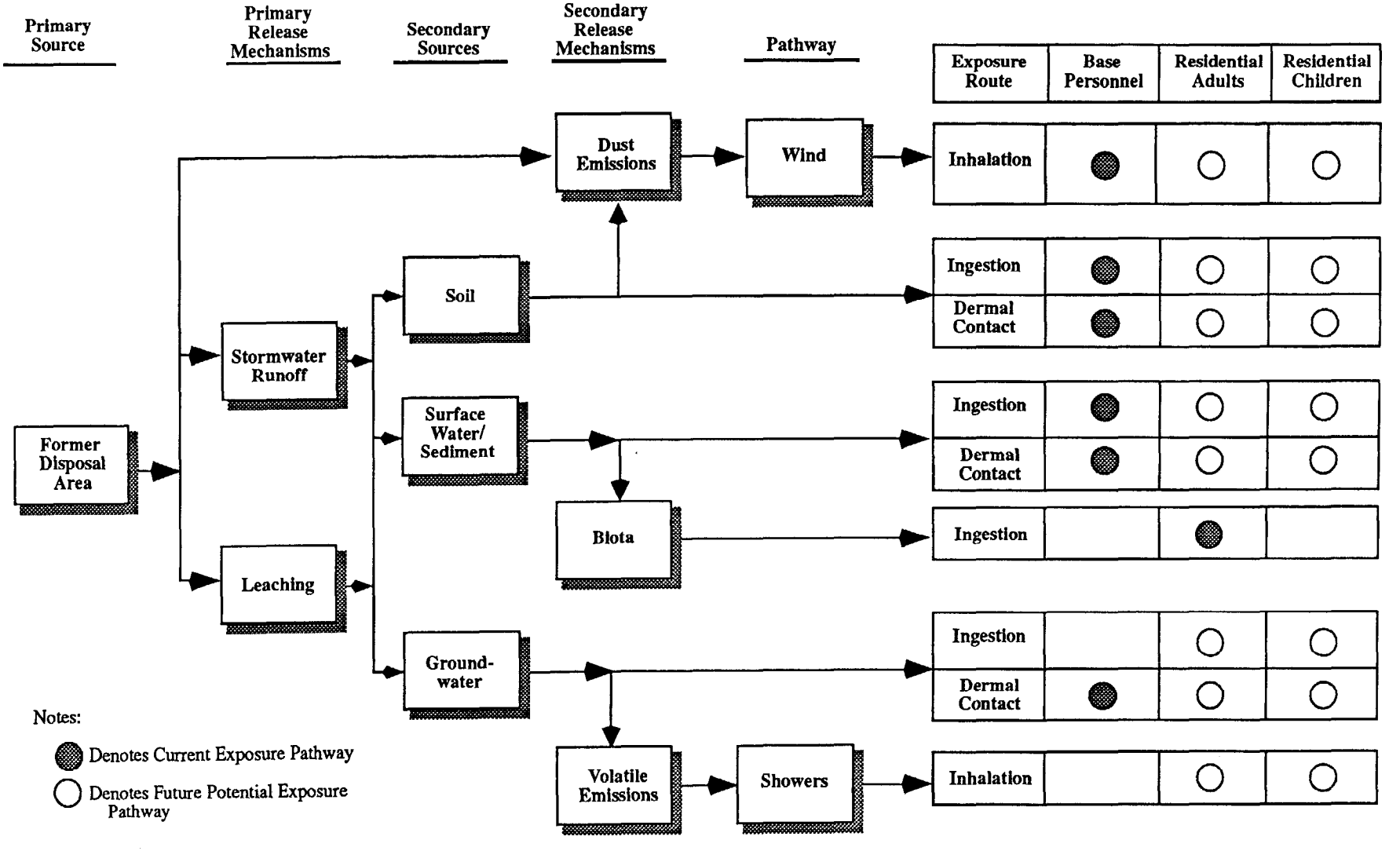
This section presents potential exposure pathways at Site 48 and the rationale for their selection. Potential exposure pathways depend on the source areas (identified by the field sampling and analytical data generated during the RI) as well as chemical fate and environmental transport potential of the selected COCs.

The following paragraphs discuss the potential exposure pathways associated with the site conceptual model of potential exposure.

6.3.2.1 Surface Soil

Direct contact with surface soil can result in dermal and accidental ingestion both now and in the future. Although DDT series pesticides present in on-site soils are not disposal related, base personnel, future residential children (ages 1 through 6) and future residential adults could be exposed, by dermal contact and accidental ingestion, to COCs in site surface soils. These pathways and receptors were, therefore, retained for quantitative evaluation.

FIGURE 6-1
CONCEPTUAL SITE MODEL OF POTENTIAL EXPOSURE
CURRENT AND FUTURE LAND USE
OPERABLE UNIT NO.3 (SITE 48)
MCB CAMP LEJEUNE, NORTH CAROLINA



6.3.2.2 Groundwater

Currently there are no receptors who are exposed to the groundwater in this area. All groundwater used at this base is taken from the Castle Hayne aquifer. Although unlikely, groundwater could be used as a potable supply if residential development of Site 48 occurs in the future and residents decide to place wells in the shallow aquifer. Ingestion and dermal contact during showering were retained as future potential exposure pathways despite the unlikeliness of potable groundwater usage.

6.3.2.3 Surface Water/Sediment

The New River is large enough to support recreational activities. In addition, it is relatively close to residential areas of the base. It is, therefore, possible that individuals (particularly adolescents) could engage in recreational activities in the New River and thereby come in contact with the surface water and sediments. Exposure could occur via accidental ingestion or dermal contact.

6.3.2.4 Air

Exposures to contaminants in the air could occur, both now and in the future, via fugitive dust emissions. The action of the wind on fine grained soils can generate fugitive dust, which can be carried downwind toward receptors. Several factors at this site limit the potential for exposure by this pathway. First, the vegetative cover at this site will result in minimal emissions; Second, the average number of days on which precipitation events occur (120 days per year) further limit site soil erosion potential. Therefore, this pathway will not be retained for current or future evaluation.

6.3.2.5 Biota

The New River and surrounding surface water bodies are large enough to support viable fish populations, therefore local residents could occasionally ingest fish taken from the river. Therefore, ingestion of aquatic biota is retained for further evaluation in the baseline RA.

6.3.3 Quantification of Exposure

The concentrations used in the estimation of chronic daily intakes must be representative of the type of exposure being considered.

Exposure to groundwaters, sediments and surface waters can occur discretely or at a number of sampling locations. These media are transitory in that concentrations change frequently over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points at discrete locations than exist within Operable Unit No. 3. As a result, the best way to represent groundwater, sediment, and surface water contaminants from an exposure standpoint is to use a representative exposure concentration.

Soils are less transitory than the aforementioned media and in most cases, exposure occurs over a wider area (i.e., residential exposure). Therefore, an upper confidence interval is used to represent a soil exposure concentration.

Since all the data sets originate from a skewed underlying distribution and since lognormal distribution best fits the majority of environmental data sets, the lognormal distribution is used to represent all facility media. This ensures conservatism in the estimation of chronic daily intake associated with potential exposures. Ninety-five percent upper confidence intervals derived for lognormal data sets (95 percent U.C.L.) produce concentrations in excess of the ninety-five percent interval derived assuming normality. For the sake of conservatism, the 95 percent U.C.L. for the lognormal distribution will be used for each contaminant in a given data set for quantifying potential exposure. In cases where the 95 percent U.C.L. for a contaminant exceeds the maximum detected value in a given data set, the maximum result will be used in the estimate of exposure of the 95 percent U.C.L.

Maximum values, arithmetic means, geometric means, standard deviations, and 95 percent U.C.L.s are presented in Appendix G and Appendix H.

6.3.4 Calculation of Chronic Daily Intakes

In order to numerically estimate the risks for current and future human receptors at Site 48, a chronic daily intake (CDI) must be estimated for each COC in every retained exposure pathway.

The following paragraphs present the general equations and input parameters used in the calculation of CDIs for each potential exposure pathway. Input parameters were taken from USEPA's default exposure factors guidelines where available and applicable. All inputs not defined by USEPA were derived from USEPA documents concerning exposure. Best professional judgment was used for input parameters not addressed by USEPA.

Carcinogenic risks were calculated as an incremental lifetime risk, and therefore incorporate terms describing to represent the exposure duration (years) over the course of a lifetime (70 years, or 25,550 days).

Noncarcinogenic risks, on the other hand, were estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per day and the number of days per year that exposure occurs. In general, noncarcinogenic risks for many exposure routes (e.g. soil ingestion) are greater for children than for adults because of the differences in body weights and similar or higher ingestion rates.

Current and future exposure scenarios consider 1 to 6 year old children weighing 15 kg, 6 to 15 year old adolescents weighing 45 kg, and adults weighing 70 kg on average. For civilian base personnel an exposure duration of 25 years was used to estimate a working lifetime.

6.3.4.1 Accidental Ingestion of Surface Soil

The CDI for COCs detected in subsurface soil can be estimated for all potential human receptors and was expressed as:

$$CDI = \frac{C \times IR \times CF \times Fi \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration in subsurface soil (mg/Kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor (10E-6 Kg/mg)
Fi = Fraction ingested from source (dimensionless)
EF = Exposure frequency (days/year)

ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of Potential COCs associated with the potential ingestion of soils.

Base Personnel

During the course of maintenance activities at Site 48, base personnel could potentially be exposed to potential COCs by the accidental ingestion of surface soils.

The IR for base personnel exposed to surficial soils was assumed to be 480 mg/day (USEPA, 1991) and that 100 percent of the exposure was with facility soils containing COCs. An exposure frequency (EF) of 250 days per year was used in conjunction with an exposure duration of 25 years.

An averaging time (AT) of 70 years or 25,550 days was used for exposure to potentially carcinogenic compounds while an averaging time of 9,125 days was used for noncarcinogenic exposures. An average body weight (BW) of 70 kg is used (USEPA, 1989).

Future On-Site Residents

Future on-site residents could potentially be exposed to COCs in the top 0 to 2 feet soil interval during recreational activities or landscaping activities around their homes. Children and adults could potentially be exposed to COCs in soils by accidental ingestion occurring through hand to mouth behavior.

Ingestion rates (IR) for adults and children in this scenario were assumed to be 50 mg/day and 100 mg/day, respectively. Exposure frequency (EF) for both receptor groups was assumed to be 350 days per year. Exposure duration (ED) was 30 years for an adult and 6 years for a child (USEPA, 1991).

The body weight (BW), for a resident child was assumed to be 15 kg, representing younger individuals than those considered to be potential trespassers. The rationale was that the

younger child (1 to 6 years), as a resident, will have access to affected on-site soils. The body weight for the future resident adult is assumed to be 70 kg.

Averaging times (AT) of 25,550 days for potential carcinogens and 10,950 days for noncarcinogenic constituents was used for estimating potential CDIs for adults. An AT of 3,285 days was used to estimate potential CDIs for children potentially exposed to noncarcinogens.

A summary of the exposure factors used in the estimation of soil CDIs associated with incidental ingestion is presented on Table 6-11.

6.3.4.2 Dermal Contact with Surface Soil

Chronic daily intakes associated with potential dermal contact of surface soils containing COCs was expressed using the following equation:

$$CDI = \frac{C \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration in subsurface soil (mg/Kg)
CF = Conversion factor (Kg/mg)
SA = Skin surface available for contact (cm^2)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Base Personnel

During construction activities, there is a potential for workers to absorb COCs by dermal contact.

TABLE 6-11

EXPOSURE ASSESSMENT SUMMARY - SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Accidental Ingestion of Surface Soil - Base Personnel, Child, Adult			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	UCL (mg/kg)	USEPA, May 1992
IR	Ingestion Rate	Base Personnel 480 mg/day Child 100 mg/day Adult 50 mg/day	USEPA, 1991 USEPA, December 1989
CF	Conversion Factor	10E-6 kg/mg	USEPA, December 1989
Fi	Fraction Ingested from Contaminated Source	100%	Conservative Professional Judgement
EF	Exposure Frequency	Base Personnel 250 days/yr Child 350 days/yr Adult 350 days/yr	USEPA, December 1989
ED	Exposure Duration	Base Personnel 25 years Child 6 years Adult 30 years	USEPA, March 1991
BW	Body Weight	Base Personnel 70 kg Child 15 kg Adult 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averging Time Noncarcinogen	Base Personnel 9,125 days Child 2,190 days Adult 10,950 days	USEPA, December 1989

It was assumed that construction workers have approximately 2,000 cm^2 (USEPA, 1989) of skin surface (SA) available for dermal exposure with COCs. Exposed body parts are the hands, head, and arms.

Values for exposure duration, exposure frequency, body weight, and averaging time were the same as those used for the accidental ingestion of soil scenario.

Future On-Site Residents

Future on-site residents could also be potentially exposed to COCs in on-site soil through dermal contact experienced during activities near their home.

Skin surface areas (SA) used in the on-site resident exposure scenario were 2,000 cm^2 and 5,910 cm^2 for adults and children, respectively. The adult SA was taken directly from USEPA's Superfund Exposure Assessment Manual (April 1988). The child SA was calculated using information presented in the Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments (USEPA, 1985). A total body surface area of 7,880 cm^2 was derived for a male child by averaging the total body surface area reported for children 2 to 3 years, 3 to 4 years, 4 to 5 years and 5 to 6 years of age. The total body surface area was then multiplied by 0.75 (75 percent) to represent potential exposure to the head (15.0%), trunk (34.6%), arms (13.4%), hands (5.0%), and feet (7.0%).

Exposure duration, exposure frequencies, body weights and averaging times were the same as those discussed for the accidental ingestion scenario presented previously.

Data on soil adherence (AF) are limited. A value of 1.0 mg/cm^2 (USEPA, 1992) was used in this assessment.

A summary of the soil exposure assessment input parameters for dermal contact is presented in Table 6-12.

6.3.4.3 Ingestion of Groundwater

Shallow groundwater is not currently being used as a potable supply at Operable Unit No. 3 (Site 48). Development of the shallow aquifer for potable use is unlikely because of the general water quality in the shallow zone and poor flow rates. However, there remains the possibility

TABLE 6-12

EXPOSURE ASSESSMENT SUMMARY - SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Dermal Contact with Surface Soil - Base Personnel, Child, Adult			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	UCL (mg/kg)	USEPA, May 1992
CF	Conversion Factor	10E-6 kg/mg	USEPA, December 1989
SA	Exposed Surface Area of Skin Available for Contact	Base Personnel 2,000 cm^2 Child 5,910 cm^2 Adult 2,000 cm^2	USEPA, 1985
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2	USEPA, Region IV, 1992
ABS	Absorption Factor (dimensionless)	Volatiles 0.10 Semivolatiles/ Pesticides 0.05 PCBs 0.03 Metals 0.01	Accounts for desorption from soil and percutaneous absorption (Feldman and Maibach, 1970; USEPA, October 1984; Wester and Maibach, 1985)
EF	Exposure Frequency	Base Personnel 250 days/yr Child 350 days/yr Adult 350 days/yr	USEPA, December 1989
ED	Exposure Duration	Base Personnel 25 years Child 6 years Adult 30 years	USEPA, December 1989
BW	Body Weight	Base Personnel 70 kg Child 15 kg Adult 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averging Time Noncarcinogen	Base Personnel 9,125 days Child 2,190 days Adult 10,950 days	USEPA, December 1989

that upon closure of this facility, residential housing could be constructed and deep groundwater used for potable purposes in the future.

The chronic daily intake of contaminants associated with the future potential consumption of groundwater can be estimated using the following general equation:

$$CDI = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration is groundwater (mg/L)
IR = Ingestion rate (liters/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Future On-Site Residents

Exposure to COCs via ingestion of groundwater was retained as a potential current and future exposure pathway for both children and adults.

An ingestion rate (IR) of 1.0 liter/day was used for the amount of water consumed by a 1 to 6 year old child. This ingestion rate provides a health conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who could potentially be more affected than adolescents, or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year [which represents the exposure frequency (EF)].

An averaging time (AT) of 25,550 days (70 years x 365 days/year) was used for potentially carcinogenic compounds and 365 days/year times the ED was used for noncarcinogenic compound exposure.

The ED used for the estimation of adult CDIs was 30 years (USEPA, 1989), which represents the national upper-bound (90th percentile) time at one residence. The ingestion rate (IR) for

adults was 2 liters/day (USEPA, 1989). The exposure time for noncarcinogens was 10,950 days.

Table 6-13 presents a summary of the input parameters for the ingestion of groundwater scenarios.

6.3.4.4 Dermal Contact with Groundwater

Groundwater is not currently being used as a potable supply at Operable Unit No. 3 (Site 48). However, there remains the possibility (however unlikely) that upon closure of this facility residential housing could be constructed and groundwater used for residential purposes in the future.

The CDI associated with the dermal contact with groundwater was estimated using the following general equation:

$$CDI = \frac{C \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where:

- C = Contaminant concentration is groundwater (mg/L)
- SA = Surface area available for contact (cm^2)
- PC = Dermal permeability constant (cm/hr)
- ET = Exposure time (hour/day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- CF = Conversion factor (1L/1000cm3)
- BW = Body weight (kg)
- AT = Averaging time (days)

Future On-Site Residents

Children could contact COCs through dermal contact with groundwater while bathing or showering.

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY - GROUNDWATER
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Ingestion of Groundwater - Child, Adult			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	UCL (mg/L)	USEPA, May 1992
IR	Ingestion Rate	Child 1 L/day Adult 2 L/day	USEPA, December 1989
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, December 1989
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, March 1991
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, December 1989

It was assumed that bathing would take place 350 days/year using site groundwater as the sole source. The whole body skin surface area (SA) available for dermal absorption by children was estimated to be 7,880 cm^2 and 18,150 cm^2 for adults (USEPA, 1989). The permeability constant (PC) reflects the movement of a chemical across the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose, yet many compounds do not have literature PC values. In this study, it was assumed that COCs are carried through the skin barrier at the same rate as that of water (USEPA, 1992). Therefore, the permeability constant of water, 8.0×10^{-4} cm/hr, was used for all constituents of concern. This value may in fact be a realistic estimate of the adsorption rate of a chemical when COC concentrations are in the part-per-billion range.

Table 6-14 presents the exposure factors used to estimate CDIs associated with the future dermal contact with COCs in groundwater.

6.3.4.5 Accidental Ingestion of Sediment

The chronic daily intake of COCs associated with the accidental ingestion of affected sediment was expressed using the following general equation:

$$CDI = \frac{C \times IR \times Fi \times EF \times ED \times CF}{BW \times AT}$$

Where:

C = Contaminant concentration in sediment (mg/Kg)
IR = Ingestion rate of sediment (mg/day)
Fi = Fraction ingested from source (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (Kg/mg)
BW = Body weight (kg)
AT = Averaging time (days)

TABLE 6-14

EXPOSURE ASSESSMENT SUMMARY - GROUNDWATER
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Dermal Contact with Groundwater - Child, Adult			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	UCL (mg/L)	USEPA, December 1989
SA	Exposed Surface Area of Skin Available for Contact	Adult 18,150 cm^2 Child 7,880 cm^2	USEPA, December 1989
PC	Permeability Constant	8.0E-04 cm/hr	USEPA, January 1992
ET	Exposure Time	0.25 hr/day	Fifteen minute shower or bath; professional judgment
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	Shower/bath every day (USEPA, March 25, 1991)
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, December 1989
CF	Conversion Factor	1L/1000 cm^3	USEPA, December 1989
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, December 1989

Future On-Site Adolescents

Accidental ingestion of COCs in sediments is also possible during recreational activities occurring at the New River.

An ingestion rate (IR) of 100 mg/day was used in calculating the chronic daily intake of COCs. This soil value was used to estimate the intake of sediments for the sake of consistency. The exposure frequency (EF) of 28 days/year was assumed.

A summary of exposure factors for this scenario are presented in Table 6-15.

6.3.4.6 Direct Contact with Sediment

The chronic daily intake of contaminants associated with the dermal contact of affected sediments was expressed using the following general equation:

$$CDI = \frac{C \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration in sediment (mg/Kg)
CF = Conversion factor (Kg/mg)
SA = Surface area available for contact (cm^2/event)
AF = Adherence factor (mg/cm^2)
ABS = Absorption factor (dimensionless)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

TABLE 6-15

EXPOSURE ASSESSMENT SUMMARY - SEDIMENT
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Accidental Ingestion of Sediment - Adolescent				
Input Parameter	Description	Value		Rationale
C	Exposure Concentration	UCL (mg/kg)		USEPA, May 1992
IR	Ingestion Rate	Adolescent	100 mg/day	USEPA, December 1989
Fi	Fraction Ingestion from Contaminated Source	100%		Conservative Professional Judgement
EF	Exposure Frequency	Adolescent	28 days/yr	Conservative Professional Judgment
ED	Exposure Duration	Adolescent	9 yr	USEPA, December 1989
CF	Conversion Factor	1.0E-06 Kg/mg		USEPA, December 1989
BW	Body Weight	Adolescent	45 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	Adolescent	25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Adolescent	3,285 days	USEPA, December 1989

Future On-Site Adolescent

During recreational use of New River surface water, direct contact with sediments could occur.

Hands, arms, legs, and feet were considered to be available for dermal exposure to sediments, totaling 7,100 cm^2 of skin surface area (USEPA, 1985). A sediment adherence factor (AF) of 1.0 mg/cm^2 was used. Dermal absorption factors (ABS) for COCs, defined previously for dermal contact of soils, was the same for sediment exposure. The exposure frequency (EF) for contact with sediments was estimated to be 28 days/year. This EF assumes that contact to sediment can occur during swimming and other recreational activities.

An averaging time (AT) of 70 years or 25,550 days was used for exposure to potentially carcinogenic compounds. An averaging time of 365 days/year times the exposure duration was used for exposure to noncarcinogenic COCs (USEPA, 1989).

Table 6-16 provides a complete summary of the input parameters used in the estimation of CDIs at Site 48.

6.3.4.7 Biota

The chronic daily intake associated with the potential ingestion of fish taken from the New River was expressed using the following general equation:

$$CDI = \frac{C \times IR \times Fi \times EF \times ED}{BW \times AT}$$

Where:

C = Contaminant concentration in fish (mg/Kg)
IR = Ingestion rate (kg/day)
Fi = Fraction ingested (dimensionless)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

TABLE 6-16

EXPOSURE ASSESSMENT SUMMARY - SEDIMENT
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Direct Contact with Sediment - Adolescent			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	UCL (mg/kg)	USEPA, May 1992
SA	Exposed Surface Area of Skin Available for Contact	Adolescent 7,100 cm^2/event	Feet, legs, arms, and hands exposed (USEPA, 1985)
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2	USEPA, Region IV, 1992
ABS	Absorption Factor (dimensionless)	Volatiles 0.10 Semivolatiles/ Pesticides 0.05 PCBs 0.03 Metals 0.01	Accounts for desorption from soil and percutaneous absorption (Feldman and Maibach, 1970; USEPA, October 1984; Wester and Maibach, 1985)
EF	Exposure Frequency	Adolescent 28 events/yr	Conservative Professional Judgment
ED	Exposure Duration	Adolescent 9 yr	USEPA, December 1989
CF	Conversion Factor	1.0 E-6 Kg/mg	USEPA, December 1989
BW	Body Weight	Adolescent 45 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Adolescent 3,285 days	USEPA, December 1989

Adults

The ingestion rate was 54 g/day which represents the upper 90th percentile consumption rate occurring in conjunction with recreational fishing. Ingestion rates are given as daily intakes averaged over a one year period (USEPA, 1989). The fraction of fish ingested from the source (FI) for adults was estimated to be 1.0 (100 percent) for the 90th percentile consumption rate. The exposure frequency is equal to 350 days/year. The exposure duration (ED) for adults was set at 30 years, and an averaging time (AT) of 70 years or 25,550 days was used for exposure to carcinogenic compounds. An averaging time of 365 days times the exposure duration (ED) was used for exposure to noncarcinogenic COCs (USEPA, 1989).

Table 6-17 presents a summary of the exposure factors used for the ingestion of biota scenario.

6.4 Toxicity Assessment

6.4.1 Toxicological Evaluation

The purpose of this section is to identify the potential health and environmental effects with potential exposure to the potential COCs identified in Section 6.2. A toxicological evaluation characterizes the inherent toxicity of a compound. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with potential exposure to various contaminants.

Human data from occupational exposures are often insufficient for determining quantitative indices of toxicity because of uncertainties in exposure estimates, and inherent difficulties in determining causal relationships established by epidemiological studies. For this reason, animal bioassays are conducted under controlled conditions and their results are extrapolated to humans. There are several stages to this extrapolation. First, to account for species differences, conversion factors are used to extrapolate from test animals to humans. Second, the relatively high doses administered to test animals must be extrapolated to the lower doses more typical of human exposures. For potential noncarcinogens, safety factors and modifying factors are applied to animal results when developing acceptable human doses. For potential carcinogens, mathematical models are used to extrapolate effects at high doses to effects at lower doses. Epidemiological data can be used for inferential purposes to establish the credibility of the experimentally derived indices.

TABLE 6-17

EXPOSURE ASSESSMENT SUMMARY - FISH INGESTION
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Fish Ingestion - Adult			
Input Parameter	Description	Value	Rationale
C	Exposure Concentration	UCL (mg/kg)	USEPA, May 1992
IR	Ingestion Rate	54 g/day	95th percentile for finfish (USEPA, December 1989)
Fi	Fraction Ingested from Contaminated Source	100	Conservative Professional Judgement
EF	Exposure Frequency	350 days/yr	USEPA, December 1989
ED	Exposure Duration	30 years	90th percentile at one residence (USEPA, December 1989)
BW	Body Weight	70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	10,950 days	USEPA, December 1989

The available toxicological information presented in contaminant of concern toxicological profiles indicates that many of the potential COCs have both potential carcinogenic and noncarcinogenic health effects in humans and/or experimental animals. Although the potential COCs may potentially cause adverse health and environmental impacts, dose-response relationships and the potential for exposure must be evaluated before the risk to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects, as discussed in the following section.

6.4.2 Dose-Response Evaluation

An important component of the risk assessment is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from the exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. The published information on doses and responses is used in conjunction with information on the nature and magnitude of exposure to develop an estimate of risk.

Standard carcinogenic slope factors and/or reference doses have been developed for many of the COCs. This section provides a brief description of these parameters.

6.4.2.1 Carcinogenic Slope Factor (CSF)

Carcinogenic slope factors are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989). This factor is generally reported in units of (mg/kg/day)-1 and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the upper 95th percent confidence limit.

These slope factors are also accompanied by weight-of-evidence (WOE) classifications which designate the strength of the evidence that the potential COC is a potential human carcinogen.

6.4.2.2 Reference Dose (RfD)

The RfD is developed for chronic and/or subchronic human exposure to chemicals and is based solely on the noncarcinogenic effects of chemical substances. It is defined as an estimate of a daily exposure level for the human population, including sensitive populations, that is likely to be without an appreciable risk of adverse effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect by an appropriate "uncertainty factor (UF)". Effect levels are determined from laboratory or epidemiological studies. The uncertainty factor is based on the availability of toxicity data.

Uncertainty factors usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These uncertainty factors are presented below and were taken from the "Risk Assessment Guidance Document for Superfund, Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989):

- A UF of 10 is to account for variation in the general population and is intended to protect sensitive populations (e.g., elderly, children).

- A UF of 10 is used when extrapolating from animals to humans. This factor is intended to account for the interspecies variability between humans and other mammals.

- A UF of 10 is used when a NOAEL derived from a subchronic instead of a chronic study is used as the basis for a chronic RfD.

- A UF of 10 is used when a LOAEL is used instead of a NOAEL. This factor is intended to account for the uncertainty associated with extrapolating from LOAELs to NOAELs.

In addition to UF's, a modifying factor (MF) is applied to each reference dose and is defined as:

- An MF ranging from >0 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base

for the chemical not explicitly addressed by the preceding uncertainty factors. The default for the MF is 1.

Thus, the RfD incorporates the uncertainty of the evidence for chronic human health effects. Even if applicable human data exist, the RfD still maintains a margin of safety so that chronic human health effects are not underestimated.

Toxicity factors and the USEPA weight-of-evidence classifications are presented in Table 6-18. The hierarchy (USEPA, 1989) for choosing these values is as follows:

- Integrated Risk Information System (IRIS);
- Health Effects Assessment Summary Table (HEAST).

The IRIS data base is updated monthly and contains both verified CSF's and RfD's. The USEPA has formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup to review and validate toxicity values used in developing CSF's. Once the slope factors have been verified via extensive peer review, they appear in the IRIS data base. Like the CSF Workgroup, the EPA has formed a RfD Workgroup to review existing data used to derive RfDs. Once the reference doses has been verified, they also appear in IRIS.

HEAST on the other hand, provides both interim (unverified) and verified CSF's and RFD's. This document is published quarterly and incorporates any applicable changes to its data base.

Appendix O present the toxicological profiles for the COCs identified at Site 48.

6.5 Risk Characterization

This section presents and discusses the estimated incremental lifetime cancer risks (ICR) and hazard indices (HI) for identified potential receptor groups which could be exposed to COCs via the exposure pathways presented in Section 6.3.

These quantitative risk calculations for potentially carcinogenic compounds estimate incremental lifetime cancer risk levels for an individual in a specified population. This unit risk refers to the cancer risk that is over and above the background cancer risk in unexposed

TABLE 6-18

TOXICITY FACTORS
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	RfD	RfI	CSF	CSFI	WOE	Reference
Trichloroethene	PDG	PDG	WD	--	--	IRIS, 1993
Acenaphthene	6.0E-02	--	--	--	--	IRIS, 1993
4,4'-DDD	--	--	2.4E-01	--	B2	IRIS, 1993
4,4'-DDE	--	--	3.4E-01	--	B2	IRIS, 1993
4,4'-DDT	5.0E-04	--	3.4E-01	3.4E-01	B2	IRIS, 1993
Lead	--	--	--	--	B2	IRIS, 1993
Mercury	3.0E-04	PDG	--	--	D	IRIS, 1993

Notes:
- RfD - Oral Reference Dose
- RfI - Inhalation Reference Dose
- CSF - Oral Cancer Slope Factor
- CSFI - Inhalation Cancer Slope Factor
- WOE - Weight of Evidence
- IRIS - Integrated Risk Information System
- -- - Not Determined
- PDG - Pending
- WD - Withdrawn

individuals. For example, an incremental lifetime cancer risk level (ICR) of 10E-6 indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals.

The incremental lifetime potential cancer risk level to individuals is estimated from the following relationship:

$$ICR = \sum_{i\text{-}1}^{n} CDI_i \, x \, CSF_i$$

The above equation is only valid at low risk levels (i.e., below estimated risks of 0.01). When estimated risks are high (i.e., greater than 0.01), the following equation should be used.

$$ICR = \sum_{i=1}^{n} \left[\left(1\text{-}exp \left(\text{-}CDI_i \, x \, CSF_i \right) \right) \right]$$

where CSFi is the cancer slope [(mg/kg/day)-1] for contaminant i, and CDIi is the chronic daily intake (mg/kg/day) for compound i. The cancer slope factor is defined in most instances as an upper 95th percentile confidence limit of the probability of a carcinogenic response based on experimental animal data and the CDI is defined as the exposure expressed as a mass of a substance contracted per unit body weight per unit time, averaged over a period of time (i.e., six years to a lifetime). The above equation was derived assuming that cancer is a non-threshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

In contrast to the above approach for potentially carcinogenic effects, quantitative risk calculations for noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects are calculated by comparing chronic daily intake levels with threshold levels (reference doses).

Noncarcinogenic effects are estimated by calculating the Hazard Index (HI) which is defined as:

$$HI = HQ_1 + HQ_2 + \ldots HQ_n$$

$$= \sum_{i=1}^{n} HQ_i$$

$$where\ HQ_i = CDI_i / RfD_i$$

HQi is the hazard quotient for contaminant i, CDIi is the chronic daily intake (mg/kg/day) of contaminant i, and RfDi is the reference dose (mg/kg/day) of the contaminant i over a prolonged period of exposure.

Estimated incremental cancer risks will be compared to the target risk range of 10E-4 to 10E-6 which the USEPA considers to be safe and protective of public health (USEPA, 1989). A value of 1.0 is used for examination of the HI. The hazard index calculated by comparing estimated chronic daily intakes with threshold levels below which, noncarcinogenic health effects are not expected to occur. Any HI equal to or exceeding 1.0 suggests that noncarcinogenic health effects are possible.

Appendix P presents the derived CDI values, ICRs and HIs for each COC by exposure pathway.

6.5.1 Human Health Effects

The following paragraphs present the quantitative results of the human health evaluation for each medium at Operable Unit No. 3 (Site 48).

6.5.1.1 Surface Soils

Table 6-19 presents the ICR and HI values derived for the potential accidental ingestion and dermal contact by base personnel, and future residents (i.e., children and adults). Surface soil ICR values for each potential receptor fall below the USEPA target risk range (10E-4 to 10E-6). Similarly, surface soil HI values, for each receptor and each exposure pathway, do not exceed unity, suggesting that the occurrence of adverse systemic health effects subsequent to exposure are unlikely.

6.5.1.2 Groundwater

Carcinogenic compounds were not detected in any of the groundwater samples collected from Site 48. Therefore, for the ingestion and dermal contact exposure routes, ICR values were not estimated. The HI values estimated for each of the exposure pathways and receptors did not

TABLE 6-19

TOTAL INCREMENTAL LIFETIME CANCER RISKS AND HAZARD INDICES
SURFACE SOIL - SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Scenario	Exposed Population					
	Base Personnel		Future Child Resident		Future Adult Resident	
	ICR	HI	ICR	HI	ICR	HI
Accidental Ingestion	1.2 E-08	1.0 E-07	4.1 E-09	1.4 E-07	2.2 E-09	1.5 E-08
Dermal Contact	2.6 E-09	1.5 E-05	1.2 E-08	1.4 E-04	4.4 E-09	2.0 E-05
TOTAL	1.5 E-08	1.5 E-05	1.6 E-08	1.4 E-04	6.6 E-09	2.0 E-05

exceed unity. Therefore, the occurrence of adverse systemic health effects are unlikely. Table 6-20 presents the HI values for ingestion and dermal contact.

6.5.1.3 Sediment

Table 6-21 presents the ICR and HI values for potential accidental ingestion and dermal contact of sediments. ICR and HI values, estimated for a future adolescent resident, indicate that carcinogenic and noncarcinogenic risks are unlikely to occur subsequent to exposure.

6.5.1.4 Biota

The ICR value estimated for ingestion of fish by an adult are presented in Table 6-22. The ICR value is within the USEPAs acceptable risk range, suggesting that systemic health effects are unlikely to occur subsequent to exposure. There were no Noncarcinogenic contaminants retained as COCs. Therefore, a HI value was not estimated for the ingestion of fish.

6.5.2 Conclusion

Human receptors at Operable Unit No. 3 (Site 48) could be potentially exposed to COCs in more than one medium and through multiple exposure pathways associated with each medium. For example, future resident children could be exposed to COCs in surface soil by ingestion and dermal contact. The same child could also be exposed to COCs in groundwater by ingestion and dermal contact. The total site risk to the child can be derived by summing the risks associated with the surface soils and groundwater and any other media applicable to the child receptor. Table 6-23 presents the total exposure ICR and HI values for the potential future and current human receptors evaluated in the quantitative risk assessment. Under current and future land use conditions, the site does not pose an unacceptable risk to any potential receptor group by USEPA standards.

6.6 Sources of Uncertainty

Uncertainties are encountered throughout the process of performing the risk assessment. This section discusses the sources of uncertainty involved with the following:

- Analytical data;
- Exposure Assessment;

TABLE 6-20

TOTAL HAZARD INDICES
GROUNDWATER - SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Scenario	Exposed Population	
	Future Child Resident	Future Adult Resident
	HI	HI
Ingestion	2.1 E-03	9.1 E-04
Dermal Contact	3.0 E-02	1.7 E-06
TOTAL	3.2 E-02	9.1 E-04

TABLE 6-21

TOTAL INCREMENTAL LIFETIME CANCER RISKS
AND HAZARD INDICES
SEDIMENT - SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Scenario	Exposed Population	
	Future Residential Adolescent	
	ICR	HI
Accidental Ingestion	1.3 E-09	2.9 E-06
Dermal Contact	9.5 E-08	2.0 E-04
TOTAL	9.6 E-08	2.0 E-04

TABLE 6-22

TOTAL INCREMENTAL LIFETIME CANCER RISKS
BIOTA - SITE 48
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Scenario	Exposed Population Adult Fisher Person ICR
Ingestion of Fish	2.1 E-06

TABLE 6-23

TOTAL SITE INCREMENTAL LIFETIME CANCER RISKS AND HAZARD INDICES
REMEDIAL INVESTIGATION CTO-0133
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Surface Soils (1)		Groundwaters (1)		Sediments (1)		Biota		Total	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Base Personnel	1.5 E-08 (100)	1.5 E-05 (100)	--	--	--	--	--	--	1.5 E-08	1.5 E-05
Future Child Resident	1.6 E-08 (100)	1.4 E-04 (5)	--	3.2 E-02 (95)	--	--	--	--	1.6 E-08	3.2 E-02
Future Adult Resident	6.6 E-09 (0.3)	2.0 E-05 (2.0)	--	9.1 E-04 (98)	--	--	2.1 E-06 (99)	--	2.1 E-06	9.4 E-04
Future Adolescent Resident	--	--	--	--	9.6 E-08 (100)	2.0 E-04 (100)	--	--	9.6 E-08	2.0 E-04

Notes:
- ICR - Incremental Lifetime Cancer Risk
- HI - Hazard Index
- (1) - Additive Ingestion and Dermal Contact Risk
- Total - Surface Soils + Groundwaters + Sediments + Biota
- ( ) - Approximate percent contribution to the total ICR or HI Value
- -- - Not evaluated as a potential exposure route

- Toxicity Assessment;and
- Compounds Not Qualitatively Evaluated

Uncertainties associated with this risk assessment are discussed in detail below.

6.6.1 Analytical Data

The development of a risk assessment depends on the reliability of and uncertainties with the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the analytical method of analysis. For example, contract laboratory program (CLP) methods have, in general, a precision of about plus or minus 50 percent depending on the sample media and the presence of interfering compounds. A value of 100 µg/kg could be as high as 150 µg/kg or as low as 50 µg/kg. In addition, the statistical methods used to compile and analyze the data (mean concentration, standard deviation, and detection frequencies) are subject to the uncertainty in the ability to acquire data.

Data validation serves to reduce some of the inherent uncertainty associated with the analytical data by establishing the usability of the data to the risk assessor who may or may not choose to include the data point in the estimation of risk.

Data qualified as "J" (estimated) is retained for the estimation of risk at Operable Unit No. 3. Data can be qualified as estimated for many reasons including a slight exceedance of holding times, high or low surrogate recovery, or intra sample variability. Organic data qualified "B" (detected in blank) or "R" (unreliable) are not used in the estimation of risk due to the unusable nature of the data. Due to the comprehensive sampling and analytical program at Operable Unit No. 3, the loss of some data points qualified "B" or "R" does not significantly increase the uncertainty in the estimation of risk.

6.6.2 Exposure Assessment

In performing exposure assessments, uncertainties arise from two main sources. First, the chemical concentration to which a receptor may be exposed must be estimated for every medium of interest. Second, uncertainties arise in the estimation of contaminant intakes resulting from contact by a receptor with a particular medium.

Estimating the contaminant concentration in a given medium to which a human receptor could potentially be exposed can be as simple as deriving the 95th percent upper confidence limit of the mean for a data set. More complex methods of deriving the contaminant concentration is necessary when exposure to COCs in a given medium occur subsequent to release from another medium and analytical data are not available to characterize the release. In this case, modeling is usually employed to estimate the potential human exposure.

Modeling the potential release of volatile organics from groundwater during showering was not attempted because groundwater is not currently used as a potable source at Operable Unit No. 3. If groundwater in the study area were to be developed as a future potable supply, volatilization of COCs during showering, washing clothes, cooking, etc. could be a significant human exposure pathway. Risk estimates associated with the potential future potable use of groundwater presented in this risk assessment may underestimate the potential human exposure for the aforementioned reason. However, risk estimates for potential human exposure via groundwater ingestion estimated a risk of greater than 10E-04.

Groundwater samples were analyzed for total (unfiltered) and dissolved (filtered) inorganic contaminants. These samples were obtained from wells which were constructed using USEPA Region IV monitoring well design specifications. Groundwater taken from monitoring wells cannot be considered representative of potable groundwater or groundwater which is obtained from a domestic well "at the tap". The use of total inorganic analytical results overestimates the potential human health risks associated with potable use scenarios. However, for the sake of conservatism total organic results have been used to estimate the potential intake associated with groundwater use.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of contaminants by the receptor. Exposure factors, have been generated by the scientific community and have undergone review by the USEPA. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited number of individuals. In all instances, values used in the risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA. Conservative assumptions designed not to underestimate daily intakes were employed throughout the risk assessment and should err on conservatively, thus adequately protecting human health and allowing the establishment of reasonable clean-up goals.

6.6.3 Toxicity Assessment

In making quantitative estimates of the toxicity of varying dosage of a compound to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are available at all. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used and new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental animals, high doses of a compound are used over a relatively short time period. In this situation, a high dose means that experimental animal exposures are much greater than human environmental exposures. Therefore, when applying the results of the animal experiment to the human condition, the effects at the high doses must be extrapolated to approximate effects at lower doses.

In extrapolating effects from animals to humans and high doses to low doses, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose response calculations, the following factors are considered:

- studies are preferred where the animal closely mimics human pharmacokinetics,
- studies are preferred where dose intake most closely mimics the intake route and duration for humans, and
- studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e., noncarcinogens) safety factors are employed in the extrapolation of effects from animals to humans, and from high to low doses.

The use of conservative assumptions results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

6.6.4 Compounds Not Quantitatively Evaluated

The following compounds were not quantitatively evaluated because of the unavailability of toxicity information:

Trichloroethene
Lead

The toxicity indices for trichloroethene and lead are under review by the USEPA. Updated values may be available in the future.

Given the concentrations of these chemicals detected in Site 48 media, promulgation of toxicity indices by USEPA will not significantly increase the potential human health risk estimates associated with the site.

7.0 SUMMARY AND CONCLUSIONS

This section summarizes the nature and extent of contamination at the site, and the results of the human health and ecological risk assessments. As mentioned previously in this report, the ecological risk assessment has been submitted under separate cover; however, the results are summarized herein.

Conclusions resulting from the evaluation of environmental data are presented in Section 7.2.

7.1 Summary

7.1.1 Nature and Extent of Contamination

Based on the soil samples collected from the three areas of concern at Site 48, the analytical results do not indicate the presence of mercury at Site 48. Other contaminants detected in soil (e.g., pesticides, metals) are similar to background levels, or were detected infrequently and at low levels and are not present in the environment as a result of previous disposal activities at the site.

Groundwater did not exhibit mercury above drinking water standards. Mercury levels reported in groundwater samples were below the Contract Required Detection Limit of 0.04 ug/l. Trace levels of trichloroethene (TCE) (1 ug/l) and phenol (3 ug/l) were detected in groundwater below drinking water standards. These contaminants were only detected in two monitoring wells. Soil did not exhibit either TCE or phenol. The source of this contamination is unknown.

Elevated levels of manganese (above State drinking water standards and Secondary MCLs) were present in groundwater; however, elevated levels of manganese are reportedly present throughout MCB Camp Lejeune and therefore may be naturally occurring in the environment (Greenhorne & O'Mara, 1992).

Surface water quality in the intermittent tributary and the marsh exhibited levels of mercury (0.04 to 0.05 ug/l) above the AWQC of 0.025 ug/l. However, upstream sampling locations also exhibited mercury above AWQC.

Surface water quality in the New River exhibited low levels of volatile organic contamination (toluene and total xylenes) below Ambient Water Quality Criteria (AWQC) for the protection of aquatic life. Because these constituents were also present in the New River upstream of the site, the presence of these constituents are not likely related to previous waste disposal activities at Site 48. In addition, neither soil or groundwater exhibited toluene or total xylenes.

Sediment in the intermittent tributary, the marsh, and the New River exhibited low levels of mercury (0.03 mg/kg to 0.17 mg/kg). Only one location (at the marsh) exceeded the EPA Region IV Sediment Quality Criteria of 0.015 mg/kg at this level, no response actions are required based on EPA guidelines. Samples collected during previous investigations (prior to this RI) also exhibited mercury at similar concentrations.

Low levels of pesticides and PAHs were detected in two sediment samples collected from the New River. The source of these contaminants is not likely from Site 48 since PAHs were not detected in soil and only one surface soil sample exhibited pesticides at low levels.

The results of the benthic macroinvertebrate study and fish study did not indicate adverse impacts to the ecology of the New River or marsh. The results of the these studies were comparable to the White Oak River, which was included in the study as a reference station.

Fish and crab samples collected for chemical analysis did not exhibit mercury. Low levels of pesticides and inorganics were present in fish.

7.1.2 Human Health Risk Assessment

A quantitative risk assessment was not warranted since limited contamination was detected in soil, groundwater, sediment, and surface waters during the remedial investigation. The qualitative risk assessment concluded that there is no risk to human health based on a comparison of site-related contaminants to ARARs.

7.1.3 Ecological Risk Assessment

A qualitative ecological risk assessment was performed based on the information collected during the aquatic survey. The results indicated that the ecology of the New River and marsh

area appears to be healthy and are comparable to other similar waters (i.e., the White Oak River).

7.2 Conclusions/Recommendations

The environmental quality at Site 48 is good. Soil and groundwater do not exhibit contamination that would be expected by the disposal of mercury.

The ecology of the study area appears to be healthy. Contaminants detected in surface water and sediment do not appear to be related to Site 48.

No further environmental investigations are recommended. The sampling and analysis performed is sufficient to characterize the site and develop conclusions with respect to potential impacts to the public health and the environment.

No remedial response actions are justifiable at Operable Unit No. 3 since the site media pose no adverse impacts to public health or the environment. Therefore, a feasibility study is not recommended.

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