03.13-01/31/96-01695

FINAL

REMEDIAL INVESTIGATION REPORT
OPERABLE UNIT NO. 8 (SITE 16)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

TEXT AND FIGURES

CONTRACT TASK ORDER 0274

JANUARY 31, 1996

Prepared For:

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

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AET	Apparent Effect Threshold
AOC	Area of concern
AQUIRE	Aquatic Information Retrieval Database
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AT	averaging time
AWQC	Federal Ambient Water Quality Criteria
b	saturated thickness
Baker	Baker Environmental, Inc.
BCF	bioconcentration factor
BD	Burn Dump
bgs	below ground surface
BI	biotoxic index
BRA	baseline risk assessment
Bv	biotransfer factor leaf part of plant
BC	biotransfer factor leaf part of plant
C°	degrees centigrade
CADD	Computer Aided Drafting Design
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CL	sandy clay and clay
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
cm/sec	centimeters per second
CoC	Chain-of-Custody
COPC	contaminant of potential concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	Cancer Slope Factor
1,2-DCE	1,2-Dichloroethene
DEM	Division of Environmental Management
DDE	dichlorodiphenyldichloroethylene
DDT	diphenyltrichloroethane
DoN	Department of the Navy
DQOs	data quality objectives

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

DS	Down Slope
ED	exposure duration
EF	exposure frequency
Eh	oxidation reduction potential
EMD	Environmental Management Department
ERA	Ecological Risk Assessment
ER-L	Effects Range - Low
ER-M	Effects Range-Median
ESE	Environmental Science and Engineering, Inc.
°F	Fahrenheit
FB	Field Blank
FCV	Final Chronic Water Quality Value
FFA	Federal Facilities Agreement
FMF	Fleet Marine Force
FSAP	Field Sampling and Analysis Plan
ft/ft	foot per foot
FWQSV	Freshwater Water Quality Screening Values
FWS	Fish and Wildlife Service
GA	Existing or Potential Source of Drinking Water for Humans ($\leq$250 mg/L chloride)
HA	health advisory
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HI	hazard index
HQ	hazard quotient
i	hydraulic gradient
IAS	Initial Assessment Study
ICR	incremental cancer risk
ID	inside diameter
IDW	investigative derived wastes
IR	ingestion rate
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K	hydraulic conductivity
K_d	soil sorption coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol water partition coefficient
LANTDIV	Naval Facilities Engineering Command, Atlantic Division

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

LOAEL	lowest observed adverse effect level
MBI	Macroinvertebrate Biotic Index
MCB	Marine Corps Base
MCL	maximum contaminant level
MF	modifying factor
mg/kg	milligram per kilogram
mg/L	milligram per liter
mgd	million gallons per day
MH	plastic silt
MI	mobility index
ml	milliliter
mL/g	milliliters per gram
ML	low plasticity silt
mmhos/m	millimohos/meter
msl	mean sea level
MW	monitoring well
n	effective porosity
NACIP	Navy Assessment and Control of Installation Pollutants Program
NC	Northeast Creek
NC DEHNR	North Carolina Department of Environment, Health and Natural Resources
NCMFC	North Carolina Marine Fisheries Commission
NCP	National Oil Hazardous Substance Pollution Contingency Plan
NCWP	Near Coastal Waters Program
NCWQS	North Carolina Water Quality Standards
NCWRC	North Carolina Wildlife Resources Commission
NEESA	Naval Energy and Environmental Support Activity
NEHC	Navy Environmental Health Center
NEP	National Estuary Program
NOAA	National Oceanic and Atmospheric Administration
NOAEL or NOEL	No observed adverse effect level
NPL	National Priorities List
NPS	National Park Service
NREA	National Resources Environmental Affairs
NSW	nutrient sensitive waters
NTU	Nephtelometric Turbidity Unit
NWI	national wetlands inventory
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PEF	particulate emissions factor
PID	photoionization detector
ppb	parts per billion
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QI	quotient index
RA	risk assessment
RBC	risk based concentrations
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	remedial investigation/feasibility study
ROD	record of decision
S	water solubility
SA	estuarine waters suitable for commercial shell fishing
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SC	estuarine water sample not suited for body contact sports or commercial fishing
SD	sediment
SDA	Surface Drainage Area
Sj	Jaccard Coefficient
SM	silty sand
SMCL	Secondary Drinking Water Regulations
SOPs	standard operating procedures
SP	poorly graded sands with little to no fines
SQC	sediment quality criteria
SSV	sediment screening value
S.U.	standard units
SVOCs	semivolatile organic compounds
SWSV	surface water screening value
T	transmissivity
TAL	target analyte list
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TEF	toxicity equivalency factor
TICs	tentatively identified compounds
TOC	total organic carbon or top of casing
TRVs	terrestrial reference values

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

UCL	upper confidence limit
UF	uncertainty factor
µg/kg	microgram per kilogram
µg/L	micrograms per liter
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
V	groundwater velocity
VOCs	volatile organic compounds
VP	vapor pressure
WAR	Water and Air Research, Inc.
WOE	weight of evidence
WQS	water quality standards
WQSV	water quality screening values
WS	Wilderness Society

the intersection with Coolidge Road and Harding Road, and connects to the storm line southeast of the site. A four-foot wide ditch, believed to be a fire break is evident advancing from the storm sewer line to the southwest of the study area and extending around the western side of the former burn dump. There are no permanent structures at this site.

Limited information is available concerning the operational history of the burn dump. Practices at other burn dumps at MCB, Camp Lejeune indicate that this dump may have accepted municipal waste/trash from the surrounding area housing and activity buildings. Records indicate that small amounts of liquids (waste oils) were also disposed of at this site. Previously existing asbestos (less than one cubic yard) has been removed from the site. Typically, the debris was burned, then graded to the perimeter of the disposal area so that more debris could be dumped and burned. Currently, the study area is being used for staging vehicles and for vehicle training exercises. In the center of the study area is a mock-up jet aircraft. This aircraft is used to train in refueling exercises by tank truck operations. During these exercises; however, no fuel is used.

REMEDIAL INVESTIGATION ACTIVITIES

The RI field program at Site 16 consisted of a site survey: a soil and groundwater investigation which included drilling and sampling; a groundwater investigation which included monitoring well installation and sampling; a habitat evaluation; and a surface water and sediment investigation. The surface water and sediment investigation was conducted from June 26 through June 27, 1994. The remainder of the RI field program commenced on October 10, 1994 and continued through December 12, 1994. Baker returned to Camp Lejeune from January 30 through February 5, 1995 to coordinate the disposal of Investigative Derived Waste (IDW), and to conduct a second round of groundwater sampling at Site 16. Confirmatory surface soil sampling was conducted on December 14, 1995. The following details the various investigation activities which were implemented during the RI.

Site 16 encountered one deviation from the approved Project Plans while the RI investigation was being conducted. Originally, a soil boring grid (150 foot by 100 foot) resulting in 22 boring locations was demarcated onto a MCB, Camp Lejeune Computer Aided Drafting Design (CADD) figure during the development of project plans. However, when the sampling grid was surveyed, site characteristics did not correlate with the existing base CADD. This resulted in a smaller investigative area then was previously identified. Two soil borings were removed from the sampling grid since the placement of these borings would be outside of the investigative area, and the information obtained from analytical findings would not be applicable. Also, five sampling locations were relocated to the central portion of the site between grid lines to provide more thorough coverage of the site.

The site survey task was performed in two phases: Phase I - initial survey of site features and proposed sample locations; Phase II - post investigation survey of actual sampling locations and monitoring wells. For each soil boring and monitoring well, the latitude, longitude, and elevation in feet above mean sea level were recorded. The firm W. K. Dickson and Associates, Inc. was retained to perform both phases of the site survey.

A soil investigation was conducted at Site 16 to characterize soil quality at the site and to determine the presence or absence of waste materials within the boundary of the former burn dump. A total of 32 surface soil samples [0 to 1 foot below ground surface (bgs)] were collected. A total of 35 subsurface soil samples (1 foot bgs to just above the groundwater table) were collected. In addition to the soil investigation, four trenches were also performed at Site 16 as part of the subsurface soil investigation. The trenches were excavated within the boundary of the former burn dump to inspect subsurface conditions.

A confirmatory surface soil investigation which included collecting and analyzing four surface soil samples (0- to 1-foot bgs) was completed in the area of existing boring 16-BD-SB05.

A groundwater investigation was conducted at Site 16 to determine the presence or absence of contamination in the surficial aquifer resulting from past burning and disposal activities. Six shallow groundwater monitoring wells were drilled and installed as part of the investigation. One well (16-MW01) was placed in an upgradient (background) location. Three wells (16-MW02, 16-MW03, and 16-MW04) were installed downgradient of Site 16 to assess off-site groundwater quality. Two wells (16-MW05 and 16-MW06) were installed within the boundary of the former burn dump.

A habitat evaluation was performed at Site 16 from December 4 through 6, 1994. The evaluation focussed on the determination of terrestrial and aquatic ecosystems, along with the identification of plant and animal species. This information was used to aid in the ecological risk assessment.

A surface water investigation was conducted at Site 16 to assess the possible impact of the former burn dump on Northeast Creek. Five surface water samples were collected on Northeast Creek during the period from June 26 through June 27, 1994.

A sediment investigation was conducted at Site 16 to assess the possible impact of the former burn dump on Northeast Creek. Ten sediment samples were collected from the sampling locations where surface water samples were collected. Two sediment samples (samples obtained from 0 to 6 inches, 6 inches to 1 foot) were collected from each sampling location.

Field QA/QC samples were submitted during the investigation. These samples included trip blanks, equipment rinsates, and field duplicates.

Samples collected during the RI were submitted for laboratory analysis to Quanterra Environmental Services and data validation was performed by Chester Environmental, Inc. A majority of the samples (excluding general chemistry, engineering parameters, TCLP and RCRA) were analyzed by Contract Laboratory Program (CLP) methods using Level III Data Quality Objectives (DQOs). Additionally Chester Environmental, Inc. performed frequency of detection and statistical analyses on the laboratory data.

Data collected from each site were evaluated and interpreted to evaluate the extent of contamination for each media. A risk assessment was conducted to determine potential site risks related to human health and the environment. Field data related to the physical characteristics (e.g., geologic and hydrogeologic conditions) of each site were also evaluated and interpreted to assist in determining contaminant fate and transport.

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

Topography and Surface Features

Site 16 is relatively flat with a slight slope to the southeast. Most of the site is currently a cleared area; the remainder is comprised of pine trees. There is an opening in the wooded area in the southeast corner of the study area which leads to Northeast Creek. An apparent storm sewer line, located to the southeast of the burn dump, runs in a northeast-southwest direction. There is also a storm sewer line that runs from the intersection of Coolidge and Harding Roads, and connects to the storm line southeast of the site.

Surface Water Hydrology and Drainage Features

There are no standing water bodies within the site. Northeast Creek is located approximately 400 feet southeast of the burn dump. Surface drainage is in a southeast direction toward Northeast Creek. The southeast portion of the site exhibits eroded soils, and surface runoff apparently drains to Northeast Creek.

HYDROGEOLOGY

The hydrogeologic setting was evaluated by installing a network of shallow monitoring wells throughout the site. Groundwater was encountered during the RI at depths ranging from 3.68 to 18.43 feet below ground surface (bgs). The contour maps indicate linear flow in towards the southeast, in the direction of Northeast Creek. Recharge for this area is from the northwest. The shallow groundwater gradient measured from well 16-MW01 to well 16-MW04 to the southeast for December 11, 1994 was 0.002 ft/ft and from well 16-MW01 to 16-MW03 for March 27, 1995 was 0.004 ft/ft. The groundwater velocity (V) in a northwest to southeast direction is estimated to be 0.05 feet/day (18.25 feet/year).

A tidal study was conducted to determine the influence of tidal effects on the shallow groundwater within the site boundaries. A staff gauge was installed in Northeast Creek approximately 50 feet from shore. Fluctuations in the water surface from 0.2 to 0.7 feet were indicated by staff gauge readings. Well 16-MW03, near Northeast Creek, exhibited groundwater fluctuations of 0.1 to 0.3 feet. No fluctuations in groundwater were exhibited in well 16-MW05, which is located approximately 470 feet from Northeast Creek. The data indicates that there is a tidal effect on the shallow groundwater, but there is a delay between the highest elevations of the groundwater and the creek. The tidal influence from Northeast Creek reaches inland, but at a distance probably less than 300 feet.

Potable Water Supply Wells

Potable water supply wells within a one-mile radius of the site were identified. Based on information obtained from the United States Geological Society (USGS) publication (Harned, et al., 1989) there are five supply wells within a one-mile radius of Site 16.

EXTENT OF CONTAMINATION

A brief summary of the nature and extent of contamination is provided in the following sections. This summary focuses on the primary problems at the site and is not intended to address all the media or results. Detailed findings and evaluation are presented in Section 4.0 of this report.

Soils

A total of 29 surface soil and 35 subsurface soil samples were collected from the burn dump area, the surface drainage area, and the monitoring well locations at Site 16. Additionally, three (3) background surface and subsurface soils were collected.

The pesticides 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and dieldrin are the most prevalent pesticide contaminants detected in the surface soil. 4,4'-DDE was detected in 26 of the 29 surface soil samples. The maximum pesticide concentration reported is for 4,4'-DDT at 540 µg/kg. Pesticide contamination is at relatively consistent concentration levels in the surface soil samples collected across the site. Pesticide contamination in the subsurface soil is less frequent than in the surface. The most prevalent pesticide, 4,4'-DDT, was detected in only 2 of 32 samples. The pesticide levels detected in the surface and subsurface soil at Site 16 are similar to levels detected at other areas within MCB Camp Lejeune.

Surface soil contamination also consists of PCBs (Aroclor 1254 and Aroclor 1260). Aroclor 1254 is the most prevalent being detected in 13 of 29 surface soil samples. Additionally, the maximum contaminant level (2,100 µg/kg) is reported for Aroclor 1254. The maximum concentration of Aroclor 1254 was detected in soil sample 16-BD-SB13. Although not as frequent as in the surface soil, Aroclor 1254 is present in subsurface soil. Aroclor 1254 is present in 2 of 32 subsurface locations. The maximum concentration of Aroclor 1254 is detected in soil collected from location 16-BD-SB13. The detections of Aroclor 1254 and 1260 are from sampling locations across the site. PCBs are not found in the groundwater indicating that vertical migration to the water table has not occurred.

Semivolatile compounds are infrequently encountered at low levels in the surface soil. Other than bis(2-ethylhexyl)phthalate, which is believed to be blank associated, the most frequent semivolatile compound detected is chrysene (4 out of 29 samples). All of the semivolatile compounds concentrations are less than 150 µg/kg. Subsurface soil is relatively absent of semivolatile contamination. Acenaphthene and pentachlorophenol (3 out of 32 samples) are the most prevalent semivolatiles. The concentration levels and presence of semivolatile compounds in the soil is random across the site. The source of the semivolatile compounds is believed to be due to historical open burning operations.

Other than common lab contaminants (e.g., methylene chloride, acetone, and toluene) volatile organic contamination is absent in the surface and subsurface soil.

The concentrations of several inorganic constituents exceed twice the average base-specific background concentration. A continuing soil background database is being developed for MCB Camp Lejeune to support the RI/FS efforts. Comparing the results for surface and subsurface soil, it appears that there is little correlation between elevated metals concentrations in the surface and subsurface soil. For surface soils, arsenic, barium, chromium, copper, iron, lead, manganese, vanadium, and zinc were the predominant metals that exceed background levels. In contrast zinc is the only metal that exceeds background levels more than one time in the subsurface.

Groundwater

Two rounds or groundwater samples were collected from six shallow wells at Site 16.

Volatile contaminants benzene and ethylbenzene were detected in one groundwater sample collected during the first round of groundwater sampling. Both contaminants were present in monitoring well 6-MW05. Benzene and ethylbenzene were detected at levels of 37 µg/L and 1 µg/L, respectively. Volatile contaminants were absent in all groundwater samples collected as part of the second round.

Metals were the most prevalent and widely distributed contaminants in the groundwater. Elevated levels of total (unfiltered) metals during these sampling rounds included barium (maximum concentration 77.9 µg/L), calcium (maximum concentration 13,400 µg/L), iron (maximum concentration 712 µg/L), lead (maximum concentration 3.2 µg/L), magnesium (maximum concentration 5,090 µg/L), manganese (maximum concentration 31.6 µg/L), sodium (maximum concentration 16,400 µg/L), and zinc (maximum concentration 80.5 µg/L). Only iron concentrations exceed state or federal groundwater criteria.

Semivolatile contamination in the groundwater was limited to low levels of naphthalene (maximum concentration 4 µg/L) phenol (maximum concentration 1 µg/L), and bis(2-ethylhexyl)phthalate (maximum concentration 5 µg/L).

Pesticide and PCB contaminants were not detected in either round of sampling.

Surface Water/Sediment

Northeast Creek is the only surface water body in the vicinity of the site. Northeast creek lies approximately 400 feet in a southeastern direction from the site. One surface water and two sediment samples were collected from each of five sampling stations.

Volatile contaminants 1,1,2,2-Tetrachloroethane and 4-Methyl-2-pentanone were detected in surface water sample 16-NC-SW05 at a concentration of 2 µg/L and 7 µg/L, respectively. These contaminant concentrations do not exceed state surface water quality standards. However, 1,1,2,2-tetrachloroethane exceeds the federal AWQC (0.17 µg/L) for the protection of water and organisms. No other volatile organics were detected in the surface water. This location is approximately a quarter mile downstream of the site.

Semivolatile, pesticide, and PCB contaminants were not detected in the surface water. The levels of bis(2-ethylhexyl)phthalate in the samples suggests the occurrence of laboratory contamination.

Arsenic was detected in 4 out of 5 surface water samples at levels which exceed state or federal criteria.

Volatile organics carbon disulfide (1 out of 10 samples) and toluene (2 out of 10 samples) were infrequently detected in the sediment.

Semivolatile, pesticide, and PCB contamination is absent in the sediment.

Silver was detected in 1 out of 10 samples. The level of silver (1.2 mg/kg) is the only inorganic concentration to exceed either the ER-L or ER-M.

HUMAN HEALTH RISK ASSESSMENT

There are no potential noncarcinogenic or carcinogenic risks associated with current human exposure to the subsurface soils, groundwater, surface water, or sediment. There are; however, potential noncarcinogenic risks to future child residents from combined exposure to soil (ingestion, dermal contact, and inhalation). The Hazard Index 1.19 slightly exceeds the acceptable risk level of 1.0. This exceedance is primarily due to potential incidental ingestion of Aroclor 1254 in soil.

On comparison with contaminant levels from the initial round of groundwater samples with state and federal criteria, only benzene and iron exceeded both state and federal criteria. Results from the second round of groundwater sampling indicate that only iron exceeded state and federal criteria.

ECOLOGICAL RISK ASSESSMENT

No site related contaminants were detected in the surface water or sediment at concentrations that exceed any of the surface water or sediment screening values. Therefore, a potential decrease in the aquatic receptor population is not expected.

Several contaminants were detected in the surface soil at concentrations that exceed the surface soil screening values. Therefore, there is a potential for a limited decrease in the terrestrial floral and/or faunal population in this area. However, it should be noted that no areas of dead or stressed vegetation were observed during the field investigation or habitat characterization.

A potential decrease in the terrestrial vertebrate receptor population from site-related Contaminants of Potential Concern (COPCs) is not expected.

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) on October 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, the United States Environmental Protection Agency (USEPA) Region IV, The North Carolina Department of the Environment, Health and Natural Resources (NC DEHNR), the United States Department of the Navy (DoN), and Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at MCB, Camp Lejeune were thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives were developed and implemented as necessary to protect the public health, welfare, and the environment (FFA, 1989). The Site Management Plan for MCB, Camp Lejeune, a primary document referenced in the FFA, identifies 33 sites that require Remedial Investigation/Feasibility Study (RI/FS) activities. These 33 sites have been divided into 17 operable units to simplify proceeding with RI/FS activities. This report describes the RI conducted by Baker Environmental Inc. (Baker) at Operable Unit (OU) No. 8, which is comprised of Site 16. Figure 1-1 depicts the MCB Camp Lejeune location along with the location of Site 16. [Note that all tables and figures are provided in the back of each section.]

The purpose of the RI is to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants. This RI investigation was conducted through the sampling of several media (soil both surficial and subsurface, groundwater, surface water, and sediment at Site 16, evaluating the resultant analytical data, and performing a human health risk assessment (RA) and ecological RA. Furthermore, the RI report provides information in support of the FS and record of decision (ROD).

This RI Report is prepared by Baker for submittal to the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), MCB, Camp Lejeune Environmental Management Division (EMD), USEPA Region IV, the NC DEHNR, and the Navy Environmental Health Center (NEHC), for their review.

The following subsections describe the physical characteristics and history of OU No. 8 (Site 16). In addition, Section 1.1 provides an overview of the RI Report's Organization.

1.1 Report Organization

This RI Report for Site 16 is comprised of the following sections:

- Section 1.0 - Introduction - Introduction (includes OU and site description, and site history)
- Section 2.0 - Field Investigation
- Section 3.0 - Regional and Site Characteristics
- Section 4.0 - Nature and Extent of Contamination
- Section 5.0 - Contaminant Fate and Transport
- Section 6.0 - Baseline Human Health Risk Assessment
- Section 7.0 - Ecological Risk Assessment
- Section 8.0 - Conclusions and Recommendations

Appendices that are referenced in this RI Report for Site 16 are provided in separate volumes.

1.2 Operable Unit Description

Operable units are formed as an incremental step toward addressing individual site concerns and to simplify the specific problems associated with a site or a group of sites. There are currently 23 Installation Restoration Program (IRP) sites at MCB, Camp Lejeune which have been grouped into 16 operable units. [Site 16 is the only site within OU No. 8, due to it's previous history of being a burn dump, it's lack of proximity to other sites, and because that no previous investigations were conducted there]. Figure 1-2 depicts the locations of all 17 OUs and 33 sites at MCB, Camp Lejeune.

1.3 Site Description and History

Site 16, referred to as the Montford Point Burn Dump, is located southwest of Montford Landing Road and Wilson Drive intersection within the Montford Point development area of Camp Johnson. Site 16 is approximately 4 acres in size. Northeast Creek is approximately 400 feet southeast of the study area. The remainder of Site 16 is bordered by wooded areas.

Most of Site 16 is cleared; the areas which surrounds Site 16 is comprised of pine and hardwood forest. An opening in the southeast corner of the study area leads to Northeast Creek. A storm sewer, located to the southeast of the burn dump, runs in a northeast - southwest direction. Another storm sewer that flows from the intersection of Coolidge Road and Harding Road, connects to the storm sewer southeast of the site. Recently, the study area has been used for vehicle staging and for vehicle training exercises. In the center of the study area is a mock-up jet aircraft. This aircraft is used in refueling exercises by tank truck operators. During these exercises, however, no fuel is used. A four-foot wide ditch, believed to be a fire break, is present in the southwest portion of the study area. This ditch extends around the western side of the former burn dump. There are no permanent structures at this site. Figure 1-3 depicts the location of Site 16 and bordering areas.

Limited information is available concerning the past operational history of the burn dump. Practices at other burn dumps at MCB Camp Lejeune indicate that the Montford Point Burn Dump may have accepted municipal waste or trash from the surrounding housing area and activity buildings. Records indicate that waste oils were also disposed of at this site. Typically, the debris was burned and then graded to the perimeter of the disposal area so that more debris could be dumped and burned (Baker, 1994).

1.4 Previous Investigations

No investigations were conducted at Site 16 prior to this RI. Visual observations recorded during a site reconnaissance (March 1, 1994) and review of historical photographs were the only information upon which the presence or absence of contamination was used to determine the placement of sampling stations.

1.5 Data Limitations

Due to a lack of previous investigation data, it was apparent that the following media needed to be sampled at Site 16 to determine either the presence or absence of site related contamination:

- Surficial soil
- Subsurface soil
- Surficial groundwater
- Surface water
- Sediment

[Note, surface water, and sediments were included in the media types to be studied, due to the proximity of Northeast Creek to the site.]

Based upon the lack of previous investigation results, the following site-specific data needs were generated:

- The potential impact of the reported burn area to human health and the environment based on soil, groundwater, surface water and sediment data.
- The hazardous or nonhazardous nature of potential buried burn material.
- The presence or absence of site-related contaminants in the surface and subsurface soil in order to conduct a human health risk assessment.
- The hydrogeologic parameters of the shallow aquifer.
- The reliable information to support assessment of risks to human health presented by future potential exposure to shallow groundwater.
- The effects of natural discharge from the shallow groundwater on local surface water.
- The risks to human health and the environment associated with the surface water use or exposure.
- The distribution of contaminant compounds to sediments of Northeast Creek from runoff and groundwater discharge.
- The risk to human health and the environment associated with exposure to sediments in local water bodies.

From these apparent limitations, RI objectives were established to meet the data deficiencies for Site 16. The RI objectives are discussed in detail in the following section.

1.6 Remedial Investigation Objectives

The purpose of this section is to define the RI objectives aimed at characterizing past waste disposal activities at Site 16, assessing potential impacts to public health and environment, and providing feasible alternatives for consideration during preparation of the ROD. The remedial objectives presented in this section have been identified through review and evaluation of existing background information, assessment of potential risks to public health and environment, and consideration of feasible remediation technologies and alternatives. Table 1-1 presents both the RI objectives identified for Site 16 and the criteria necessary to meet those objectives. In addition, the table provides a general description of the study or investigation efforts required to obtain the necessary information. The different media investigations conducted at Site 16 are described in Section 2.0 of this report.

1.7 References

Baker Environmental, Inc. 1994. Remedial Investigation/Feasibility Study Project Plans for Operable Units Numbers 8, 11, and 12 (Sites 16, 7, 80, and 3). Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk Virginia.

SECTION 1.0 TABLES

TABLE 1-1

SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess the extent of soil contamination in the former burn dump area.	Characterize contaminant levels in surface and subsurface soils at the former burn dump area.	Soil Investigation
	1b. Assess human health and ecological risks associated with exposure to surface soils at the site.	Characterize contaminant levels in surface soils at the study area.	Soil Investigation Risk Assessment
	1c. Determine whether contamination from soils is migrating to groundwater.	Characterize subsurface soil and leaching potential. Characterize shallow groundwater.	Soil Investigation Groundwater Investigation
	1d. Identify residual wastes within the burn dump.	Identify subsurface features and debris.	Test Pit Investigation
	1e. Evaluate treatment alternatives.	Characterize areas of concern above action levels. Evaluate effectiveness and implementability of technologies.	Soil Investigation Feasibility Study Bench or Pilot-Scale Testing
2. Groundwater	2a. Assess health risks posed by potential future usage of the shallow groundwater.	Evaluate groundwater quality and compare to groundwater criteria and risk-based action levels.	Groundwater Investigation Risk Assessment
	2b. Assess nature and extent of shallow groundwater contamination.	Characterize shallow groundwater quality.	Groundwater Investigation
	2c. Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability, etc.).	Groundwater Investigation

TABLE 1-1 (Continued)

SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
3. Sediment	3a. Assess human health and ecological risks associated with exposure to sediments in Northeast Creek.	Characterize nature and extent of contamination in sediment	Sediment Investigation in Northeast Creek Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments in Northeast Creek.	Qualitatively evaluate stress to benthic and fish communities.	Evaluation of Surface Water and Sediment Investigation
	3c. Determine extent of sediment contamination for purposes of identifying areas of concern.	Identify extent of sediment contamination where contaminant levels exceed risk-based action levels or USEPA Region IV criteria.	Sediment Investigation in Northeast Creek Risk Assessment
4. Surface Water	4a. Assess the presence or absence of surface water contamination in Northeast Creek.	Determine surface water quality in Northeast Creek.	Surface Water Investigation

SECTION 1.0 FIGURES

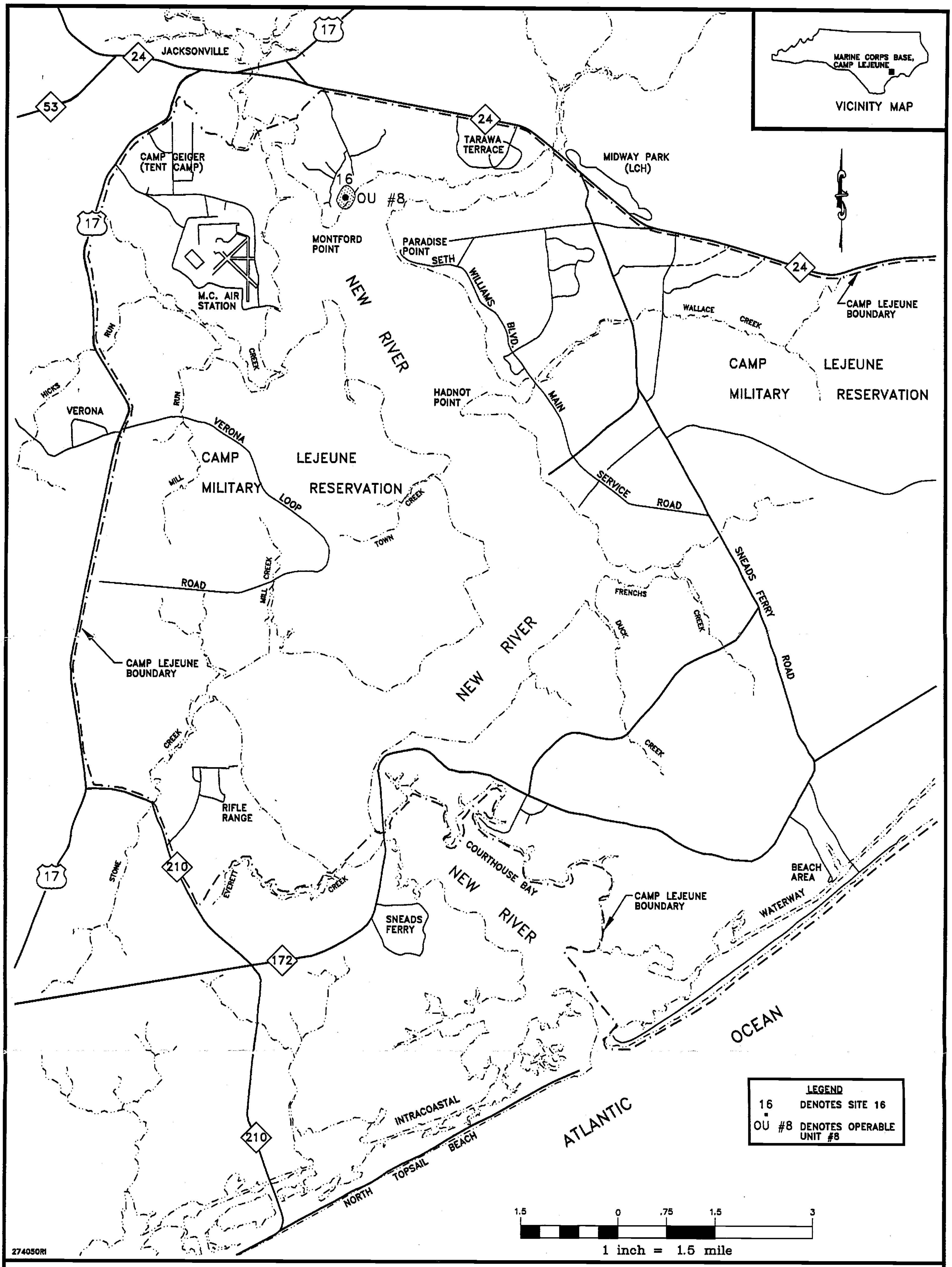


FIGURE 1-1
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q012

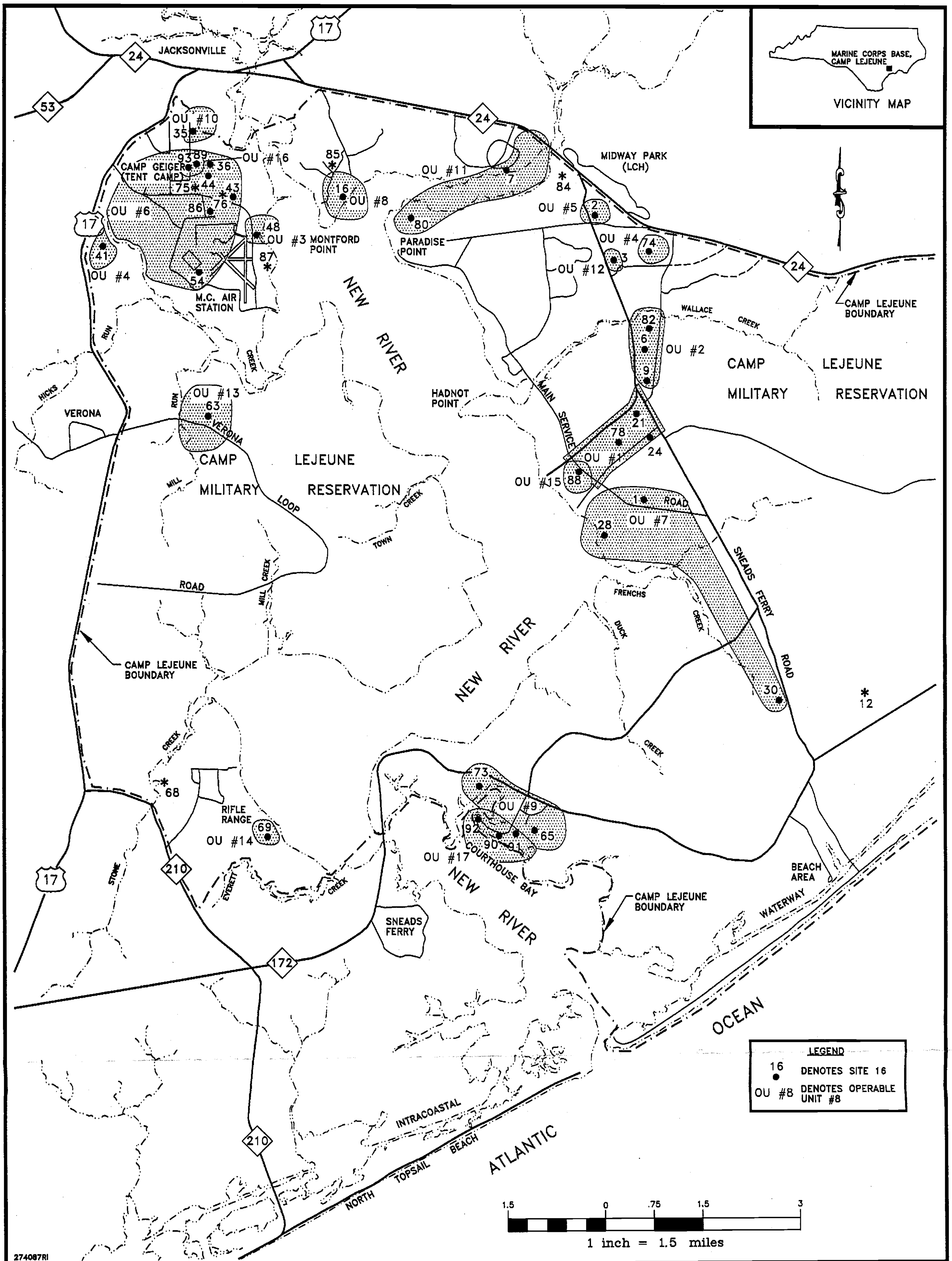
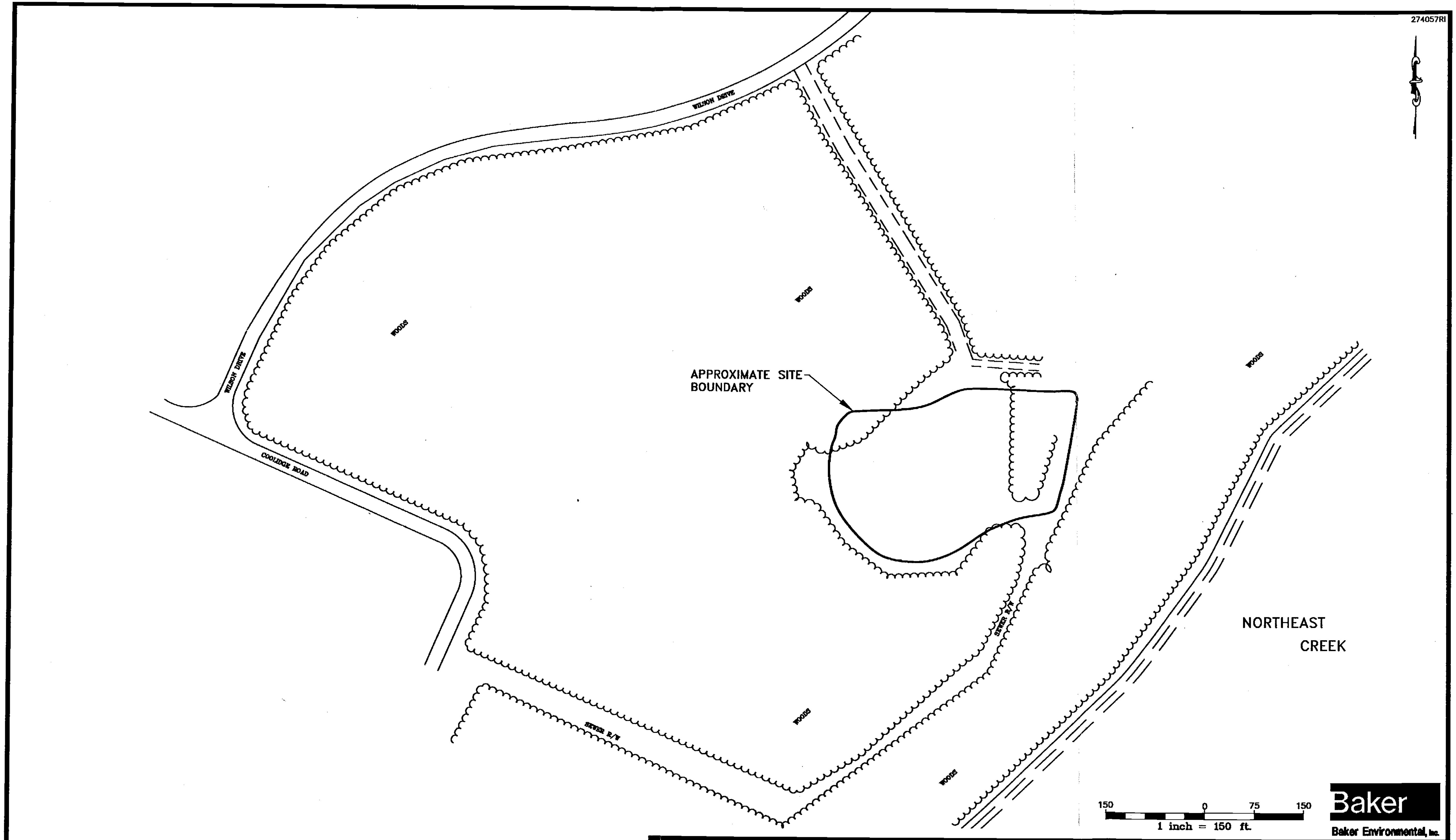


FIGURE 1-2
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q02Z



LEGEND

— APPROXIMATE SITE BOUNDARY

= = DIRT ACCESS ROAD

═ PAVED ROAD

⌒⌒⌒ TREELINE

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 1-3
SITE LOCATION MAP
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2.0 FIELD INVESTIGATION

This section discusses the site-specific RI field investigation activities that were conducted to fulfill the objectives identified in Section 1.6. The initial phase of the RI field investigation commenced on October 10, 1994 and continued through December 12, 1994. The surface water and sediment investigation was conducted earlier, from June 22, to June 27, 1994. During the week of January 30, 1995, investigative derived waste (IDW) generated during the RI was disposed of, and a second round of groundwater sampling was conducted at Site 16. The RI field program at Site 16 consisted of a site survey; a soil investigation which included drilling and sampling; a groundwater investigation which included monitoring well installation and sampling; and a surface water and sediment sampling investigation. The following sections detail the various investigation activities which were implemented during the RI.

Investigative procedures and methodologies for the RI conducted at Site 16 have been previously discussed in detail within Section 6.0 of the Final Field Sampling and Analysis Plan (FSAP), for OU No. 8, (Baker, 1994).

At Site 16, one deviation from the approved Final FSAP was required. Originally a soil boring sampling grid (150 foot by 100 foot) resulting in 22 soil boring locations was demarcated onto a MCB, Camp Lejeune Computer Aided Drafting Design (CADD) figure, during the development of project plans. However, when the sampling grid was surveyed in, existing dimensional site characteristics did not correlate with base CADD. This resulted in a smaller investigative area than was previously identified. Two soil borings were removed from the sampling grid due to the following; placement of these borings would be out of the investigative area, and that information obtained from analytical findings would not be applicable. Also, five sampling locations were relocated to the middle areas between grid lines to provide more thorough coverage of the site.

2.1 Site Survey

The site survey task was performed in two phases: Phase I - initial survey of site features and proposed sample locations; and Phase II - post investigation survey of existing sampling locations and monitoring wells. The firm of W. K. Dickson and Associates, Inc. was retained to perform both phases of the site survey. Phase I of the survey task was conducted at Site 16 during the week of October 10, 1994. Since this site was never investigated, some of the time spent in surveying this site was spent surveying in existing features (i.e., Northeast Creek, sewer line, and wood line). The proposed soil borings and monitoring well locations, provided in the Final RI/FS Work Plan for OU No. 8 (Baker, 1994), were also surveyed and then marked with wooden stakes. Each sample location was assigned a specific identification number that corresponded to the site and sampling media.

Phase II of the site survey task was completed at Site 16 during the week of November 28, 1994. During Phase II, all monitoring wells and soil borings were surveyed at Site 16. In addition, any supplemental or relocated soil borings completed during the investigation were also surveyed. For each soil boring and monitoring well, the latitude, longitude, and elevation in feet above mean sea level (msl) were recorded.

2.2 Soil Investigation

A soil investigation was conducted at Site 16 to determine the presence or absence of waste materials within the study area. In 28 out of the 32 sampling locations, soil samples were completed using a split-spoon sampler and a drill rig, the remaining soil sample locations were completed using a hand auger.

A confirmatory soil investigation was conducted at Site 16 to determine if lead levels detected in soil sample 16-BD-SB05-00 were isolated or indicated a potential source of contamination.

Investigative procedures and methodologies for the RI conducted at Site 16 are provided in Section 6.0 of the Final FSAP, for OU No. 8 (Baker, 1994). Four soil smaples were collected using a dedicated stainless steel spoon.

The following subsections describe both the surface and subsurface soil investigations conducted at Site 16.

2.2.1 Surface Soil Investigation

A total of 32 surface soils (i.e., samples collected from 0 to 1 foot bgs) were collected from Site 16 to evaluate the presence or absence of waste materials within the study area. This investigation was conducted between October 18 and 21, 1994. Twenty-seven of the 32 surface soils were collected from borings and the remaining five surface soils were collected from monitoring well test borings. Figure 2-1 provides the surface soil sampling locations. (Note, all Figures and Tables referenced in Section 2.0 are located in the back of the section.) Twenty out of the 27 surface soil borings were completed within the area believed to be the former burn dump. Four surface soil borings were collected from the drainage area to the southeast of the study area. These four surface soil samples were collected by using a hand auger. The surface drainage area (i.e., SDA) samples are presented on Figure 2-1. In addition three surface soil samples are background borings and are located to the northwest of the study area. These background sample locations are also provided on Figure 2-1. The remaining surface soil samples were collected from monitoring well test borings. The monitoring well locations are also provided on Figure 2-1. The four confirmatory surface soil samples were collected in a 10-foot radial direction of existing boring 16-BD-SB05. These samples were collected due to elevated TAL lead detections found in 16-BD-SB05, and were collected on December 13, 1995. Table 2-1 lists the sample identification, depth of borehole, sampling interval, and analytical parameters requested for each of the surface soil samples collected at Site 16.

All surface soils were classified in the field by a geologist. Soils were classified using the United Soil Classification System (USCS) by the visual-manual methods described in ASTM D-2488. Lithologic descriptions were recorded in a field logbook and later transposed onto boring log records. Soil classification included characterization of soil type, grain size, color, moisture content, relative density, plasticity, and other pertinent information such as indications of contamination. Lithologic descriptions of the site soils are provided on Test Boring Records in and on Test Boring and Well Construction Records in Appendix A.

The firm of Quanterra Environmental Services (Quanterra) was retained to provide analytical laboratory services throughout the project. All of the surface soil samples collected were sent to the laboratory and analyzed for full Target Compound List (TCL) organics and Target Analyte List (TAL) total metals. Provided on Table 2-1, are the analytical parameters requested for the surface soils collected at Site 16. Results of the surface soil investigation conducted at Site 16 are discussed within Section 4.0 of this report. Chain-of-Custody (CoCs) documentation, provided in Appendix B, accompanied the samples to the laboratory. Information such as sample number, date, analytical parameters requested, and time of sampling was included on these forms. Internal sample and analytical tracking forms for Site 16 are also provided in Appendix B. Samples were shipped overnight via Federal Express to Quanterra for analysis.

2.2.1.1 Quality Assurance and Quality Control

Field QA/QC samples were also collected during the surface soil investigation. These samples were obtained in order to : (1) ensure that decontamination procedures were properly implemented (e.g., equipment rinsate samples); (2) evaluate field methodologies (e.g., field duplicate samples); (3) establish field background conditions (e.g., field blanks); and (4) evaluate whether cross-contamination occurred during sampling and/or shipping (e.g., trip blanks). Data Quality Objectives (DQOs) for the QA/QC samples were implemented in accordance with DQO Level IV as defined in the Environmental Compliance Branch Standard Operating Procedures (SOPs) and Quality Assurance Manual, (USEPA Region IV, 1991). The DQO Level IV is equivalent to the Naval Facilities Engineering Service Center (NFESC) DQO Level D, as specified in the Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Programs document (NFESC, 1988).

Field duplicate samples are identified on Table 2-1. In addition to field duplicates, the remaining QA/QC samples which were collected during the surface soil investigation are provided on Table 2-2.

Four types of field QA/QC samples were collected and analyzed including: duplicate samples; equipment rinsate samples; field blanks; and trip blanks. Definitions for the different field QA/QC samples are provided below (USEPA, 1991):

- Field Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under the identical conditions. Field duplicate samples were collected at a frequency of 1 out of 10 environmental samples.

- Equipment Blanks: Equipment field blanks (or rinsate 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 are used to determine if decontamination procedures are adequate. Equipment blanks were collected daily but only samples collected on every other day were analyzed.

- Field Blanks: Organic-free water is taken to the field in sealed containers and poured into the appropriate sample containers at designated locations. This is done to determine if 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 where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled. Two field blanks were collected to test both the potable and distilled water used in drilling and decontamination investigative operations.

- 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 return to 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 for each shipment but not necessarily for each cooler(i.e., coolers with samples for Volatile Organic Contaminants [VOC] analysis only). One set of trip blanks accompanied each cooler that contained samples with requested VOC analysis.

2.2.1.2 Air Monitoring and Field Screening

Two 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 Photoionizing Detector (PID) to monitor for airborne contaminants. A lower explosive limit/oxygen meter (LEL/O_2) was also utilized to monitor the borehole during drilling operations. Moreover, samples (i.e., surface and split-spoon samples) were screened with a PID to measure for volatile organic vapor. Measurements obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records and the Test Boring and Well Construction Records which are provided in Appendices A and B, respectively. Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

2.2.2 Subsurface Soil Investigation

A total of 35 subsurface soils (i.e., 1-foot bgs to just above the groundwater table) were collected from Site 16 to evaluate the presence or absence of waste materials within the study area. This investigation was conducted between October 18 and 21, 1994. Subsurface soil samples were collected at the same locations as surface soil samples identified in Section 2.2.1. Soil boring 16-BD-SB10 was the only boring to have two depth samples collected from it. The first depth sample was from the depth interval 03 (5 to 7 feet) and the second sample was collected from the depth interval 07 (9 to 11 feet). The first sample collected at depth, was done so due to a 2 inch piece of treated lumber which became lodged within the split-spoon. The second sample collected at depth, was from just above the groundwater table. Figure 2-1 provides the subsurface soil sampling locations.

Twenty-one out of the 35 subsurface soil samples were collected from soil borings in the area believed to be the former burn dump. Four out of the 35 subsurface soil samples were collected from the drainage area to the southeast of the study area. These subsurface soil samples were collected by using a hand auger. Additionally, three out of the 35 subsurface soil samples were background borings and are located to the northwest of the study area. These background sample locations are also provided on Figure 2-1. The remaining seven out of 35 subsurface soil samples were collected from monitoring well test borings, as depicted on Figure 2-1. Table 2-1 lists the sample identification, depth of borehole, sampling interval, and analytical parameters requested for each subsurface soil samples collected at Site 16.

In addition to the subsurface soil investigation, four test pits were also performed at Site 16 as part of the subsurface soil investigation. These test pits were excavated within the boundary of the study area to determine the if any remaining trash or debris was present. Each test pit was at least 20 feet in length, 10 feet in depth or to the top of the groundwater table (whichever was encountered first), and 3 feet in width. The content and lithology of each test pit was described and photographs were taken as supplemental documentation. Lithologic descriptions were recorded in a field logbook and later transposed onto Test Pit Records, provided in Appendix A. Test pit locations are provided on Figure 2-2. Test pit 16-TP-01 and 16-TP-03 where the only test pits that had evidence of debris. Test pit 16-TP-01 had large treated timbers bisecting the test pit, and test pit 16-TP-03 had some roofing shingles, metal wire and a distinct layer of pine needles. Samples were not collected from the test pits due to the proximity of soil borings to the test pit locations, lack of encountering waste material, and no elevated PID readings were detected.

All subsurface soils were classified according to procedures and guidelines described in Section 2.2.1. Lithologic descriptions of the site soils are provided on Test Boring Records, Test Boring and Well Construction Records, and Test Pit Records in Appendix A.

All of the subsurface soil samples collected were sent to the laboratory and analyzed for full TCL organics and TAL total metals. Provided on Table 2-1, are the analytical parameters requested for the subsurface soils collected at Site 16. Results of the subsurface soil investigation conducted at Site 16 are provided in Section 4.0 of this report. Internal sample and analytical tracking forms and CoCs for Site 16 are provided in Appendix B. Subsurface samples were shipped overnight via Federal Express to the laboratory for analysis.

2.2.2.1 Quality Assurance and Quality Control

Field QA/QC samples were also collected during the subsurface soil investigation. These samples were obtained according to procedures and guidelines for surface soils that have been previously addressed in Section 2.2.1.1.

Field duplicate subsurface samples collected at Site 16 are identified on Table 2-1. In addition to field duplicates, QA/QC samples that were collected during the subsurface soil investigation are provided on Table 2-2.

2.2.2.2 Air Monitoring and Field Screening

Two air monitoring and field screening procedures were implemented during drilling, sampling, and trenching activities for health and safety and initial contaminant monitoring. During drilling, ambient air monitoring in the vicinity of the borehole was performed with a PID to monitor for airborne contaminants. A lower explosive limit oxygen meter (LEL/O_2) was also utilized to monitor the borehole during drilling operations. Samples (i.e., split-spoon samples) were screened with a PID to measure for volatile organic vapor. Lastly, soils excavated during test pitting activities were also screened with a PID. Measurements obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records, Test Boring and Well Construction Records, and Test Pit Records which are provided in Appendix A. Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

2.3 Groundwater Investigation

A groundwater investigation was conducted at Site 16 to determine the presence or absence of contamination in the surficial aquifer which may have resulted from past burning and disposal activities. Six shallow groundwater monitoring wells were installed as part of this investigation. One well (16-MW01) was placed in an upgradient (i.e., background) location. Three wells (16-MW02, 16-MW03, and 16-MW04) were installed downgradient of Site 16 to assess the quality of groundwater which may have migrated from Site 16. Two wells (16-MW05, and 16-MW06) were installed within the boundary of the study area. Monitoring wells locations at Site 16 are provided on Figure 2-3. These monitoring wells were installed during the period between October 18 and 21, 1994. Depths of the monitoring wells ranged from 16 to 33 feet bgs. All monitoring wells were constructed with 2 inch inside diameter (ID) PVC pipe, with 15 feet of 0.01-inch slot well screen. A summary of monitoring well construction details (i.e., boring depth, well depth, and screen interval depth) are provided on Table 2-3.

All monitoring wells were developed prior to sampling. During development operations water quality readings and turbidity comments were recorded on monitoring well development records. These records are provided in Appendix C.

Monitoring well installation and development procedures are provided in Section 6.0 of the Final FSAP, for OU No. 8 (Site 16). In addition, groundwater sampling procedures are also discussed within Section 6.0 of the FSAP (Baker, 1994).

Groundwater at Site 16 was sampled by using the USEPA Region IV's low flow purging and sampling technique. Although this technique has not yet been finalized, the Technical Compliance Branch of USEPA Region IV, located in Athens Georgia, has set up procedures and guidelines. Procedurally this technique requires that the groundwater be purged at less than 0.33 gallons per minute, by means of either a submersible or peristaltic pump. In this case Baker utilized a 2 inch submersible pump system. While the well was being purged, water quality readings were collected. The water quality readings collected were: pH, conductivity, temperature, and turbidity. Results of the water quality readings are discussed within Section 4.0 of this report. Once water quality readings had stabilized over three well volumes the groundwater sample was collected directly from the pump. Two rounds of groundwater sampling were conducted at Site 16. The first round of groundwater sampling was conducted during November 29, to December 1, 1994. Additionally, water quality readings were collected during Round 2 for the same parameters as those collected in Round 1. All monitoring wells were sampled for full TCL organics, TAL total metals, and dissolved metals. The second round of groundwater sampling was conducted during February 3, to 4, 1994. All monitoring wells were sampled for full TCL organics and TAL total metals. Internal sample and analytical tracking forms and CoCs for Site 16 are provided in Appendix B. Results from both groundwater sampling rounds are provided and discussed in Section 4.0 of this report. All samples were shipped via Federal Express overnight to Quanterra for laboratory analysis. Both rounds of groundwater sampling collected from the monitoring wells are provided on Table 2-4.

2.3.1 Water Level Measurements

Static water level measurements were collected on two separate occasions. Measurements were recorded from top-of-casing reference points, marked on the PVC at each monitoring well. Two complete rounds of static water level measurements were collected on December 11, 1994 and March 27, 1995. Groundwater measurements were recorded using an electric measuring tape (i.e., M-scope). Measurements were recorded to the nearest 0.01 foot from the top-of-casing. Water level data are presented in Section 3.0 of this report.

2.3.2 Quality Assurance and Quality Control

Field QA/QC samples were also submitted during the groundwater investigation. These samples included trip blanks, equipment rinsates, and field duplicates. Equipment rinsates were collected from the submersible pump prior to and during daily usage. Table 2-5 summarizes the QA/QC sampling program employed for the groundwater investigation conducted at Site 16.

2.3.3 Field Screening and Air Monitoring

Several air monitoring and field screening procedures were implemented during the groundwater sampling activities for health and safety and initial contaminant monitoring. Air monitoring and field screening procedures implemented at Site 16 include the screening of well heads, and the purged groundwater with a PID for volatile organic vapors. Measurements obtained during air monitoring and field screening were recorded in a field logbook. Prior to daily monitoring, field instruments were calibrated and recorded in a field logbook and on calibration forms.

2.4 Surface Water Investigation

A surface water investigation was conducted at Site 16 to assess the possible impact of past waste disposal practices at Site 16. Northeast Creek is located approximately 400 feet to the southeast of the study area. Also, surface runoff from the burn dump is to the southeast and eventually flows into Northeast Creek.

Five surface water samples were collected on Northeast Creek during June 26 to 27, 1994. Surface water samples 16-NC-SW01 and 16-NC-SW02 were collected on Northeast Creek upstream of Site 16. Surface water sample 16-NC-SW03 was collected on Northeast Creek adjacent to Site 16, and samples 16-NC-SW04 and 16-NC-SW05 were collected on Northeast Creek downstream of Site 16. Surface water sampling locations are provided on Figure 2-4.

Surface water sample collection procedures are provided within Section 6.0 of the Final FSAP, for OU No. 8 (Baker, 1994).

The five surface water samples collected at Site 16 were submitted to the laboratory for TCL organics and TAL total metals analysis. Table 2-6 provides the sample identification and the corresponding requested analyses. After sample collection, the following water quality measurements were obtained; temperature, pH, dissolved oxygen, salinity, and specific conductance. These water quality measurements were then recorded in a field logbook.

The sampling location was marked by placing a wooden stake and bright colored flagging at the nearest bank or shore. The stake was marked with indelible ink. In addition the distance from the shore and the approximate sampling location was estimated and recorded in the field logbook. Photographs were also taken to document the physical and biological characteristics of the sampling location.

Internal sample and analytical tracking forms and CoCs for Site 16 are also provided in Appendix B. Results of the surface water sampling are provided in Section 4.0 of this report. All surface water samples were shipped via Federal Express overnight to Quanterra for laboratory analysis.

2.4.1 Quality Assurance and Quality Control

Field QA/QC samples were also submitted during the surface water investigation. These samples included trip blanks, equipment rinsates, and field duplicates. Trip blanks were placed into all shipping coolers containing sample jars with requested volatile analyses. Equipment rinsates were collected from the sediment corer during the sediment investigation, which was conducted during the same time period as the surface water investigations. The sample location at which a field duplicate sample was collected is provided on Table 2-6. Table 2-7 summarizes the QA/QC sampling program employed during the surface water investigation conducted at Site 16.

2.5 Sediment Investigation

A sediment investigation was conducted at Site 16 to assess the possible impact to aquatic environments. Northeast Creek is located approximately 400 feet to the southeast of the study area. Also, surface runoff from Site 16 flows to the southeast and eventually into Northeast Creek.

Ten sediment samples were collected from the same locations as the surface water samples, on Northeast Creek during June 26 to 27, 1994. Two sediment samples were collected from each sampling location (i.e., from 0 to 6 inches, and 6 inches to 1-foot). Sediment samples 16-NC-SD01-06, 16-NC-SD01-612 and 16-NC-SD02-06, 16-NC-SD02-612 were collected in Northeast Creek upstream, of Site 16. Sediment samples 16-NC-SD03-06 and 16-NC-SD03-612 were collected adjacent to Site 16, and samples 16-NC-SD04-06, 16-NC-SD04-612 and 16-NC-SD05-06, 16-NC-SD05-612 were collected downstream, of Site 16. Sediment sampling locations are provided on Figure 2-4.

Sediment sample collection procedures are provided within Section 6.0 of the Final FSAP, for OU No. 8 (Baker, 1994).

The ten sediment samples collected at Site 16 were submitted to the laboratory for TCL organics and TAL total metals analyses. Additionally, the sediment samples from the 0 to 6 inch sampling interval where also analyzed for Total Organic Carbon (TOC), and grain size. Table 2-8 provides the sediment sampling identifications, sampling depths (i.e., 06 and 612), and the requested analyses.

The sampling location was marked by placing a wooden stake and bright colored flagging at the nearest bank or shore. The stake was marked with indelible ink. In addition the distance from the shore and the approximate sampling location was estimated and recorded in the field logbook. Photographs were also taken to document the physical and biological characteristics of the sampling location.

Internal sample and analytical tracking forms and CoCs for Site 16 are also provided in Appendix B. Results of the sediment sampling are provided and discussed in Section 4.0 of this report. All sediment samples were shipped via Federal Express overnight to Quanterra for laboratory analysis.

2.6 Habitat Evaluation

A habitat evaluation was performed at Site 16 from December 4 to 6, 1994. The evaluation focussed on the determination of terrestrial and aquatic ecosystems, along with the identification of plant and animal species. The evaluation was conducted by performing a thorough site reconnaissance. During the reconnaissance, particular species (botanical and/or animal) identified on site were documented in a field logbook. Also, unknown botanical species were collected for further identification. In addition, sketches of the site were also produced to show the different areas of varying species or zones (i.e., the general locations of a deciduous forest, hardwood forest, shrub, industrial, swamp, wetland, and water body areas). These sketches were later transferred onto a biohabitat map with each area identified by a unique color and pattern legend. In addition, information from the National Wetlands Inventory (NWI) maps and from base-specific endangered species surveys were transferred to the biohabitat map, if applicable. A detailed discussion of the habitat evaluation is provided within Section 3.0 of this report.

2.7 Decontamination Procedures

Decontamination procedures performed in the field were initiated in accordance with USEPA Region IV SOPs. Sampling and drilling equipment were divided into two decontamination groups, heavy equipment and routine sample collection equipment. Heavy equipment included: drill rigs, holllow-stem augers, drill and sampling rods. Routine sample collection equipment included: split spoons, stainless steel spoons, and bowls.

For heavy equipment, the following procedures were implemented:

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

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

- Clean with distilled water and laboratory detergent (Liquinox soap solution)
- Rinse thoroughly with distilled water
- Rinse with isopropyl alcohol
- Air dry and/or bake off through the use of heaters (latter dependent upon air temperature)
- Wrap in aluminum foil, if appropriate

Temporary decontamination pads, constructed of wood and plastic, were used 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 2.8.

2.8 Investigation Derived Waste (IDW) Handling

Field investigation activities at Site 16 resulted in the generation of various IDW. This IDW included well development and purge water, and solutions used to decontaminate non-disposable sampling equipment. The general management techniques utilized for the IDW were:

- Collection and containerization of IDW material (i.e., development water, and decontamination fluids).
- Temporary storage of IDW while awaiting confirmatory analytical data.
- Final disposal of aqueous and solid IDW material.

The management of the IDW was performed in accordance with guidelines developed by the USEPA Office of Emergency and Remedial Response, Hazardous Site Control Division.

The development and purge water along with the decontamination fluids, did not show contamination at a concentration that would make them hazardous. Therefore the water and decontamination fluids were deposited back onto Site 16. Appendix D provides information regarding the management, results, and disposal of the IDW.

2.9 References

Baker Environmental Inc. 1994. Remedial Investigation, Feasibility Study Project Plans for Operable Units 8, 11, and 12 (Sites 16, 7, 80, and 3). Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

USEPA. 1991. United States Environmental Protection Agency Region IV. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. Environmental Services Division. Atlanta, Georgia. February, 1991.

U.S. Navy, NEESA. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. Prepared by Martin Marietta Energy Systems, Inc. for U.S. Department of Energy, Contract No. DE-AC05-840R21400. Neesa 20.2-047B. June 1988.

SECTION 2.0 TABLES

TABLE 2-1

SOIL SAMPLING SUMMARY
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274.
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Surface Drainage Area									
16-SDA-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
16-SDA-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
16-SDA-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
16-SDA-SB04	00	1.0	0.0 - 1.0	X	X	X	X	X	X
	02	5.0	3.0 - 5.0	X	X	X	X		
Burn Dump Area									
16-BD-SB01	00	0.0	0.0 - 1.0	X	X	X	X	X	X
	06	13.0	11.0 - 13.0	X	X	X	X		
16-BD-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
16-BD-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
16-BD-SB04	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Burn Dump Area (Cont.)									
16-BD-SB05	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
16-BD-SB06	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
16-BD-SB07	00	1.0	0.0 - 1.0	X	X	X	X		
	04	9.0	7.0 - 9.0	X	X	X	X		
16-BD-SB08	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
16-BD-SB09	00	1.0	1.0 - 3.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X		
16-BD-SB10	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
16-BD-SB11	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
16-BD-SB12	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Burn Dump Area (Cont.)									
16-BD-SB13	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
16-BD-SB14	00	1.0	0.0 - 1.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X	X	
16-BD-SB15	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
16-BD-SB16	00	1.0	0.0 - 1.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X	X	
16-BD-SB17	00	1.0	0.0 - 1.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X		
16-BD-SB18	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
16-BD-SB19	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
16-BD-SB20	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
16-PBA-SB01	00	1.0	0.0 - 1.0				X		
16-PBA-SB02	00	1.0	0.0 - 1.0				X		
16-PBA-SB03	00	1.0	0.0 - 1.0				X		
16-PBA-SB04	00	1.0	0.0 - 1.0				X		

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Background Borings									
16-BB-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
16-BB-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
16-BB-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	05	11.0	9.0 - 11.0	X	X	X	X		
Monitoring Wells									
16-MW01	01	2.0	0.0 - 2.0	X	X	X	X		
	04	9.0	7.0 - 9.0	X	X	X	X		
16-MW02	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
16-MW03	00	1.0	0.0 - 1.0	X	X	X	X		
	02	5.0	3.0 - 5.0	X	X	X	X		
16-MW04	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
16-MW05	00	1.0	0.0 - 1.0	X	X	X	X		
	08	17.0	15.0 - 17.0	X	X	X	X		
16-MW06	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X	X	X

TABLE 2-2

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL
SAMPLING PROGRAM FOR THE SURFACE AND SUBSURFACE SOIL INVESTIGATION
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters(3)
Trip Blanks(2)	One per Cooler	4	TCL Volatiles
Field Blanks(4)	One per Event	2	TCL Organics/TAL Inorganics
Equipment Rinsates(5)	One per Day	4	TCL Organics/TAL Inorganics
Number of Environmental Samples(6)		67	TCL Organics/TAL Inorganics
Field Duplicates (7)	10% of Sample Frequency	5	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.2.1.1 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 CLP Protocol.
(4) Field blanks collected during Site 16 soil investigation (October 17 through December 4, 1994).
(5) Equipment rinsates collected from various sampling equipment (e.g., split spoons, stainless steel spoons, and stainless steel bowls. Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.
(6) Refer to Table 2-1 for duplicate sample identification.
(7) Field duplicates were segregated into three areas (Surface Drainage Area, Burn Dump Area, and Monitoring Well Area), actual field duplicates collected are not indicative of the total frequency of surface and subsurface samples.

TABLE 2-3

SUMMARY OF WELL CONSTRUCTION DETAILS
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation (feet,above msl)[1]	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)	Sand Pack Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)	Stick-Up (feet, above ground surface)
16-MW01	10/18/94	19.88	17.8	23.5	23.0	23.0 - 13.0	23.5 - 11.0	11.0 - 9.0	2.08
16-MW02	10/19/94	6.76	4.70	16.5	16.0	16.0 - 6.0	16.5 - 4.0	4.0 - 2.0	2.06
16-MW03	10/18/94	11.63	9.50	17.5	17.0	17.0 - 7.0	17.5 - 5.0	5.0 - 3.0	2.13
16-MW04	10/19/94	12.55	11.00	18.5	18.0	18.0 - 8.0	18.5 - 6.0	6.0 - 4.0	1.55
16-MW05	10/21/94	21.28	19.4	33.5	33.0	33.0 - 18.0	33.5 - 16.0	16.0 - 14.0	1.88
16-MW06	10/21/94	18.43	16.7	31.5	31.0	31.0 - 16.0	31.5 - 14.0	14.0 - 12.0	1.73

Notes: [1] msl - mean sea level

TABLE 2-4

MONITORING WELL SAMPLING SUMMARY
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Monitoring Well (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Total Metals	TAL Dissolved Metals	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Permanent Monitoring Wells Round 1 (11/29 through 12/1/94)								
16-MW01-01	23.0	X	X	X	X	X		
16-MW02-01	16.0	X	X	X	X	X		
16-MW03-01	17.0	X	X	X	X	X		
16-MW04-01	18.0	X	X	X	X	X		
16-MW05-01	33.0	X	X	X	X	X		
16-MW06-01	31.0	X	X	X	X	X	X	X
Permanent Monitoring Wells Round 2 (2/3 through 2/4/95)								
16-MW01-02	23.0	X	X	X	X			
16-MW02-02	16.0	X	X	X	X			
16-MW03-02	17.0	X	X	X	X			
16-MW04-02	18.0	X	X	X	X			
16-MW05-02	33.0	X	X	X	X			
16-MW06-02	31.0	X	X	X	X			

TABLE 2-5

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters[3]
Trip Blanks[2]	One per Cooler	3	TCL Volatiles
Field Blanks[4]	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates[5]	One per Day	2	TCL Organics/TAL Inorganics
Number of Environmental Samples[6]		6	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	1	TCL Organics/TAL Inorganics

Notes:

(1) QA/QC sample types defined in Section 2.3.2 in text.

(2) Trip blanks submitted with coolers which contained samples for volatil analysis. Samples analyzed for TCL volatiles only.

(3) Parameters analyzed according to CLP Protocol.

(4) Field blanks collected during Site 16 soil investigation (October 17 through December 4, 1994).

(5) Equipment rinsates collected from various sampling equipment (e.g., submersible pump, and pump discarge hose. Note that samples were collected daily but were analyzed every other day of sampling event. Acordingly, the number of samples presented represents the number of samples analyzed.

(6) Refer to Table 2-4 for duplicate sample identification.

TABLE 2-6

SURFACE WATER SAMPLING SUMMARY
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Northeast Creek Area						
16-NC-SW01	X	X	X	X		
16-NC-SW02	X	X	X	X		
16-NC-SW03	X	X	X	X		
16-NC-SW04	X	X	X	X	X	X
16-NC-SW05	X	X	X	X		

TABLE 2-7

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE WATER INVESTIGATION
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[1]	Frequency of Collection	Number of Samples	Analytical Parameters[3]
Trip Blanks[2]	One per Cooler	1	TCL Volatiles
Field Blanks[4]	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates [5]	One per Day	2	TCL Organics/TAL Inorganics
Number of Environmental Samples[6]		5	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	1	TCL Organics/TAL Inorganics

Notes:
[1] QA/QC sample types defined in Section 2.4.1 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 CLP Protocol.
[4] Field blanks collected during Site 16 soil investigation (October 17 through December 4, 1994).
[5] Equipment rinsates were not collected for representing the surface water investigation due to surface water sample collection involved dipping laboratory bottles into the surface water and then transfering the contents into bottles with presevitive. However, equipment rinsates were collected from sediment sampling equipment, which was conducted during the same period as the surface water investigation.
[6] Refer to Table 2-6 for duplicate sample identification.

TABLE 2-8

SEDIMENT SAMPLING SUMMARY
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	Grain Size	TOC	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Noetheast Creek Area										
16-NC-SD01	06	0.0 - 0.5	X	X	X	X	X	X		
	612	0.5 - 1.0	X	X	X	X				
16-NC-SD02	06	0.0 - 0.5	X	X	X	X	X	X		
	612	0.5 - 1.0	X	X	X	X				
16-NC-SD03	06	0.0 - 0.5	X	X	X	X	X	X		
	612	0.5 - 1.0	X	X	X	X				
16-NC-SD04	06	0.0 - 0.5	X	X	X	X	X	X	X	X
	612	0.5 - 1.0	X	X	X	X				
16-NC-SD05	06	0.0 - 0.5	X	X	X	X	X	X		
	612	0.5 - 1.0	X	X	X	X				

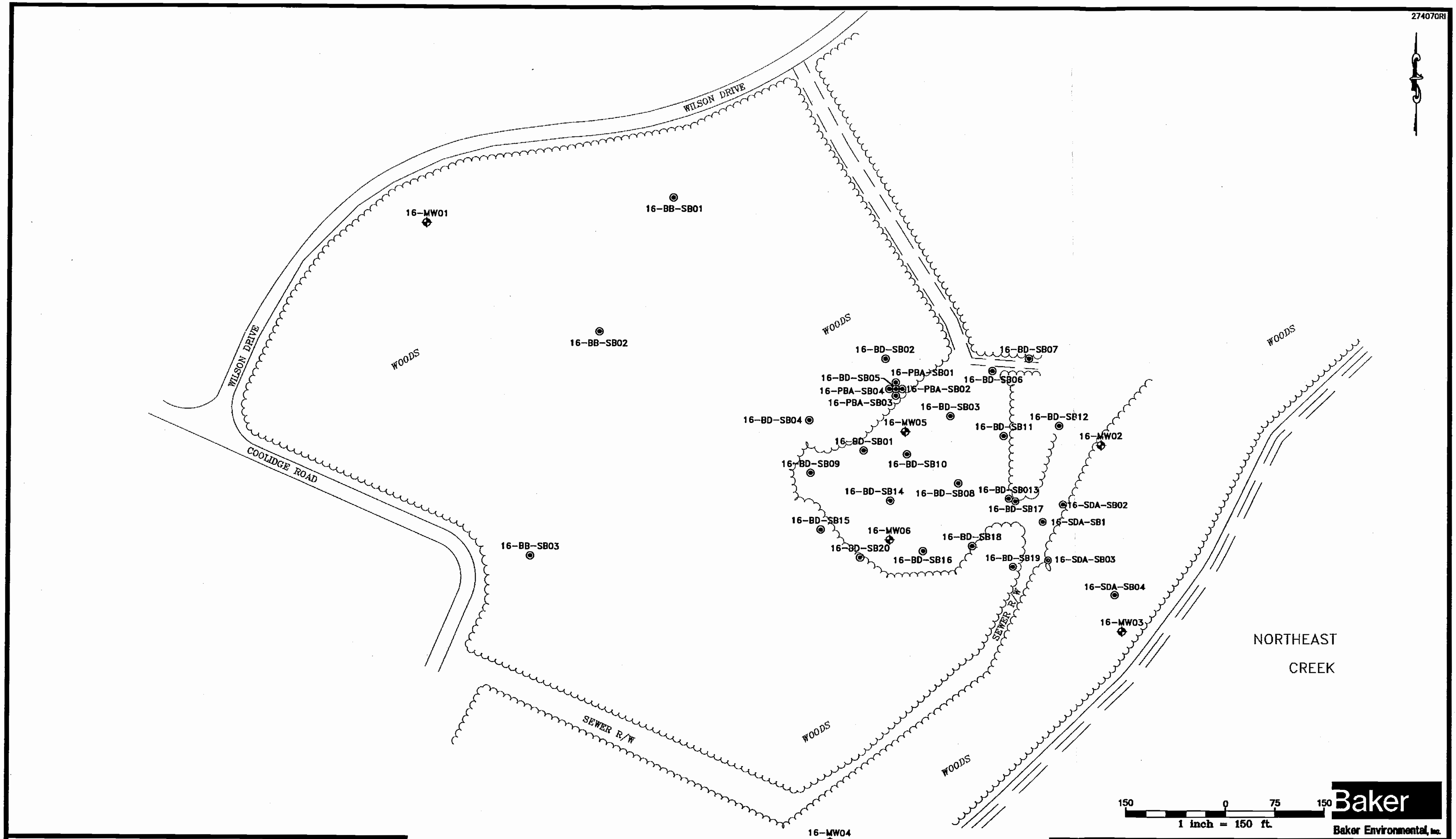
TABLE 2-9

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SEDIMENT INVESTIGATION
OPERABLE NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample[(1)]	Frequency of Collection	Number of Samples	Analytical Parameters[(3)]
Trip Blanks[(2)]	One per Cooler	1	TCL Volatiles
Field Blanks[(4)]	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates[(5)]	One per Day	2	TCL Organics/TAL Inorganics
Number of Environmental Samples[(6)]		10	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	1	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.5.1 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 CLP Protocol.
(4) Field blanks collected during Site 16 soil investigation (October 17 through December 4, 1994).
(5) Equipment rinsates collected from various sampling equipment (e.g., sediment sleeve, and brass sediment extruder. Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.
(6) Refer to Table 2-8 for duplicate sample identification.

SECTION 2.0 FIGURES



LEGEND

16-MW01 NEWLY INSTALLED MONITORING WELL LOCATION

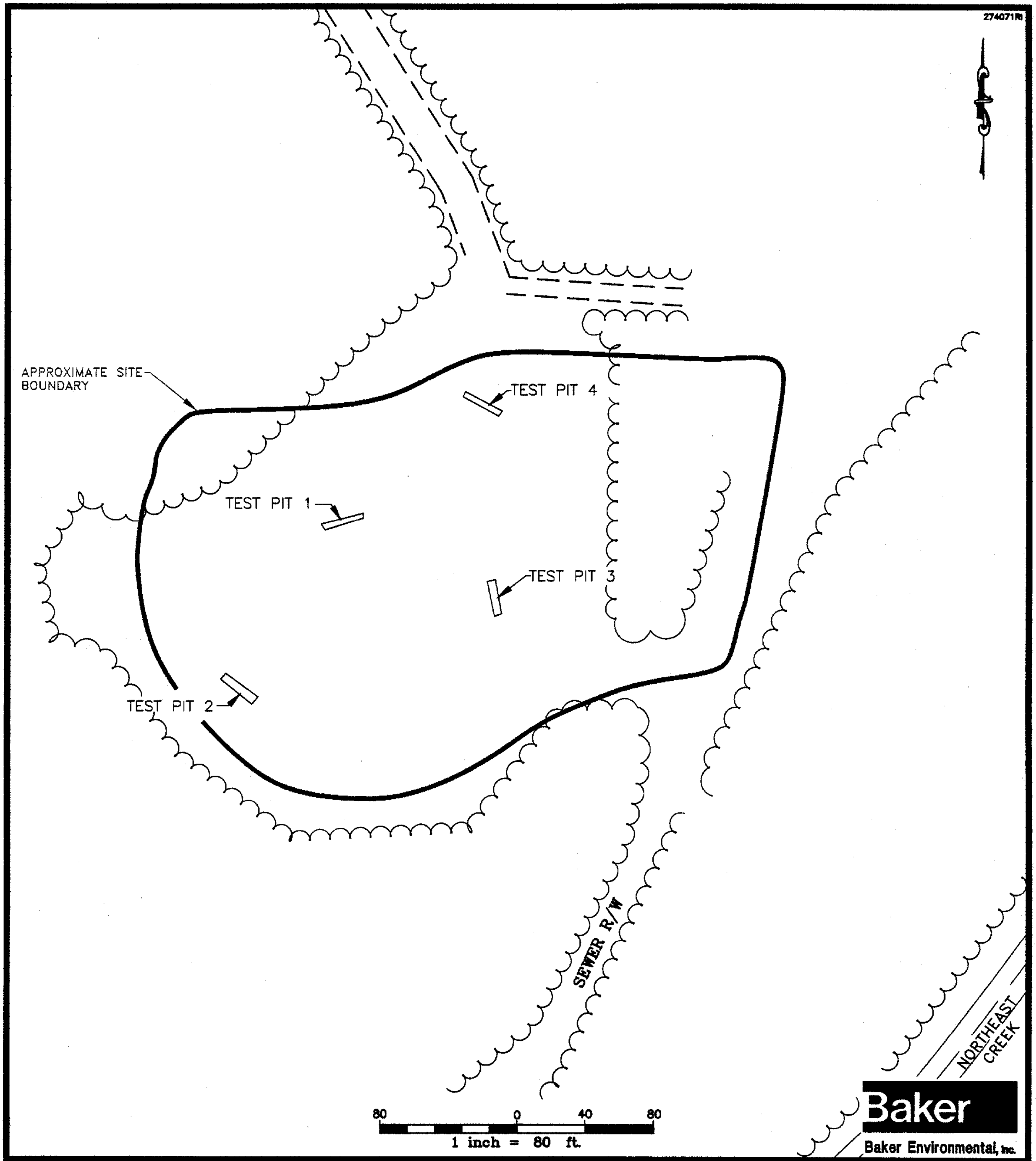
16-BD-SB01 ● SOIL BORING LOCATION

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 2-1
SOIL SAMPLING LOCATIONS
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q04Z

274071R1



LEGEND

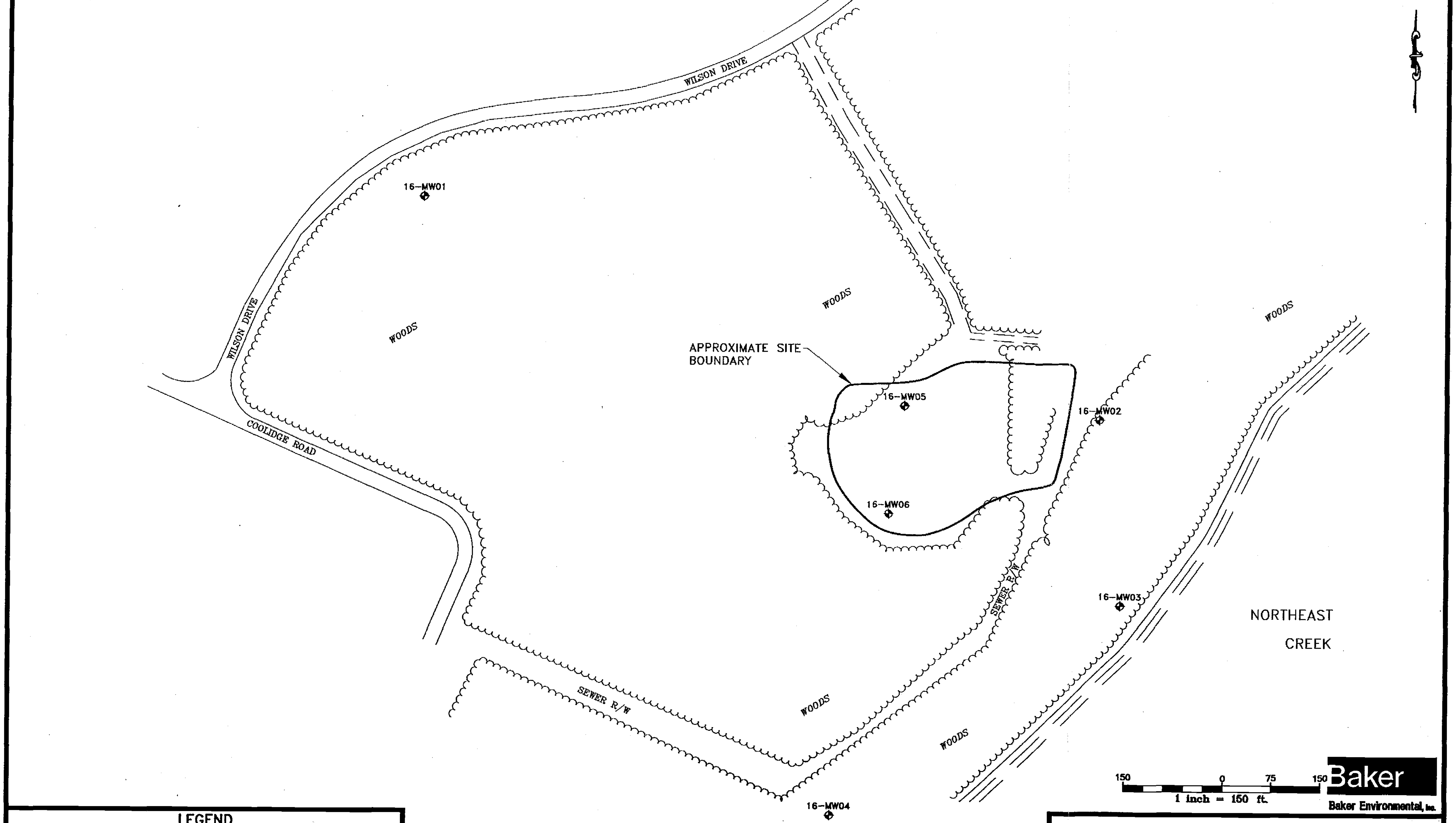
TEST PIT 1 TEST PIT LOCATION

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 2-2
TEST PIT LOCATIONS
SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274072RI



Baker

Baker Environmental, Inc.

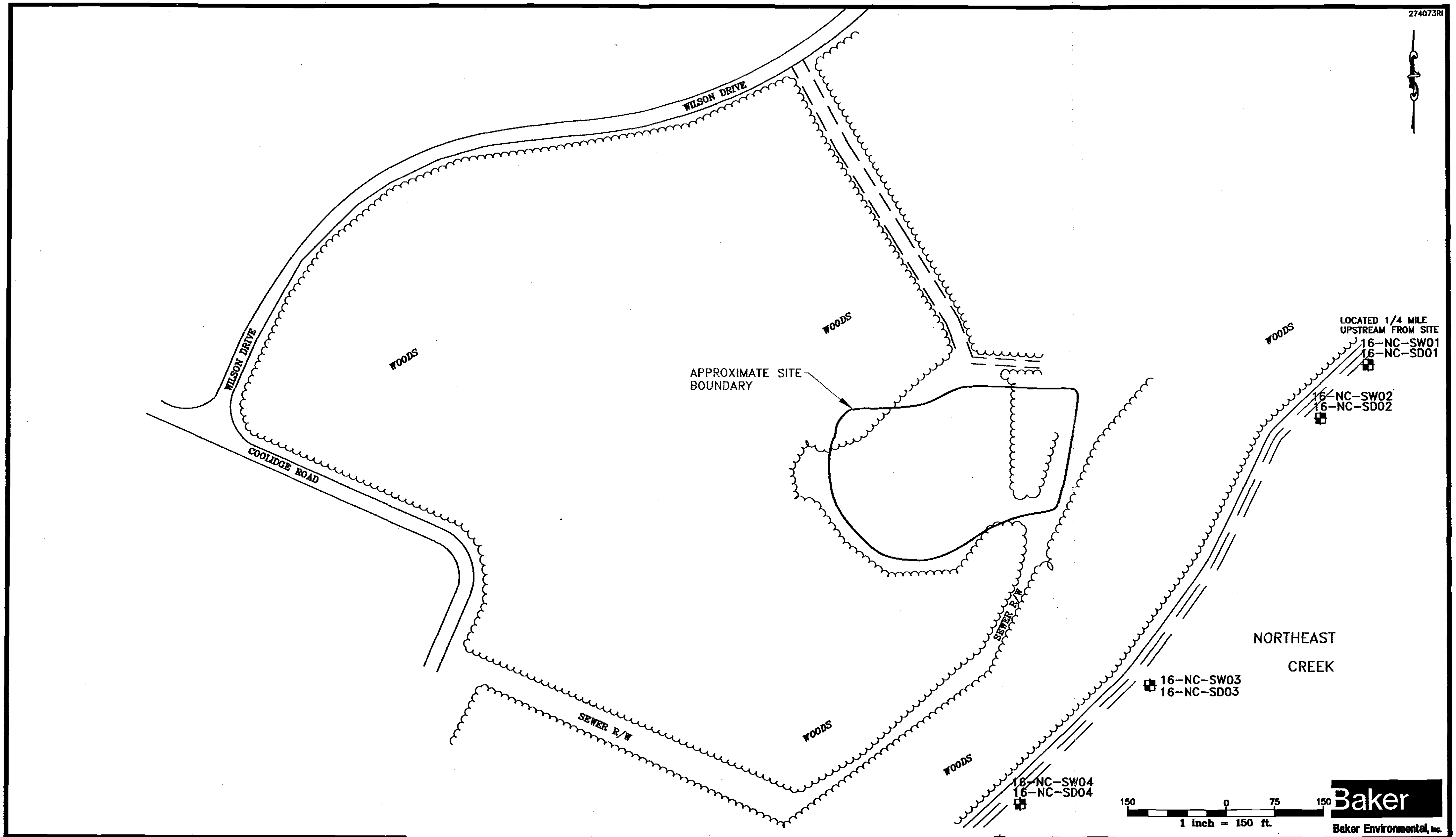
LEGEND

16-MW01 ⊕ NEWLY INSTALLED MONITORING WELL LOCATION

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 2-3
MONITORING WELL SAMPLING LOCATIONS
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q05Z



LEGEND

16-NC-SW01
16-NC-SD01 SURFACE WATER AND SEDIMENT SAMPLING LOCATION

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 2-4
APPROXIMATE SURFACE WATER AND
SEDIMENT SAMPLING LOCATIONS
SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3.0 REGIONAL AND SITE CHARACTERISTICS

This section describes the regional and site-specific environmental settings. A discussion of topography, surface hydrology and drainage, geology, hydrogeology, ecology, land use and demographics, climate/meteorology, and water supplies is presented for Marine Corps Base (MCB), Camp Lejeune and Operable Unit (OU) No. 8 (Site 16). The tables and figures for Section 3.0 are contained at the back of the section.

3.1 Topography and Surface Features

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

Site 16, Montford Point Burn Dump, is relatively flat, with a slight slope to the southeast. Most of the site is currently a cleared area; the other areas are comprised of pine trees. There is an opening in the wooded area in the southeast corner of the study area which leads to Northeast Creek. An apparent storm sewer line, located to the southeast of the burn dump, runs in a northeast-southwest direction. There is also a storm sewer line that runs from the intersection of Coolidge and Harding Roads, and connects to the storm line southeast of the site. Previously, the study area was used for staging vehicles and for vehicle training exercises. Training exercises continue to be conducted in the study area. In the center of the study area is a mock-up jet aircraft. This aircraft is used in refueling exercises by tank truck operators. During these exercises, however, no fuel is used. The Director of Support for the Marine Corps Service Support School, Major Steve Forney, was the source for information on refueling exercises at Site 16. A four-foot wide ditch, believed to be a fire break, was observed extending from the storm sewer right-of-way on the southwest side of the study area around the western side of the site and up towards the north. There are no permanent structures at this site. Figure 3-1 presents the topography and surface features identified at Site 16.

3.2 Surface Water Hydrology

3.2.1 Regional

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

The dominant surface water feature of MCB, Camp Lejeune is the New River. It receives drainage from most of the base. The New River is short, with a course of approximately 50 miles on the central coastal plain of North Carolina. Over most of its course, the New River is confined to a relatively narrow channel entrenched in the Eocene and Oligocene limestones. South of Jacksonville, the river widens dramatically as it flows across less resistant sands, clays and marls. At MCB, Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain the area of MCB, Camp Lejeune that are not associated with the New River and its tributaries. These creeks flow into the Intracoastal Waterway, which is connected to the Atlantic Ocean by Bear Inlet, Brown's Inlet, and the New River Inlet. The New River, the Intracoastal Waterway, and the Atlantic Ocean meet at the New River Inlet.

Water quality criteria for surface waters in North Carolina have been published under Title 15A of the North Carolina Administrative Code. At MCB, Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body contact sports or commercial shell fishing) and SA (estuarine waters suited for commercial shell fishing). The northern area of the New River near Montford Point at MCB, Camp Lejeune falls into the SA classification.

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

The U.S. Corps of Engineers has mapped the limits of the 100-year floodplain at Camp Lejeune at 7 feet above msl in the upper reaches of the New River.

3.2.2 Site-Specific

There are no standing water bodies within the site. Northeast Creek is located approximately 400 feet southeast from the boundary of the burn dump. Surface drainage is towards the southeast. The southeast portion of the site exhibits eroded soils, and surface runoff apparently drains to Northeast Creek.

3.3 Geology and Soil

3.3.1 Regional

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 lay in interfingering beds and lenses that gently dip and thicken to the southeast (ESE, 1990). These sediments were deposited in marine and near-marine environments and range in age from early Cretaceous to Quaternary time and overlie igneous and metamorphic basement rocks of pre-Cretaceous age. Table 3-1 presents a generalized stratigraphic column for this area (ESE, 1990).

United States Geological Survey (USGS) studies (Harned, et al., 1989 and Cardinell, et al., 1993) conducted at MCB, Camp Lejeune indicates that the base is underlain by seven sand and limestone aquifers separated by confining/semiconfining units of silt and clay. These include the water table (i.e., surficial, water-bearing layer), Castle Hayne, Beaufort, Peedee, Black Creek, and the upper and lower Cape Fear aquifers. The combined thickness of these sediments is approximately 1500 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 illustrating the relationship between the aquifers in this area is presented on Figures 3-2 and 3-3.

3.3.2 Site-Specific

The RI was limited to investigating the shallow groundwater zone; therefore, site-specific geology describes the site to depth of approximately 35 feet bgs. The site is primarily underlain by sands and silty sands with lenses and/or discontinuous layers of sand and clay, clay, and sandy clay. These surficial soils represent the Quaternary age "undifferentiated" Formation that characterizes the shallow water table aquifer. Results of the standard penetration tests (ASTM D1586-84) indicates the relative density of the soils range from loose to very dense. Unified Soil Classification System (USCS) classification for the surficial soils identified at the site are SM (silty sand), SP (poorly graded sands with little to no fines), and CL (sandy clay and clay). Fill material was identified at some borehole locations (within the open site area), ranging in thickness from one to nine feet. This fill material consisted of replaced soil, as well as treated timbers, rubber tires, and gravel. Only shallow groundwater monitoring wells were installed during the RI, therefore, no specific information on the depth of the surficial soils or the lithology of the underlying soils is available.

Geologic cross-sections were developed for the surficial soils based on samples collected during the RI. As shown on Figure 3-4, two cross-sections were developed using the groundwater monitoring boreholes. Cross-section A-A' (Figure 3-5) depicts the surficial lithology from north to south and cross-section B-B' (Figure 3-6) depicts the lithology from southwest to northeast of the surficial soils.

3.4 Hydrogeology

3.4.1 Regional

The following summary of regional hydrogeology was originally presented in Harned, et al. (1989) and reevaluated by Cardinell, et al. (1993).

The surficial water table aquifer consists of a series of sediments, primarily sand and clay, which commonly extend to depths of 75 feet. This unit is not used as a water supply on the Base.

The principal water supply for the base is found in the series of sand and limestone beds that occur between 50 and 300 feet below ground surface (bgs). This series of sediments generally is known as the Castle Hayne Formation, associated with the Castle Hayne Aquifer. This aquifer is about 150 to 450 feet thick in the area and is the most productive aquifer in North Carolina.

Clay layers occur in both of the aquifers. However, the layers are thin and discontinuous in most of the area, and no continuous clay layer separates the surficial aquifer from the Castle Hayne Aquifer. The clay layers range from 10 to 15 feet thick and comprise between 15 and 24 percent of the combined thickness of the two aquifers. The clay layers appear to be thicker and more continuous in the northwest part of the base, particularly in the area of the MCAS. It is inferred from their generally thin and discontinuous nature that considerable leakage of groundwater occurs across and around the clay layers, particularly in the upper portion of the Castle Hayne Aquifer.

Onslow County and MCB, 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. Overpumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer contains water having less than 250 milligrams per liter (mg/L) chloride (State criteria for saltwater classification) throughout the area of the Base.

The aquifers below the Castle Hayne Aquifer lie in 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 MCB, Camp Lejeune area and are not used.

Rainfall in the MCB, 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, groundwater flows in the direction of lower hydraulic head, moving through the system to discharge areas such as the New River and its tributaries, or the ocean.

The water table varies seasonally. The water table receives more recharge in the winter and summer than in the fall and spring 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/summer months and lowest in spring/fall.

In confined aquifers, water is under excess hydraulic (i.e., head) pressure and the level to which it rises in a tightly cased well is called the potentiometric surface. The hydraulic head in a confined or semiconfined aquifer, such as the Castle Hayne, shows a different pattern of variation over time than 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.

According to the North Carolina Administrative Code, Title 15A, Subchapter 2L, "Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina", the surficial water table aquifer and the Castle Hayne Aquifer are classified as GA - for existing or potential sources of drinking water supplies for humans with a chloride concentration equal to or less than 250 mg/L. This groundwater classification is for waters which are considered suitable for drinking in their natural state.

3.4.2 Site-Specific

Groundwater was encountered during the RI at elevations ranging from 1.37 to 6.93 feet above msl. Measured shallow groundwater levels for Site 16 are presented on Table 3-2. Groundwater elevation contour maps for the shallow aquifer on December 11, 1994 and March 27, 1995 are presented on Figures 3-7 and 3-8, respectively. The contour maps indicate a linear flow towards the southeast, in the direction of Northeast Creek. Recharge for this area is from the northwest. The shallow groundwater gradient measured from well 16-MW01 to well 16-MW04 to the southeast for December 11, 1994 was 0.002 ft/ft and from well 16-MW-1 to 16-MW03 for March 27, 1995 was 0.004 ft/ft. Shallow groundwater discharges to Northeast Creek.

The shallow aquifer was characterized by performing in situ rising and falling head slug tests in all newly installed monitoring wells. The tests were performed on December 6 and 7, 1994. An electronic data logger (In Situ Hermit Model SE2000) and pressure transducer assembly were used to record the recovery of groundwater in the monitoring wells to static level. All data was recorded on logarithmic scale to more closely monitor the initial changes in groundwater elevation. The data resulting from the slug tests were converted into time (in minutes) and the corresponding change in water level displacement (in feet). Results from the rising head tests were analyzed using Geraghty & Miller's AQTESOLV computer program for performing quantitative groundwater assessments. Results from falling head tests were analyzed for wells 16-MW02, 16-MW05, and 16-MW06 due to the fact that these shallow wells exhibited groundwater levels at or above the top of the sand packs, making the falling head tests valid at these locations. The Bouwer and Rice solution for slug tests in unconfined aquifers was used to evaluate all test data. The input parameters and plots generated from the slug tests are contained in Appendix E.

Table 3-3 lists the K values obtained from the data analysis, the average hydraulic gradient from the two groundwater elevation contour maps, the assumed effective porosity, and the calculated value for groundwater velocity. The average estimated K value from the six wells (total of 9 tests) was 5.69 feet/day (2.01 x 10^{-3} cm/sec), which is within the typical range for silty sands (Freeze/Cherry, 1979). The average hydraulic gradient from groundwater measurements between wells 16-MW01 and 16-MW04 on December 11, 1994, and wells 16-MW01 and 16-MW03 on March 27, 1995 was 0.003 ft/ft. Published effective porosity values indicate a range of 25 to 50 percent for sands and silts (Freeze/Cherry, 1979). Due to the silty nature of the sands, a value of 35 percent was used for effective porosity. The estimated average linear groundwater velocity was calculated by using the following formula:

$$V=Ki/n$$

Where: V = groundwater velocity
K = hydraulic conductivity
i = hydraulic gradient
n = effective porosity

Using these variables, the groundwater velocity (V) in a northwest to southeast direction is estimated to be 0.05 feet/day (18.25 feet/year). This is a conservative estimate because of the nature of the silty sand and the variability in the estimated K values from the slug tests. An approximate transmissivity value (T) can be obtained from multiplying the hydraulic conductivity (K) by the saturated thickness (b) of the aquifer. Using a saturated thickness of 33.5 feet, which corresponds to the maximum depth of the shallow wells installed at Site 16, an approximate T value for the shallow aquifer in this direction is 190.62 feet^2/day (14.3 x 10^{2} gallons/day/ft). A recent hydrogeologic investigation conducted by Baker in the Camp Geiger area (1994), which included an aquifer pump test within the shallow water-bearing zone (approximately 25 foot depth), indicated T and K values of 94.92 ft^2/day (7.1 x 10^{2} gallons/day/ft) and 6.3 feet/day (2.2 x 10^{3} cm/sec), respectively. Values for T determined from a pump test performed at Hadnot Point on the opposite side of the New River from Camp Geiger were 75 feet^2/day (5.61 x 10^2 gallons/day/ft). The average transmissivity value from these two pump tests is 85 feet^2/day (6.36 x 10^{2} gallons/day/ft). The calculated transmissivity value of 190.62 feet^2/day from the slug tests is one order of magnitude higher than the average pump test value.

3.4.3 Tidal Study

A tidal study was conducted at Site 16 to determine the influence of tidal effects on the shallow groundwater within the site boundaries. A staff gauge was installed in Northeast Creek, approximately 50 feet from shore. It was placed in a southeasterly direction from the former burn dump. A pressure transducer was attached to the staff gauge, positioned approximately 1 foot off the creek bottom. Pressure transducers were also installed in monitoring wells 16-MW03, just on-shore from Northeast Creek (approximately 10 feet), and 16-MW05, within the former burn dump. Measurements were recorded with an In-Situ Hermit Model 2000 data logger and a Hermit Model 1000C data logger over a period of three days (December 1-4, 1994). Figure 3-9 presents a graph of the readings from the staff gauge, and monitoring wells 16-MW03 and 16-MW05. The "0" mark on the Y-axis is referenced to the level of the creek and groundwater levels in the monitoring wells at the start of the study.

The staff gauge in Northeast Creek indicated fluctuations in the water surface from 0.2 to 0.7 feet. Well 16-MW03, near Northeast Creek, exhibited groundwater fluctuations of 0.1 to 0.3 feet. No fluctuations in groundwater were exhibited in well 16-MW05, which is located approximately 470 feet from Northeast Creek. Figure 3-9 illustrates that the cyclic nature of the fluctuations of the creek and groundwater in well 16-MW03 are "offset". A rise in the level of the creek coincides with a decrease in the groundwater level. The data indicates that there is a tidal effect on the shallow groundwater at Site 16, but there is a delay between the highest elevations of the groundwater and the creek. The tidal influence from Northeast Creek reaches inland, but at a distance probably less than 300 feet.

3.5 Ecological Features

3.5.1 Regional

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

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

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

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

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

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

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

3.5.2 Site-Specific

Four habitat types are present at Site 16. These four include an open area, deciduous forest, pine forest, and an ecotone between the open area and the forests. The open area, a clearing in the middle of the forest, is sparsely vegetated. Much of the area has no vegetation at all growing on it. Scattered pines were identified within the deciduous forest. Numerous birds and mammals were identified in the area. No protected species were observed at Site 16. Site 16 is not within or in close proximity (i.e., one-half mile) to either a natural area or protected area. Protected areas have only been established for the red-cockaded woodpecker.

3.6 Land Use Demographics

3.6.1 Base-Wide

MCB, Camp Lejeune presently covers approximately 236 square miles. Present military population of MCB, Camp Lejeune is approximately 40,928 active duty personnel. The military dependent community is in excess of 32,081. About 36,086 of these personnel and dependents reside in Base housing units. The remaining personnel and dependents live off base and have dramatic effects on the surrounding area. An additional 4,412 civilian employees perform facilities management and support functions. The population of Onslow County has grown from 17,739 in 1940, prior to the formation of the base, to its present population of 121,350 (Master Plan, Camp Lejeune Complex, North Carolina, 1988). During World War II, MCB, Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam conflicts, and the recent Gulf War (i.e., Desert Storm). Toward the end of World War

II, the camp was designated as a home base for the Second Marine Division. Since that time, Fleet Marine Force (FMF) units also have been stationed here as tenant commands.

3.6.2 Site-Specific

Montford Point is one of the Marine Corps Bases' oldest areas and has seen little planning over the decades. Most of the 233 acres of development are congregated on the eastern side of Montford Landing Road. Of the 233 acres of development, 35 percent (i.e., 82 acres) consist of troop housing. Community facilities are located near troop housing in the northeast section of the area. The troop housing facilities located at the southern tip of Montford Point have very limited community facilities nearby.

Classroom training facilities are scattered throughout the developed areas of Montford Point. This use constitutes nearly 21 percent (i.e., 48 acres) of the developed area and, therefore, is the second largest land use category existing at Montford Point. Site 16 is located within this area.

The existing land use pattern for the various developed geographic areas within the MCB are listed, per geographic area, on Table 3-4. In addition, the number of acres comprising each land use category has been estimated and provided on the table. Site 16 is located in the northern region of MCB, Camp Lejeune in Montford Point (Camp Johnson).

3.7 Climate and Meteorology

MCB, Camp Lejeune experiences mild winters, and hot and humid summers. The average yearly rainfall is greater than 50 inches, and the potential evapotranspiration in the region varies from 34 to 36 inches of rainfall equivalent per year. The winter and summer seasons usually receive the most precipitation. Temperature ranges are reported to be 33 to 53 degrees Fahrenheit (°F) in the winter (i.e., January) and 71 to 88 °F in the summer (i.e., July). Winds are generally south-southwesterly in the summer, and north-northwesterly in the winter (Water and Air Research, 1983). Table 3-5 presents a summary of climatic data readings from the MCAS at New River. These measurements were collected between January 1955 and December 1990.

3.8 Water Supply

MCB, Camp Lejeune water is supplied entirely from groundwater. Groundwater is obtained from approximately 90 water supply wells, and treated. There are eight water treatment plants with a total capacity of 15.821 million gallons per day (mgd). Groundwater usage is estimated at over 7 mgd (Harned, et al., 1989).

All of the water supply wells utilize the Castle Hayne Aquifer. The Castle Hayne Aquifer is a highly permeable, semiconfined aquifer that is capable of yielding several hundred to 1,000 gallons per minute (gpm) in municipal and industrial wells in the MCB, Camp Lejeune Area. The water retrieved is typically hard, calcium bicarbonate type.

There are five base supply wells within a one-mile radius of Site 16: M-142, M-243, M-267, T-12, and M-629 (Harnad, et al., 1989). Table 3-6 presents a summary of the water supply wells within a one-mile radius of Site 16. The location of these base water supply wells are shown on Figure 3-10.

3.9 References

ASTM. 1984. American Society of Testing and Materials. Penetration Test and Split Barrel Sampling of Soils. Annual Book of Standards, V.4.08, Philadelphia

Baker. 1994. Baker Environmental, Inc. Evaluation of Metals in Groundwater for MCB Camp Lejeune, North Carolina. Draft. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

Baker. 1994. Baker Environmental, Inc. Site Assessment Report, Additional Assessment Activities at the Campbell Street Fuel Farm and UST System AS-143, MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. April 29, 1994.

Cardinell, A.P., Berg, S.A., and Lloyd O.B., Jr. 1993. Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina. USGS. Water-Resources Investigations Report 93-4049.

DoN. 1988. Master Plan, Camp Lejeune Complex, North Carolina. COMNAVFACENGCOM, April 8, 1988.

ESE. 1990. Environmental Science and Engineering, Inc. Site Summary Report. Final. Marine Corps Base, Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. ESE Project No. 49-02036.

Freeze, R. Allan and John A. Cheery. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Harned, D.A., Llyod, O.B., Jr., and Treece, M.W., Jr. 1989. Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina. USGS. Water-Resources Investigations Report 89-4096.

North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2B. North Carolina Department of Environment, Health, and Natural Resources. Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina.

North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L. North Carolina Department of Environment, Health, and Natural Resources. Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina.

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

SECTION 3.0 TABLES

TABLE 3-1

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
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
	Miocene		Yorktown Aquifer
		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		--	--

(1) Geologic and hydrologic units probably not present beneath MCB,. 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.

TABLE 3-2

SUMMARY OF WATER LEVEL MEASUREMENTS FOR MONITORING WELLS ON DECEMBER 11, 1994, FEBRUARY 3-4 , 1995, AND MARCH 27, 1995
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation(1) (feet, above msl)	Depth to Groundwater (feet, below top of casing) (12/11/94)	Groundwater Elevation (feet, above msl) (12/11/94)	Depth to Groundwater (feet, below top of casing) (02/3-4/95)	Groundwater Elevation (feet, above msl) (02/3-4/95)	Depth to Groundwater (feet, below top of casing) (03/27/95)	Groundwater Elevation (feet, above msl) (03/27/95)
16-MW01	19.88	15.61	4.27	13.72	6.16	12.95	6.93
16-MW02	6.76	4.51	2.25	3.9	2.86	3.68	3.08
16-MW03	11.63	10.26	1.37	9.8	1.83	9.87	1.76
16-MW04	12.55	10.89	1.66	10.35	2.2	10.36	2.19
16-MW05	21.28	18.43	2.85	17.22	4.06	16.84	4.44
16-MW06	18.43	15.7	2.73	14.46	3.97	14.16	4.27

TABLE 3-3

AQUIFER CHARACTERISTICS - MONITORING WELLS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity (K) (feet/day)	Hydraulic Gradient (i) (feet/feet)	Effective Porosity (n)	Groundwater Velocity (V) (feet/day)
16-MW01 (Rising Head)	10.19	0.003	0.35	0.09
16-MW02 (Rising Head)	6.09	0.003	0.35	0.05
16-MW02 (Falling Head)	3.46	0.003	0.35	0.03
16-MW03 (Rising Head)	1.07	0.003	0.35	0.01
16-MW04 (Rising Head)	13.02	0.003	0.35	0.11
16-MW05 (Rising Head)	3.34	0.003	0.35	0.03
16-MW05 (Falling Head)	2.74	0.003	0.35	0.02
16-MW06 (Rising Head)	7.68	0.003	0.35	0.07
16-MW06 (Falling Head)	6.34	0.003	0.35	0.05

TABLE 3-4

LAND UTILIZATION: DEVELOPED AREAS ACRES/LAND USE (PERCENT)
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Geographic Area	Oper.	Training (Instruc.)	Maint.	Supply/ Storage	Medical	Admin.	Family Housing	Troop Housing	CM	CO	Recreat.	Utility	Total
Hadnot Point	31 (2.9)	15 (1.4)	154 (14.3)	157 (14.4)	10 (0.9)	122 (11.3)	22 (2.0)	196 (18.1)	115 (10.7)	36 (3.3)	182 (16.9)	40 (3.7)	1,080 (100)
Paradise Point	1 (0)		3 (0.4)	1 (0)			343 (34)	19 (1.9)	31 (3.1)		610 (60.4)	2 (0.2)	1,010 (100)
Berkeley Manor/ Watkins Village							406 (80)		41 (8.1)	1 (0.2)	57 (11.2)	2 (0.5)	507 (100)
Midway Park		1 (0.4)		2 (0.7)		2 (0.7)	248 (92.2)		8 (3.0)	3 (1.1)	4 (1.5)	1 (0.4)	269 (100)
Tarawa Terrace I and II			3 (0.5)			1 (0.3)	428 (77.4)		55 (9.9)	11 (2.0)	47 (8.5)	8 (1.4)	553 (100)
Knox Trailer							57 (100)						57 (100)
French Creek	8 (1.4)	1 (0.2)	74 (12.7)	266 (45.6)	3 (0.5)	7 (1.2)		122 (20.9)	22 (3.8)	6 (1.0)	74 (12.7)		583 (100)
Courthouse Bay		73 (28.6)	28 (10.9)	14 (5.5)		12 (4.7)	12 (4.7)	43 (16.9)	15 (5.9)	4 (1.6)	43 (16.9)	11 (4.3)	255 (100)
Onslow Beach	6 (9.8)	1 (1.6)	3 (4.8)	2 (3.2)	1 (1.6)	2 (3.2)		2 (3.2)	12 (19.3)		25 (40.3)	8 (13.0)	62 (100)
Rifle Range		1 (1.3)	1 (1.3)	7 (8.8)	1 (1.3)	5 (6.3)	7 (8.8)	30 (37.5)	5 (6.3)	1 (1.3)	9 (11.3)	13 (16.3)	80 (100)
Camp Geiger	4 (1.9)	15 (6.9)	19 (8.8)	50 (23.1)		23 (10.6)		54 (25.0)	27 (12.5)	2 (1.0)	16 (7.4)	6 (2.8)	216 (100)
Montford Point	6 (2.6)	48 (20.5)	2 (0.9)	4 (1.7)	2 (0.9)	9 (3.9)		82 (35.2)	20 (8.6)	1 (0.4)	49 (21.0)	10 (4.3)	233 (100)
Base-wide Misc.	1 (0.8)			87 (68.0)		3 (2.3)			19 (14.8)			18 (14.1)	128 (100)
TOTAL	**57** **(1.1)**	**155** **(3.1)**	**287** **(5.7)**	**590** **(11.7)**	**17** **(0.38)**	**186** **(3.7)**	**1,523** **(30.2)**	**548** **(10.8)**	**370** **(7.4)**	**65** **(1.3)**	**1.116** **(22.2)**	**119** **(2.4)**	**5,033** **(100)**

CM = Community Development
CO = Commercial Development

TABLE 3-5

CLIMATIC DATA SUMMARY
MARINE CORPS AIR STATION, NEW RIVER
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Precipitation (Inches)			Relative Humidity (Percent)	Temperature (Fahrenheit)			Mean Number of Days With				
								Precipitation		Temperature		
	Maximum	Minimum	Average		Maximum	Minimum	Average	>=0.01"	>=0.5"	>=90F	>=75F	<=32F
January	7.5	1.4	4.0	79	54	34	44	11	2	0	1	16
February	9.1	.9	3.9	78	57	36	47	10	3	0	2	11
March	8	.8	3.9	80	64	43	54	10	3	*	5	5
April	8.8	.5	3.1	79	73	51	62	8	2	1	13	*
May	8.4	.6	4.0	83	80	60	70	10	3	2	25	0
June	11.8	2.2	5.2	84	86	67	77	10	4	7	29	0
July	14.3	4.0	7.7	86	89	72	80	14	5	13	31	0
August	12.6	1.7	6.2	89	88	71	80	12	4	11	31	0
September	12.8	.8	4.6	89	83	66	75	9	3	4	27	0
October	8.9	.6	2.9	86	75	54	65	7	2	*	17	*
November	6.7	.6	3.2	83	67	45	56	8	2	0	7	3
December	6.6	.4	3.7	81	58	37	48	9	2	0	2	12
Annual	65.9	38.2	52.4	83	73	53	63	118	35	39	189	48

* = Mean no. of days less than 0.5 days

Source: Naval Oceanography Command Detachment, Asheville, North Carolina. Measurements obtained from January 1955 to December 1990.

TABLE 3-6

SUMMARY OF WATER SUPPLY WELLS WITHIN A ONE-MILE RADIUS OF SITE 16[1]
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

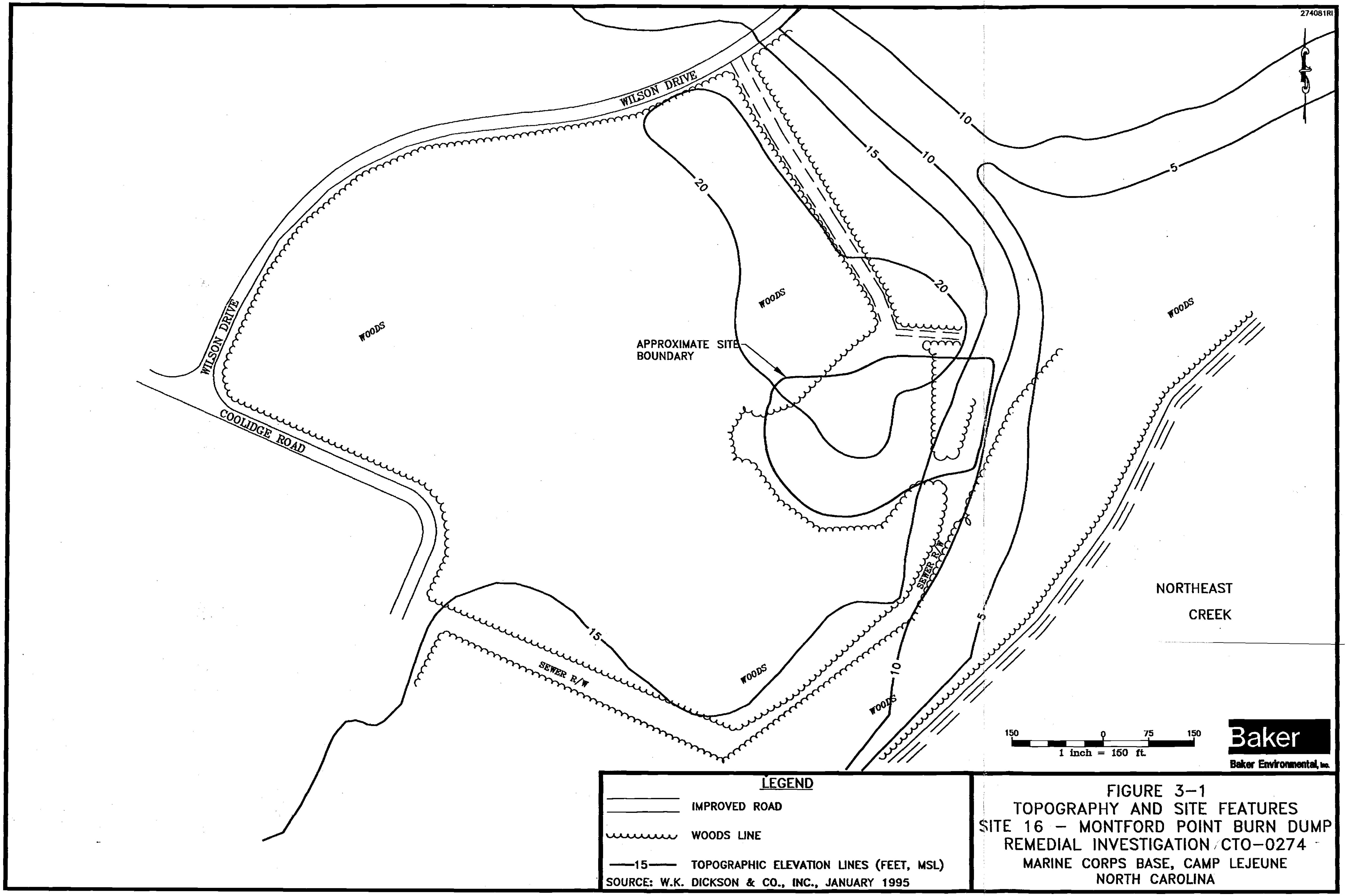
Well No.	USGS Identification Number	Total Depth (feet)	Screened Intervals (feet)	Specific Capacity (gal/min/foot)	Estimated Transmissivities (feet^2/day)	Approximate Distance/ Direction from Site[3] (feet)
Site 16: M-142	3443470772430.1	69	--	(2)	(2)	2380/northeast
M-243	3443420772449.1	95	60-65 75-90	(2)	(2)	2380/northwest
M-267	3443360772451.1	150	50-70 125-145	(2)	(2)	1580/northwest
M-629	3443470772450.1	70	--	(2)	(2)	2380/northwest
T-12	3443030772459.1	352	--	2.9	5,600	2380/northwest

Notes: [1] Information obtained from "Assessment of Hydrogeologic and Hydraulic Data at Camp Lejeune Marine Corps Base, North Carolina," 1989.

[2] Information not available.

[3] Distance measured from site location mark on Figure 3-25.

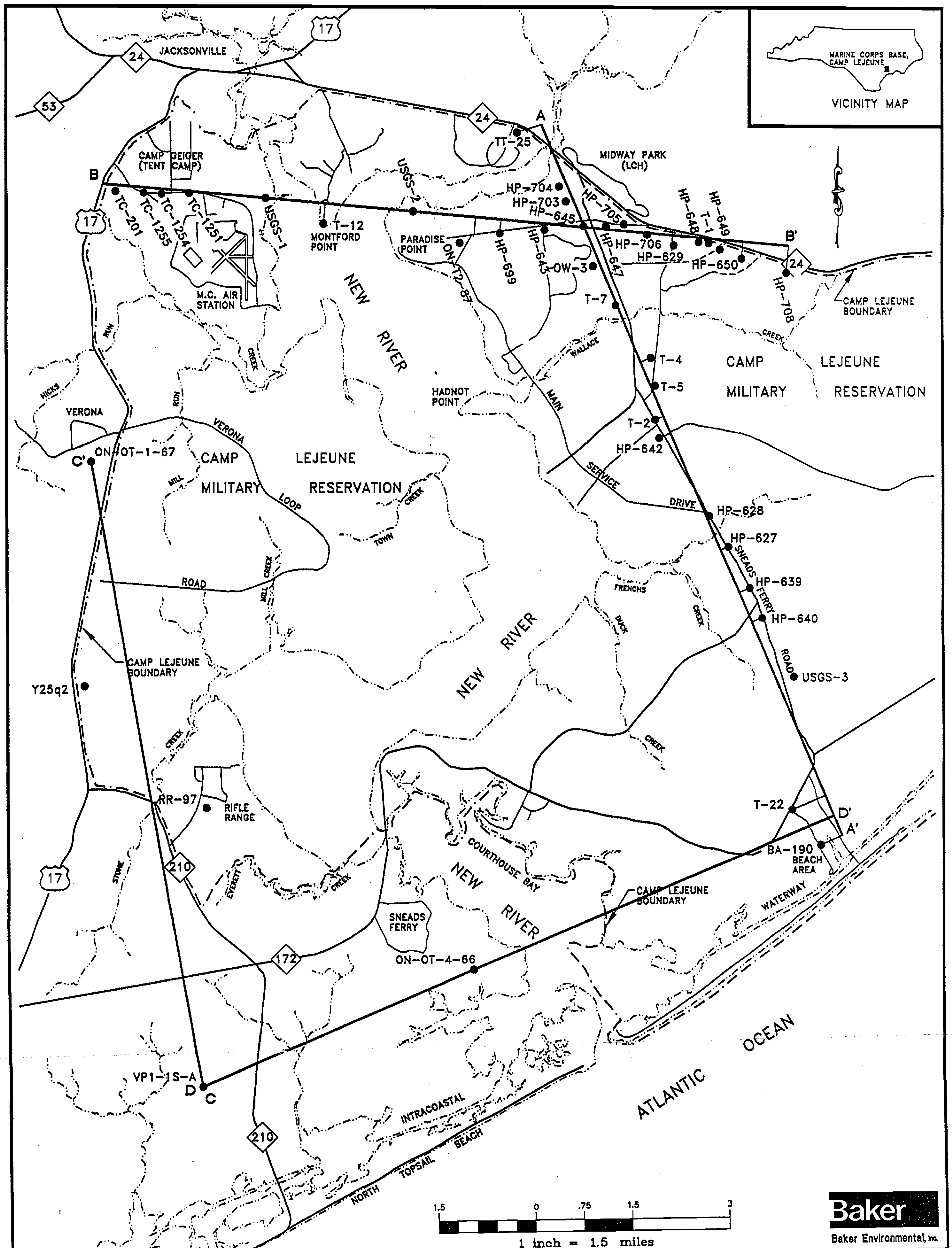
SECTION 3.0 FIGURES



SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 3-1
TOPOGRAPHY AND SITE FEATURES
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q072



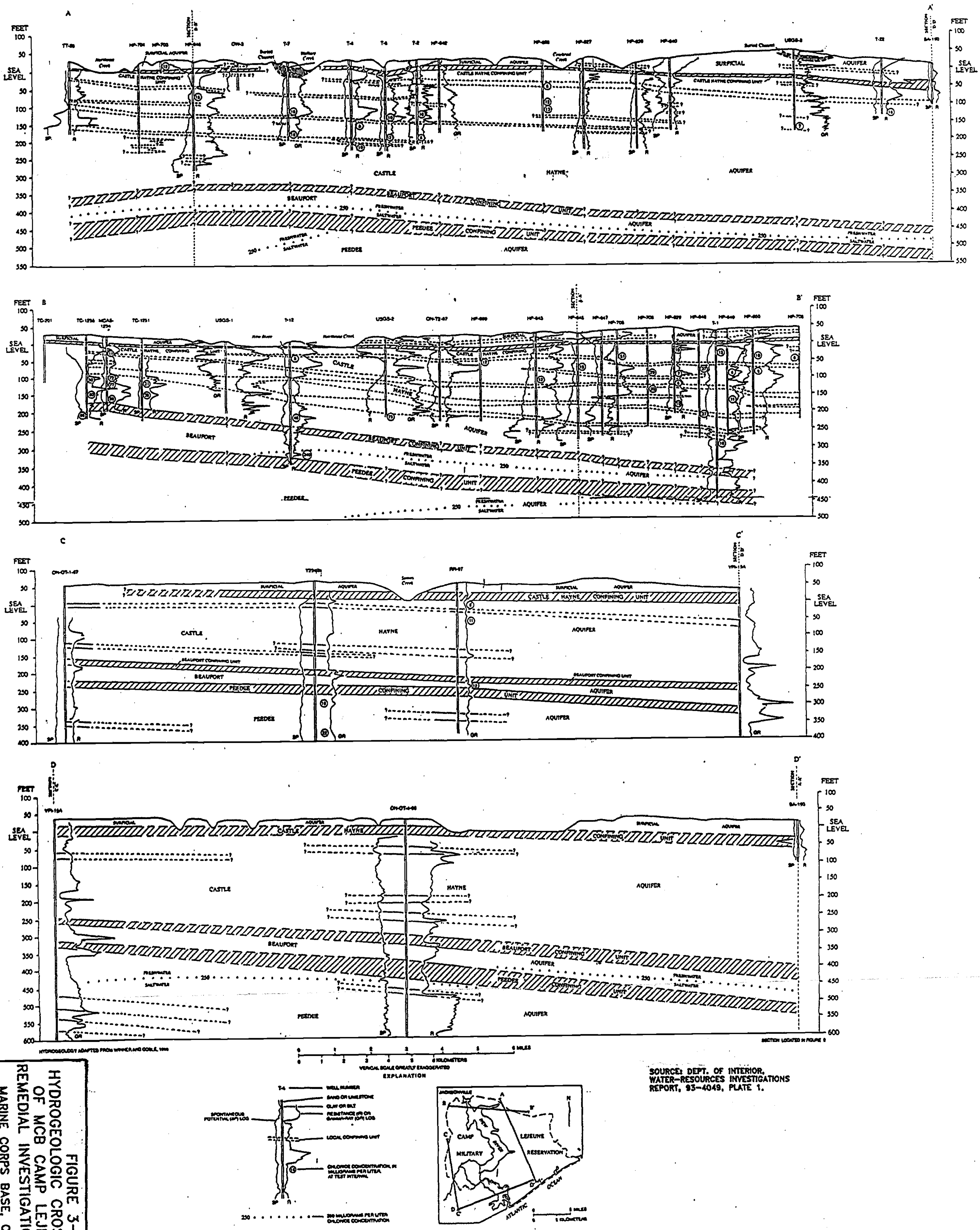
274021R1

SOURCE: DEPT. OF INTERIOR,
WATER-RESOURCES INVESTIGATIONS
REPORT, 93-4049, FIGURE 9

FIGURE 3-2
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

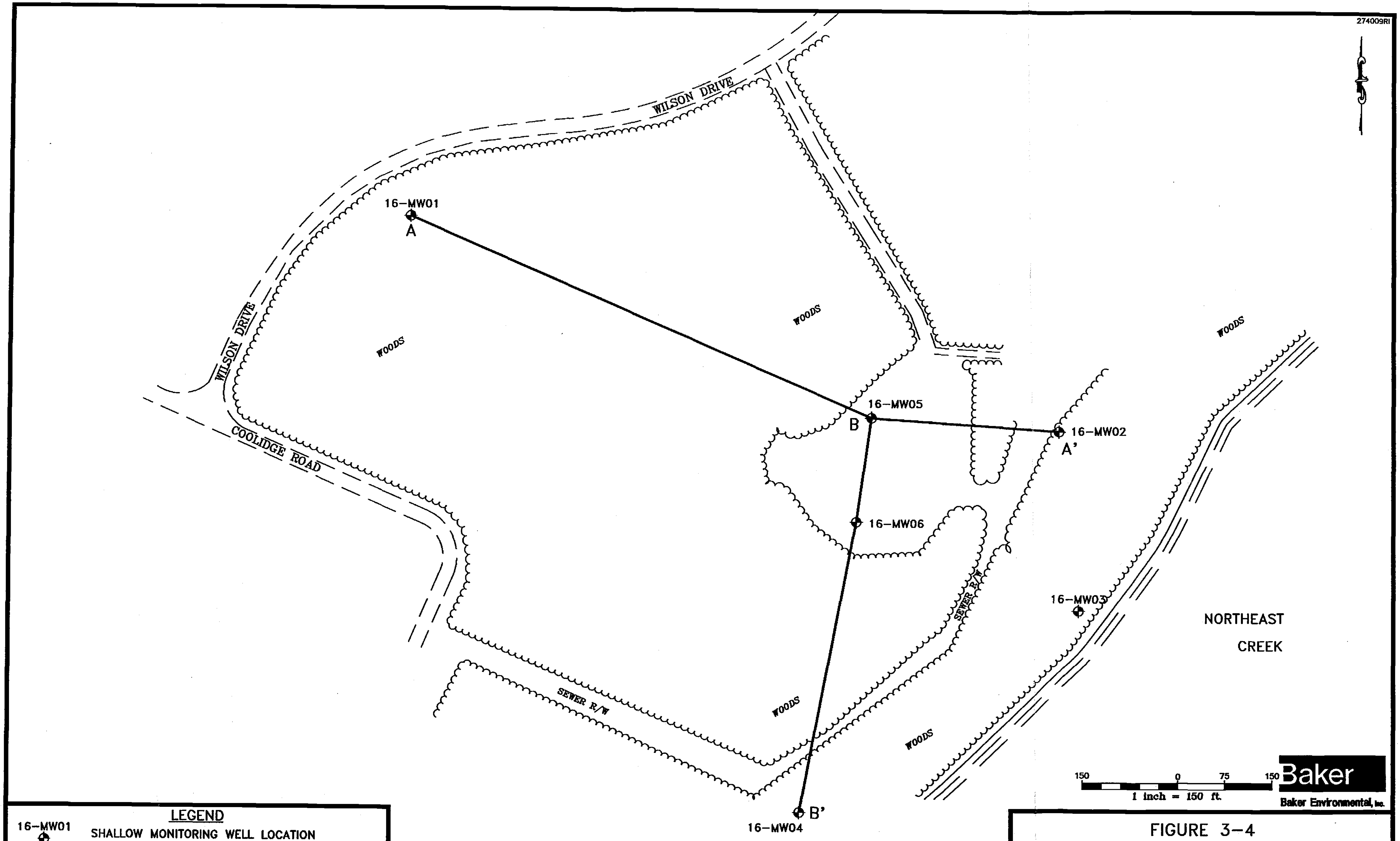
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695082



SOURCE: DEPT. OF INTERIOR,
WATER-RESOURCES INVESTIGATIONS
REPORT, 93-4049, PLATE 1.

FIGURE 3-3
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB CAMP LEJEUNE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker
Baker Environmental, Inc.

LEGEND

16-MW01 ⊕	SHALLOW MONITORING WELL LOCATION
A'-A'	CROSS SECTION LINE
⌒⌒⌒	WOODS LINE
— — —	ROADWAY

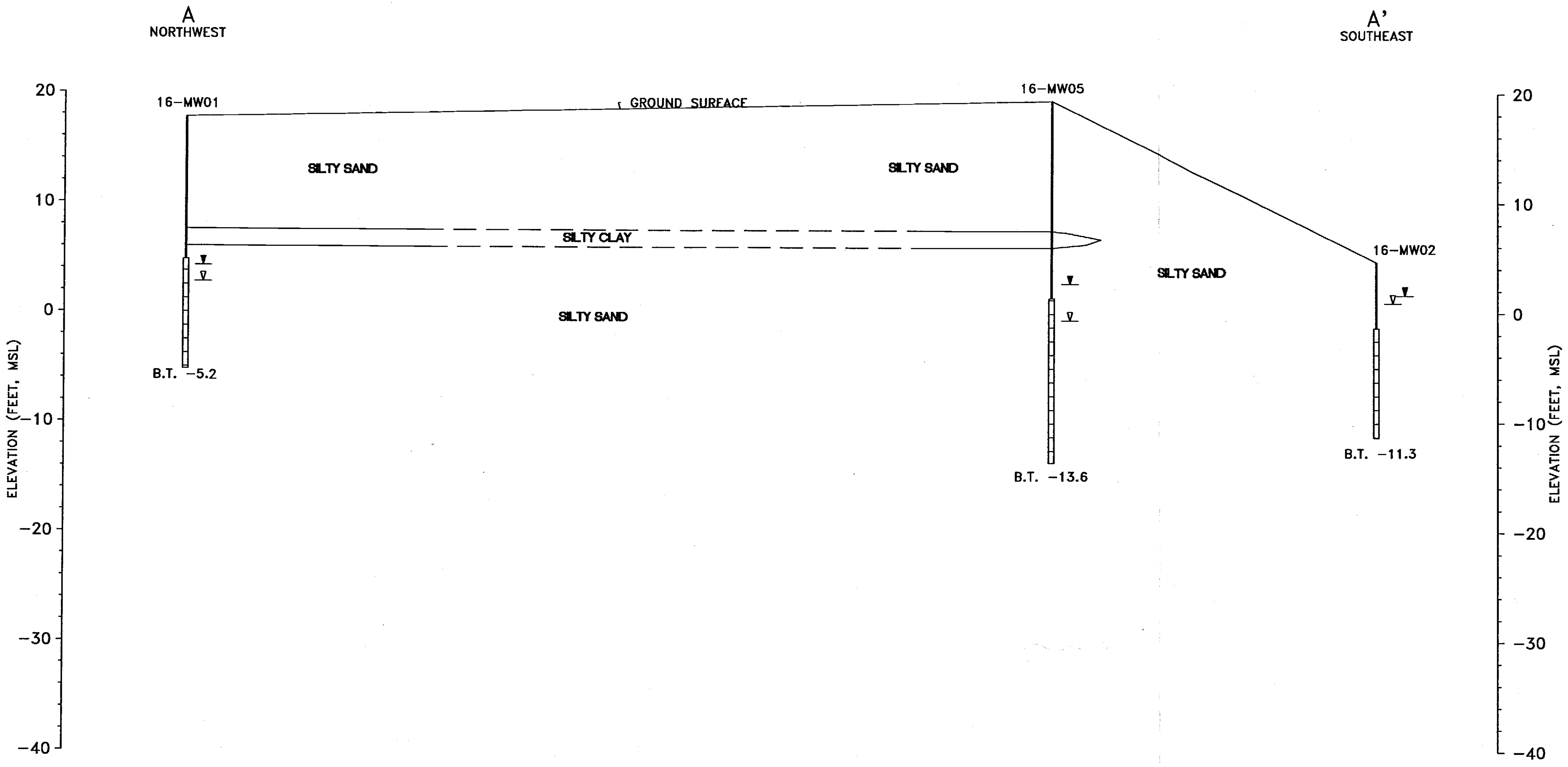
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 3-4
CROSS-SECTION LOCATION MAP
SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q10Z

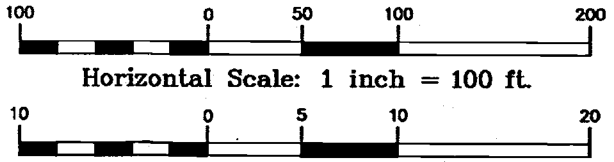
274010RI



Baker
Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION (12/11/94)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. −5.2	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED



Horizontal Scale: 1 inch = 100 ft.

Vertical Scale: 1 inch = 10 ft.

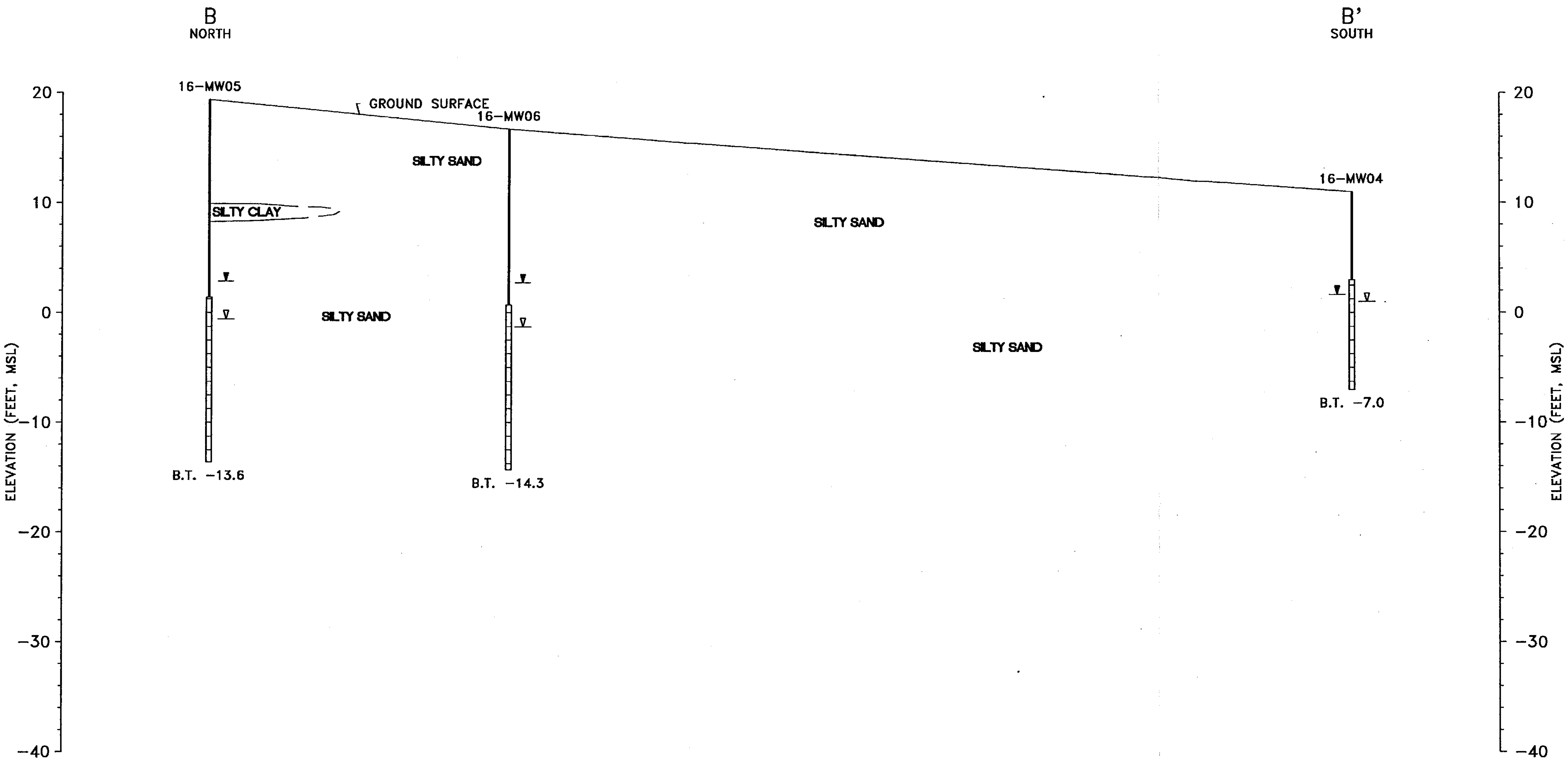
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3−5
HYDROGEOLOGIC CROSS−SECTION A−A'
SITE 16 − MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO−0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q112

274011RI



Baker
Baker Environmental, Inc.

LEGEND

▼ GROUNDWATER ELEVATION (12/11/94)
▽ GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. -13.6 BORING TERMINATED, ELEVATION MSL
▯ WELL SCREEN INTERVAL
— ESTIMATED

60 0 30 60 120
Horizontal Scale: 1 inch = 60 ft.

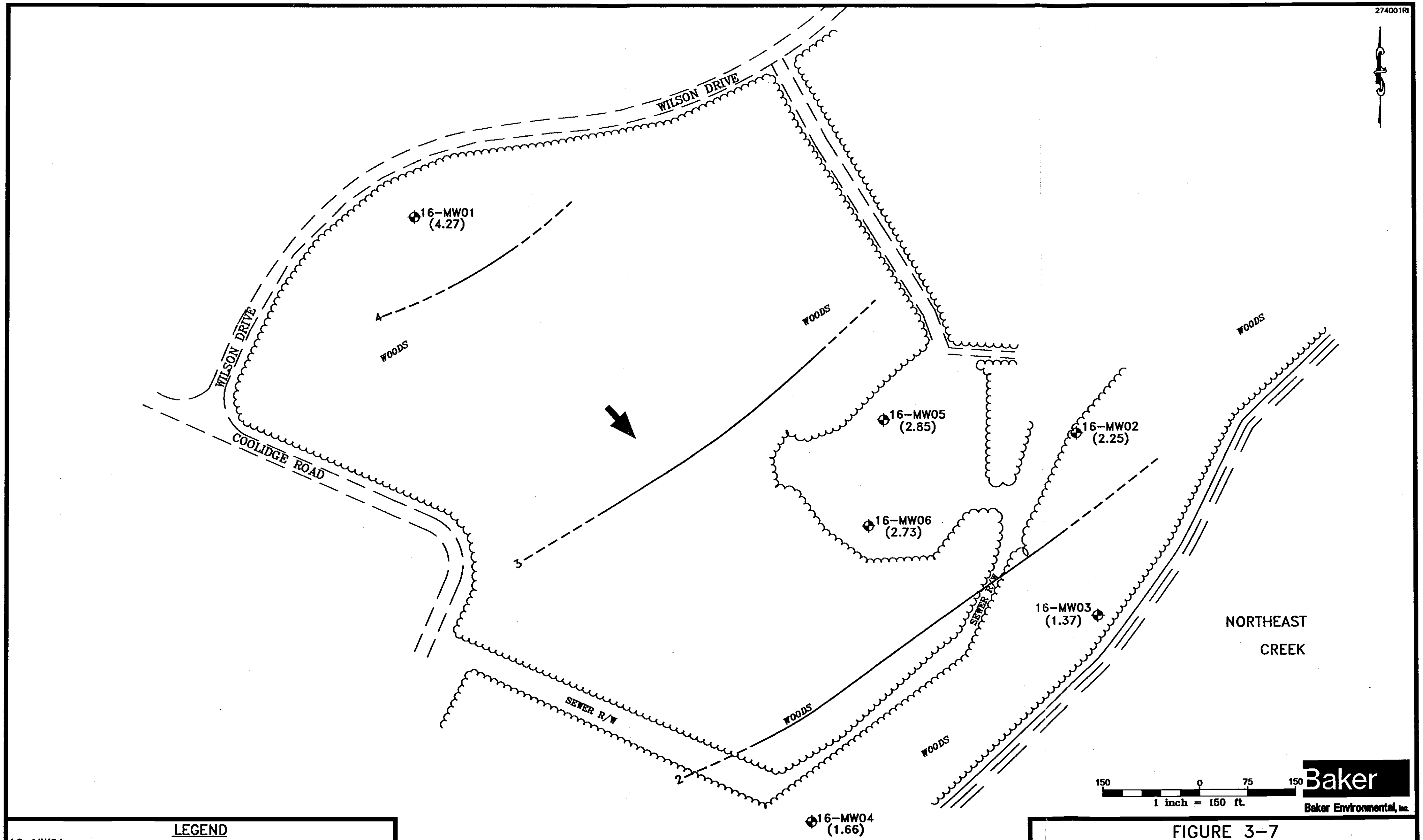
10 0 5 10 20
Vertical Scale: 1 inch = 10 ft.

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 3-6
HYDROGEOLOGIC CROSS-SECTION B-B'
SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q12Z



Baker

Baker Environmental, Inc.

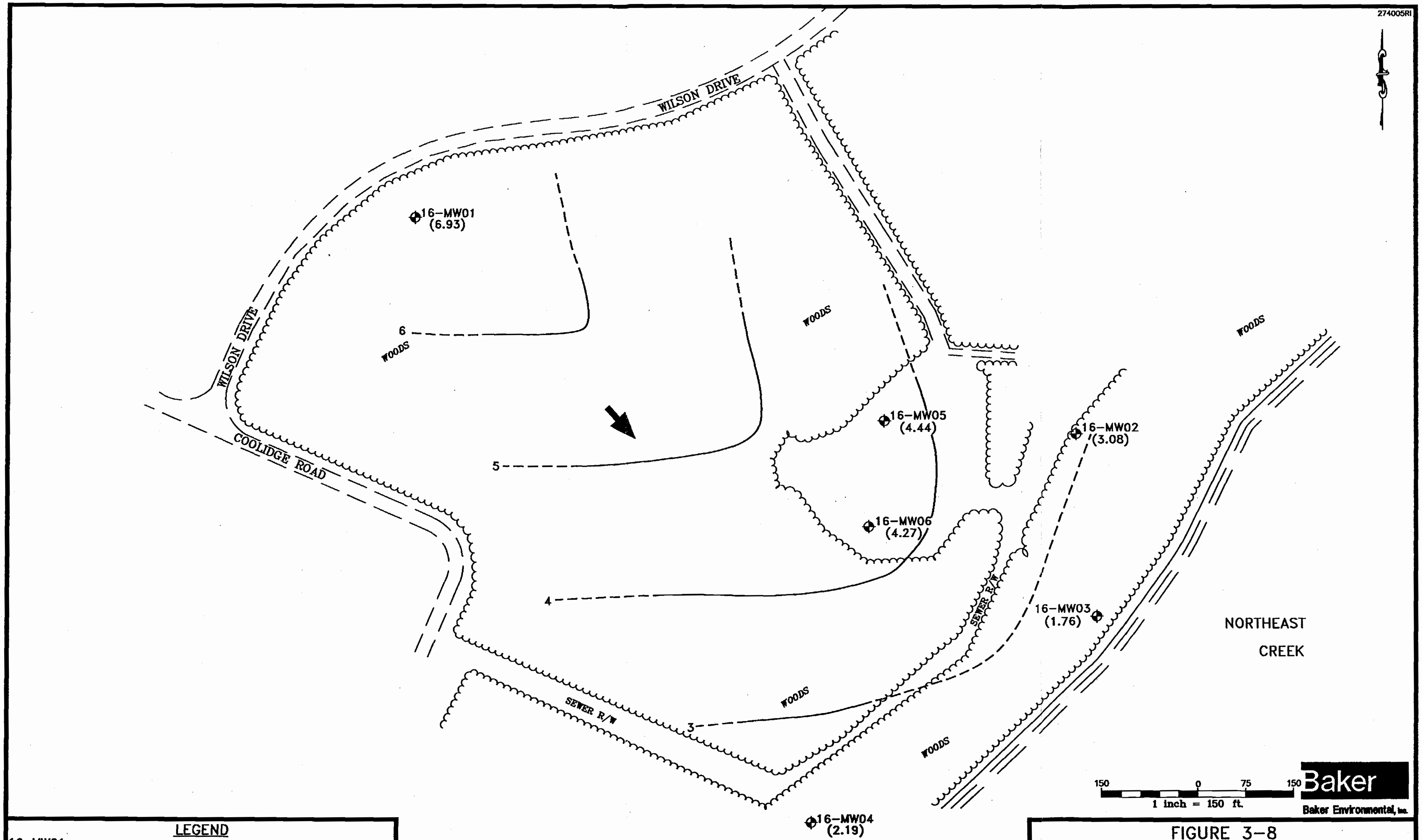
LEGEND

16-MW01 ⊕ EXISTING SHALLOW MONITORING WELL
(4.27) GROUNDWATER ELEVATION
—— GROUNDWATER ELEVATION CONTOUR
- - - GROUNDWATER ELEVATION CONTOUR – INFERRED
→ GROUNDWATER FLOW DIRECTION

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 3-7
SHALLOW GROUNDWATER ELEVATION
CONTOUR MAP – DECEMBER 11, 1994
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATIONCTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q132



LEGEND

16-MW01 ⊕ EXISTING SHALLOW MONITORING WELL

(6.93) GROUNDWATER ELEVATION

——— GROUNDWATER ELEVATION CONTOUR

- - - GROUNDWATER ELEVATION CONTOUR – INFERRED

➔ GROUNDWATER FLOW DIRECTION

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 3-8
SHALLOW GROUNDWATER ELEVATION
CONTOUR MAP – MARCH 27, 195
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATIONCTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q142

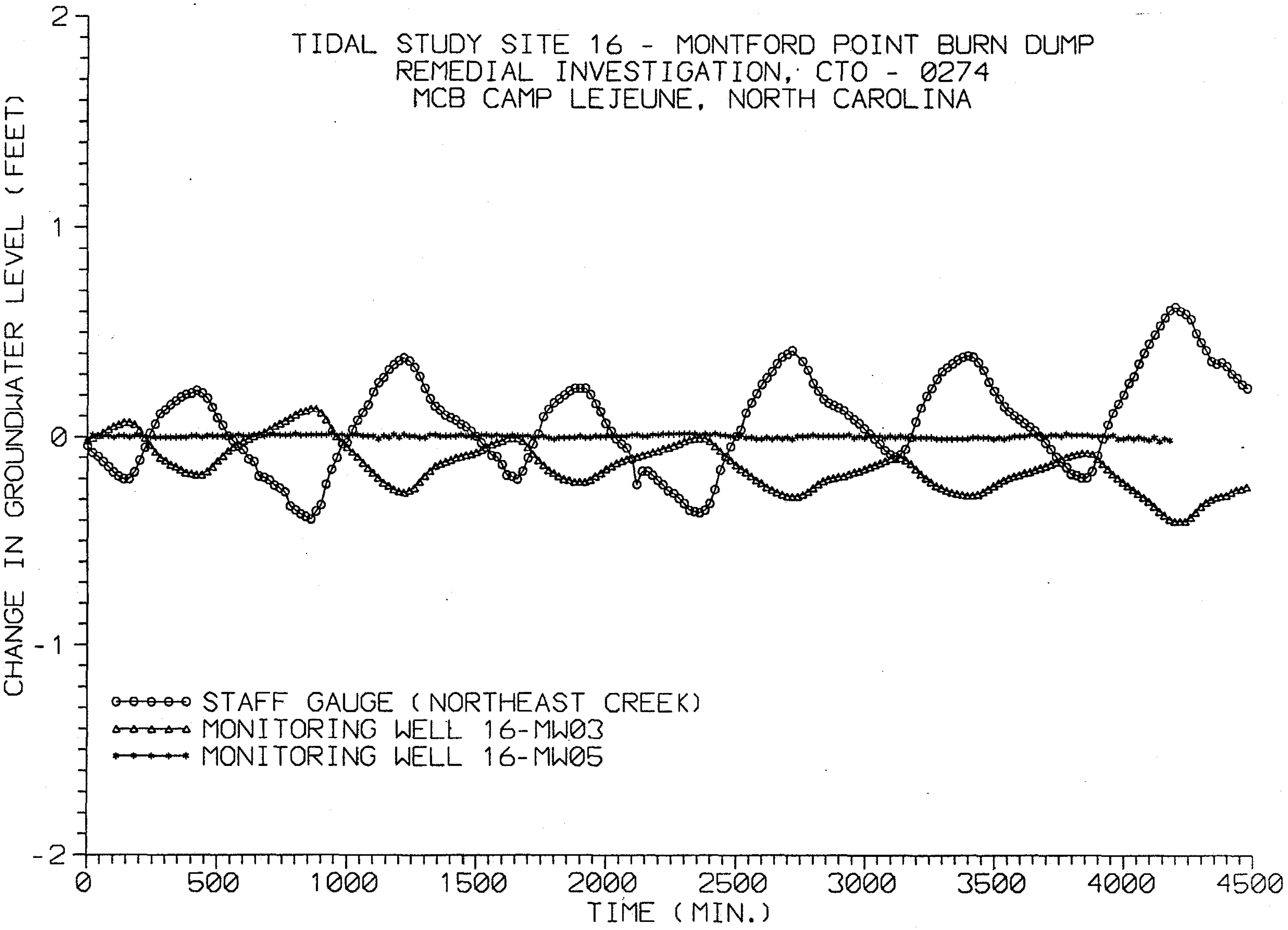
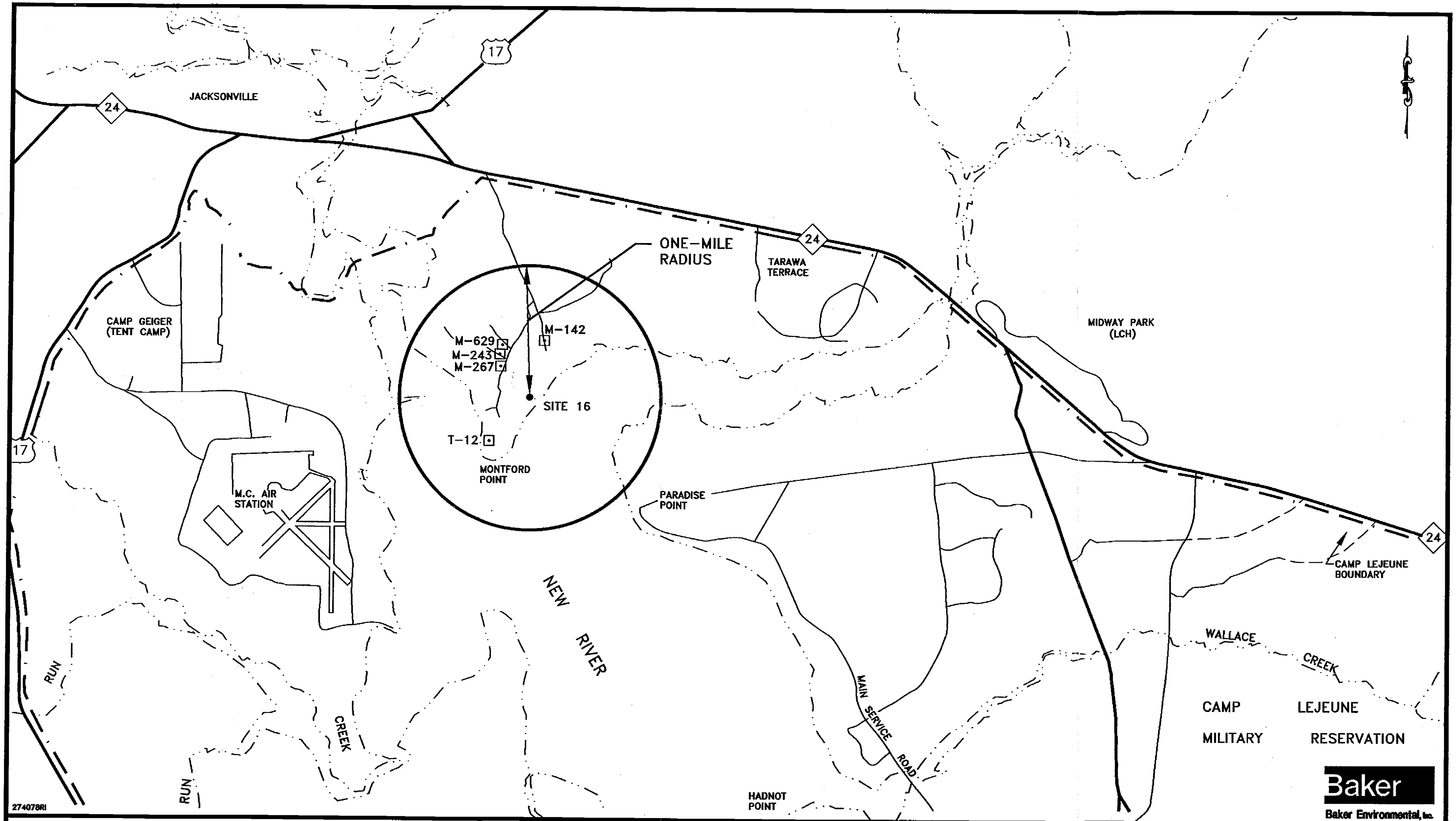


FIGURE 3-9
GRAPH OF TIDAL STUDY READINGS
SITE 16 - FORMER BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

Baker
Baker Environmental, Inc.



LEGEND

T-12 ⊡ WATER SUPPLY WELL

.75 0 .375 .75
1 INCH = .75 MILES

FIGURE 3-10
WATER SUPPLY WELL LOCATIONS SITE 16
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q152

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents and evaluates the results of the Remedial Investigation (RI) performed at Operable Unit (OU) No. 8, Site 16. The objectives of the section are to characterize the nature and extent of contamination at Site 16. This characterization was accomplished through environmental sample collection and laboratory analysis of soil, groundwater, surface water, and sediments. The positive detection summary tables and detection figures referenced in the text are presented at the end of Section 4.0.

4.1 Data Management and Tracking

Analytical data generated during the RI was submitted for third-party validation to Chester Engineers, Inc. Procedures established by the National Functional Guidelines for Organic (USEPA, 1991) and Inorganic (USEPA, 1988) Analyses were adhered to during the validation process. Validation of the analytical data, through established procedures, served to reduce the inherent uncertainties associated with its usability. Data qualified as "J" were retained as estimated. Estimated analytical results within a data set are common and considered usable by the USEPA. Data may be qualified as estimated for several reasons, including an exceedance of holding times, high or low surrogate recovery, or intra-sample variability. In addition, values may be assigned an estimated "J" qualifier if the reported value is below the Contract Required Detection Limit (CRDL) or the Contract Required Quantitation Limit (CRQL).

Analyses for over 11,000 separate contaminants were included in the Site 16 RI. No data was rejected as unusable.

Additional data qualifiers were employed during the validation of data. The "NJ" qualifier denotes that a compound was tentatively identified, but the reported value may not be accurate or precise. Compounds which were not detected and had inaccurate or imprecise quantitation limits were assigned the "UJ" qualifier.

The management and tracking of data from the time of field collection to receipt of the validated electronic analytical results is of primary importance and reflects the overall quality of the analytical results. Field samples and their corresponding analytical tests were recorded on the chain-of-custody sheets, which are included as Appendix B. The chain-of-custody forms were checked against the Field Sampling and Analysis Plan (Baker, 1994) to determine if all designated samples were collected for the appropriate parameters. Upon receipt of the laboratory results, a comparison to the field information was made to determine if each sample received by the laboratory was analyzed for the correct parameters. Similarly, the validated information was compared to laboratory information as a final check. In summary, the tracking information was used to identify the following items:

- Identify sample discrepancies between the analysis plan and the field investigation
- Verify that the laboratory received all samples, and analyzed for the correct parameters
- Verify that the data validator received a complete data set

- Ensure that a complete data set was available for each media of concern prior to entering results into the database

4.2 Non-Site Related Analytical Results

Many of the organic and inorganic constituents detected in soil, groundwater, surface water, and sediment at Site 16 are attributable to non-site related conditions or activities. Two primary sources of non-site related results include laboratory contaminants and naturally-occurring inorganic elements. In addition, non-site related operational activities and conditions may contribute to "on-site" contamination. A discussion of non-site related analytical results for Site 16 is provided in the following subsections.

4.2.1 Laboratory Contaminants

Blank samples (i.e., rinsate, field, trip) provide a measure of contamination that has been introduced into a sample set during the collection, transportation, preparation, and/or analysis of samples. To remove non-site related contaminants from further consideration, the concentrations of chemicals detected in blanks were compared with concentrations of the same chemicals detected in environmental samples.

Common laboratory contaminants (i.e., acetone, 2-butanone, chloroform, methylene chloride, toluene, and phthalate esters) were considered as positive results only when observed concentrations exceeded ten times the maximum concentration detected in any blank. If the concentration of a common laboratory contaminant was less than ten times the maximum blank concentration, then it was concluded that the chemical was not detected in that particular sample (USEPA, 1989a). The maximum concentrations of detected common laboratory contaminants in blanks were as follows:

acetone	14 µg/L
methylene chloride	10 µg/L
chloroform	17 µg/L
2-butanone	6J µg/L
bis(2-ethylhexyl)phthalate	1J µg/L

Organic constituents contained in blanks that are not considered common laboratory contaminants [i.e., all other Target Compound List (TCL) organics] were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds of less than five times the maximum level of contamination noted in any blank were considered to be not detected in that sample. The maximum concentrations of all other detected blank contaminants were as follows:

chloromethane	7J µg/L
1,2-dichloroethane	3J µg/L
bromodichloromethane	14 µg/L
dibromochloromethane	8J µg/L

A limited number of solid environmental samples that exhibited high concentrations of tentatively identified compounds (TICs) underwent an additional sample preparation. Medium level sample preparation provides a corrected Contract Required Quantitation Limit (CRQL) based on the volume of sample used for analysis. The corrected CRQL produces higher detection limits than the low level sample preparation. A comparison to laboratory blanks used in the medium level preparation was used to evaluate the relative amount of contamination within these samples.

4.2.2 Naturally-Occurring Inorganic Elements

In order to differentiate inorganic contamination due to site operations from naturally-occurring inorganic elements in site media, the results of the sample analyses were compared to information regarding background conditions at MCB, Camp Lejeune. The following guidelines were used for each media:

Soil:	MCB, Camp Lejeune Background Soil Samples
Groundwater:	MCB, Camp Lejeune Background Groundwater Samples
Surface Water:	MCB, Camp Lejeune Base Upgradient Levels
Sediments:	MCB, Camp Lejeune Base Upgradient Levels

The following subsections address the various comparison criteria used to evaluate the analytical results from soil, groundwater, surface water, and sediment samples collected at Site 16.

4.2.2.1 Soil

In general, chemical-specific standards and criteria are not available for soil. As a result, base-specific background concentrations have been compiled from a number of locations throughout MCB, Camp Lejeune to evaluate background levels of inorganic elements in the surface and subsurface soil. Organic contaminants, unlike inorganic elements, are not naturally-occurring. Therefore, it is probable that all organic contaminants detected in the surface and subsurface soil are attributable to activities which have or are currently taking place within or surrounding the study area.

Site background and base background concentration values for inorganic elements in surface and subsurface soil at MCB, Camp Lejeune are presented in Tables 4-1 and 4-2, respectively. The base background ranges are based on analytical results of background samples collected in areas known to be unimpacted by site operations or disposal activities at MCB, Camp Lejeune. In subsequent sections, which discuss the analytical results of samples collected during the soil investigation, only those inorganic parameters with concentrations exceeding these ranges will be considered. Appendix F contains the summary of the base soil background database for inorganics.

4.2.2.2 Groundwater

A monitoring well (16-MW01) was installed in an upgradient direction of Site 16 to assess background groundwater conditions. Background wells are often installed to assess the natural state and quality of groundwater. Natural in this sense implies that the groundwater has not been altered due to human activity. In some cases, these monitoring wells provide data that is representative of naturally occurring conditions. In other cases, these wells may not be representative of naturally occurring conditions, if other base-related activities have altered the natural state of groundwater. In the latter cases, the well samples would be classified as "control" samples. Control samples are samples which may not represent background conditions, but represent the current state of groundwater quality upgradient of the site. During the past four years, a number of background wells have been installed throughout the base as part of individual site investigations. Most of the background wells installed throughout the base provide control samples. The data collected from these wells have generated data that is representative of "base-wide" groundwater quality.

Chemical-specific standards and criteria are available for evaluation of groundwater analytical results. In the subsequent sections, which address the analytical results of samples collected during the groundwater investigation, only those inorganic parameters with concentrations exceeding applicable Federal and/or State regulations will be discussed. In order to supplement comparison criteria, a number of base-specific background (i.e., upgradient) samples were compiled as part of a study to evaluate levels of inorganic elements in groundwater at MCB, Camp Lejeune. Appendix G presents Baker's Draft Report Evaluation of Metals in Groundwater, June 1994, prepared for the Department of the Navy, Atlantic Division Naval Facilities Engineering Command.

Groundwater samples were analyzed for total and dissolved (i.e.,"unfiltered" and "filtered", respectively) inorganic parameters. Concentrations of dissolved inorganics were found to be generally lower than total inorganics for each sample, particularly for metals such as chromium, iron, lead and manganese. For dissolved metal samples, a 0.45-micron filter was used in the field to remove small particles of silt and clay that would otherwise be dissolved during sample preservation and generate an unrealistically high apparent value of metals in groundwater. The total metals, or unfiltered samples, thus reflect the concentrations of inorganics in the natural lithology and inorganic elements dissolved in the groundwater.

To more accurately represent total metals in groundwater, a "low-flow" purging technique has been adopted at MCB, Camp Lejeune. This technique allows for the purging of groundwater monitoring wells at a low rate prior to sampling. This reduces the amount of suspended solids in the groundwater sample which contributes to the overall concentration of metals. This "low-flow" purging allows for the collection of a much more representative sample. The procedures followed for this purging were based on discussions with the USEPA Region IV research office in Athens, Georgia. The USEPA is currently researching the use of "low-flow" purging and sampling, and anticipates issuing Standard Operating Procedures (SOPs) later this year.

Relatively high concentrations of metals in unfiltered groundwater are not considered abnormal, based on experience gained from several other studies at MCB, Camp Lejeune (see Appendix G). The difference between the two analytical results (i.e., unfiltered and filtered) is important in terms of understanding and separating naturally-occurring elements (e.g., lead) from contamination by site operations (e.g., lead in gasoline).

USEPA Region IV requires that unfiltered inorganic concentrations be used in evaluating ARARs and risk to human health and the environment. In the subsequent sections, which discuss the groundwater sample analytical results, both total and dissolved inorganics (which exceed applicable Federal and/or State standards) will be presented and discussed.

Groundwater in the MCB, Camp Lejeune area is naturally rich in iron and manganese. Iron and manganese concentrations (i.e., total and dissolved) in groundwater at MCB, Camp Lejeune often exceed the Federal MCLs and NCWQS of 300 and 50 µg/L, respectively. Elevated levels of iron and manganese, at concentrations above the MCL and NCWQS, were reported in samples collected from a number of Base potable water supply wells which were installed at depths greater than 162 feet bgs (Greenhorne and O'Mara, 1992). Iron and manganese concentrations in several monitoring wells at Site 16 exceeded the MCLs and NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. There is no record of any historical use of iron and manganese at Site 16. In light of this, it is assumed that iron and manganese are naturally-occurring inorganic elements in groundwater, and their presence is not attributable to site operations.

4.2.2.3 Surface Water and Sediment

Upgradient freshwater surface water and sediment samples have been collected at four sites at MCB Camp Lejeune and the results summarized for metals. Samples were collected from the following areas:

Site 2 -	Overs Creek
Site 6 -	Bearhead Creek Wallace Creek
Site 41 -	unnamed tributary Tank Creek northeast tributary to unnamed tributary
Site 69 -	unnamed tributary

Metal concentrations in surface water at the Base vary widely. A total of 22 upgradient samples have been analyzed for metals with aluminum, barium, calcium, iron, magnesium, manganese, potassium, and sodium detected in at least 75 percent of the upgradient samples. These metals exhibited the highest detected concentrations within the surface water metal concentrations. Table 4-3 contains a summary of the frequency of detection with the calculated average concentrations for each metal.

The most detected metals in sediments include aluminum, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc. These metals were detected in approximately 70 percent of the upgradient samples. Table 4-4 contains a summary of the frequency of detection with the calculated average concentrations for each metal.

In the summer of 1994, Baker collected surface water, sediment, fish, and benthic macroinvertebrate samples from the three creeks in the White Oak River basin (Holland Mill Creek, Hadnot Creek, and Webb Creek). The samples collected are used as off-site reference stations to determine the regional levels of contaminants in the surface water and sediment, and regional population of fish and benthic macroinvertebrate species.

Baker collected three samples from Holland Mill Creek. One sample was at an upstream freshwater station, one sample was at a mid-stream tidal station, and one sample was collected in the White Oak River at the mouth of Holland Mill Creek. Baker collected four samples from Hadnot Creek. Two samples were at an upstream freshwater station, one sample was at a mid-stream tidal station, and one sample was collected in the White Oak River at the mouth of Hadnot Creek. Of the two upstream samples in Hadnot Creek, one was collected in a relatively small creek, while the other was collected in a large ponded area. Finally, Baker collected two samples from Webb Creek. One sample was at a mid-stream tidal station, and one sample was collected in the White Oak River at the mouth of Webb Creek. Appendix H presents the results of the White Oak River Basin study.

4.3 State and Federal Criteria and Standards

Contaminant concentrations can be compared to contaminant-specific established Federal and State criteria and standards such as Maximum Contaminant Levels (MCLs) or North Carolina Water Quality Standards (NCWQS).

The only enforceable Federal regulatory standards for water are the Federal MCLs. In addition to the Federal standards, the State of North Carolina has developed the North Carolina Water Quality Standards (NCWQS) for groundwater and surface water. Regulatory guidelines were used for comparative purposes to infer the potential health risks and environmental impacts when necessary. Relevant regulatory guidelines include Federal Ambient Water Quality Criteria (AWQC) and Health Advisories.

In general, chemical-specific criteria and standards are not available for soil. Therefore, base-specific background concentrations were compiled to evaluate background levels of inorganic constituents in the surface and subsurface soil. Organic contaminants were not detected in the base-specific background samples. Therefore, it is likely that all organic contaminants detected in the surface and subsurface soil, within OU No. 8, are attributable to the practices which have or are currently taking place within the areas of concern.

A brief explanation of the criteria and standards used for the comparison of site analytical results is presented below.

North Carolina Water Quality Standards (Groundwater) - NCWQSs are the maximum allowable concentrations resulting from any discharge of contaminants 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.

Maximum Contaminant Levels - 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 are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply.

North Carolina Water Quality Standards (Surface Water) - The NCWQSs for surface water are the standard concentrations, that either alone or in combination with other wastes, in surface waters that will not render waters injurious to aquatic life or wildlife, recreational activities, public health, or impair waters for any designated use.

Ambient Water Quality Criteria - AWQCs are non-enforceable Federal regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. 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 the 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 (i.e., the 10E-7 to 10E-5 range).

Region IV Sediment Screening Values - Federal sediment quality criteria for the protection of aquatic life are being developed. In the interim, the USEPA Region IV Waste Management Division recommends the use of sediment values compiled by the National Oceanic and Atmospheric Administration (NOAA) as screening values for evaluating the potential for chemical constituents in sediments to cause adverse biological effects. NOAA developed this screening method through evaluation of biological effects data for aquatic (marine and freshwater) organisms, obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed, and the lower 10 percentile (called an Effects Range-Low, or ER-L) and the median (called Effects Range-Median, or ER-M) were determined.

If sediment contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable. If contaminant concentrations are between the ER-L and the ER-M, adverse effects are considered possible, and USEPA recommends conducting sediment toxicity tests as a follow-up. If contaminant concentrations are below the ER-L, adverse effects are considered unlikely.

4.4 Analytical Results

The analytical results of the soil, groundwater, surface water, and sediment sampling performed at Site 16 are presented in the following sections. A summary of site contamination, by media, is provided in Table 4-5. The Data and Frequency Summaries for all media at Site 16 are presented in Appendix I.

All samples submitted for analysis were analyzed for full TCL organics, including volatiles, semivolatiles and pesticides/PCBs, and TAL inorganics, using CLP protocols and Level III data quality.

4.4.1 Soil Investigation

Surface soil positive detection summaries for organics and inorganics are presented in Tables 4-6 and 4-7, respectively. Table 4-7a presents the positive detection summary for inorganics for the confirmatory samples collected in December, 1995. Positive detection summary tables for organics and inorganics in subsurface soil are presented in Tables 4-8 and 4-9, respectively.

4.4.1.1 Surface Soil

A total of 36 samples were collected from the burn dump, surface drainage area, and the monitoring well locations. Toluene was detected at low levels in 3 samples with concentrations ranging from 1J µg/kg (16-BD-SB08) to 4J µg/kg (16-BD-SB14). Acetone was detected in 3 samples at concentrations ranging from 11J µg/kg (16-BD-SB15) to 1,200 µg/kg (16-MW04). The acetone concentrations detected in samples 16-MW06 (200 µg/kg) and 16-MW04 (1200 µg/kg) were greater than 10 times the maximum concentration detected in QA/QC blanks. Acetone was detected in background/control location 16-BB-SB01 at a concentration of 16µg/kg, which is greater than the maximum concentration (14 µg/L) detected in QA/QC blanks. A source for the detected acetone is still believed to be laboratory and/or field procedures. Methylene chloride was detected in

3 samples, but at concentrations less than 10 times the maximum QA/QC blank concentration. The one acetone concentration and the methylene chloride detections can be considered as laboratory contaminants due to their being detected at less than 10 times the maximum concentration detected in QA/QC blanks.

Semivolatile polynuclear aromatic hydrocarbon (PAH) constituents were detected at various locations within the burn dump. The PAH constituent with the highest concentration was benzo(a)pyrene (130J µg/kg) at location 16-BD-SB16. Sample 16-BD-SB09 exhibited the only detected phenol concentration (70J µg/kg). Bis(2-ethylhexyl)phthalate was detected in 6 of the 29 samples at concentrations ranging from 37J µg/kg (16-SDA-SB02) to 490 µg/kg (16-BD-SB16). All concentrations of bis(2-ethylhexyl)phthalate were greater than 10 times the highest concentration detected in the QA/QC blanks. Bis(2-ethylhexyl)phthalate was detected at location 16-BB-SB01 at a concentration of 70 µg/kg, which was greater than the maximum concentration in QA/QC blanks. Phthalate esters detected in the background and site surface soil may be from laboratory and field procedures, and equipment. Butyl benzyl phthalate was detected in one sample at a concentration of 64J µg/kg (16-BD-SB16). This phthalate was not detected in any QA/QC blanks.

Pesticides were detected in 26 samples. 4,4'-DDE and 4,4'-DDT exhibited the highest concentrations (440 µg/kg and 540J µg/kg, respectively) and were detected the most frequently. The highest concentrations of 4,4'-DDE and 4,4'-DDT were detected at location 16-BD-SB05. The pesticides 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, and dieldrin were detected in background/control surface soil locations at Site 16. These pesticides were also detected in site surface soil samples. It does not seem unusual for pesticides to be detected in background areas of the base due to the historic use of pesticides at the base. PCBs were detected in the surface soil at Site 16. Aroclor 1254 was detected in 13 of 29 samples at concentrations ranging from 41 µg/kg (16-BD-SB20) to 2,100 µg/kg (16-BD-SB13). Aroclor 1260 was detected in two samples at concentrations of 50J µg/kg (16-MW06) and 210J µg/kg (16-BD-SB05).

Occurrences of inorganics is widespread, as at other sites at MCB, Camp Lejeune. All detected inorganics, except silver and sodium, had at least one concentration above the base background levels. Inorganic concentrations were within an order of magnitude or less of the base background levels, except for manganese which was two orders of magnitude higher. Antimony was the only inorganic not detected. Four confirmatory surface soil samples were collected around soil boring location 16-BD-SB05 due to the high level of lead detected during the initial field investigation. These samples were only submitted for inorganics analyses. Lead concentrations in these samples were one order of magnitude less than base background levels.

4.4.1.2 Subsurface Soil

A total of 35 samples were collected. Bromomethane was detected in one sample (16-BD-SB06, 13 to 15 feet) at a concentration of 1J µg/kg. Acetone was detected in 12 of 32 samples at concentrations ranging from 42J µg/kg (16-BD-SB18, 11 to 13 feet) to 900J µg/kg (16-BD-SB14, 9 to 11 feet). Eight concentrations of acetone exceeded 10 times the maximum concentration reported for QA/QC blanks. Location 16-BB-SB01 exhibited an acetone concentration of 62 µg/kg, which is greater than the maxdimum concentration (14 µg/L) detected in QA/QC blanks. A source for the detected acetone is still laboratory and/or field procedures.

PAHs were the most frequently detected semivolatile organics. Sample 16-BD-SB10 (5 to 7 feet) exhibited the highest concentrations of PAHs. Total PAH concentration in sample 16-BD-SB10

(5 to 7 feet) was 6,328 µg/kg. 1,4-Dichlorobenzene and 1,2,4-trichlorobenzene were detected in samples 16-MW02 (5 to 7 feet) (50J µg/kg and 45J µg/kg, respectively) and 16-BD-SB12 (3 to 5 feet) (67J µg/kg and 66J µg/kg, respectively). Dibenzofuran was detected in sample 16-BD-SB10 (5 to 7 feet) at a concentration of 310J µg/kg. Pentachlorophenol was detected in 3 samples at concentrations ranging from 38NJ µg/kg (16-BD-SB12, 3 to 5 feet) to 94J µg/kg (16-BD-SB10, 5 to 7 feet). The phthalate esters di-n-butylphthalate, bis(2-ethylhexyl)phthalate and di-n-octylphthalate were detected. Di-n-butylphthalate and di-n-octylphthalate were each detected in one sample at concentrations of 270J µg/kg (16-BD-SB10, 5 to 7 feet) and 46J µg/kg (16-MW06, 11 to 13 feet), respectively. Bis(2-ethylhexyl)phthalate was detected at concentrations ranging from 58J µg/kg (16-BD-SB20, 11 to 13 feet) to 71J µg/kg (16-MW05, 15 to 17 feet). Bis(2-ethylhexyl)phthalate was detected in background boring 16-BB-SB01 (13 to 15 feet) at a concentration of 77J µg/kg. The bis(2-ethylhexyl)phthalate concentrations exceeded 10 times the maximum concentration detected in QA/QC blanks. Phthalate esters detected in the background and site surface soil are still believed to be from laboratory, and field procedures and equipment. Di-n-butylphthalate and di-n-octylphthalate were not detected in QA/QC blanks.

The maximum concentration of pesticides 4,4'-DDE, 4,4'-DDD and 4,4'-DDT were detected in sample 16-BD-SB05 (13 to 15 feet). Endosulfan II, alpha-chlordane and gamma-chlordane were detected in subsurface soils at relatively low concentrations. PCBs were detected in the subsurface soil at Site 16. Aroclor 1254 was detected in two subsurface soil samples at concentrations of 40 µg/kg (16-SDA-SB01, 3 to 5 feet) and 45 µg/kg (16-BD-SB13, 3 to 5 feet).

Barium, lead, manganese, and zinc were detected within one order of magnitude above base background levels. Antimony, cadmium, cobalt, nickel, silver, and thallium were not detected.

4.4.2 Groundwater Investigations

Two rounds of groundwater samples were collected and analyzed from the six shallow wells installed during the RI. The first round of samples were collected on November 29-30, 1994. Round One samples were analyzed for full TCL organics and Target Analyte List (TAL) metals (total and dissolved). The second sampling round was conducted on March 29, 1995. The second sampling round was a confirmatory round as these were all newly installed monitoring wells (no previous investigations had been performed at this site). Round Two samples were analyzed for full TCL organics and TAL total metals.

4.4.2.1 Round One

Positive detection summary tables for full TCL organics and TAL metals (total and dissolved) are presented in Tables 4-10, 4-11 and 4-12, respectively.

Benzene was detected in one sample (16-MW05) at a concentration of 37 µg/L, which is above State and/or Federal standards. Ethylbenzene was also detected in this sample (1J µg/L) but below State and/or Federal standards.

The semivolatile phenol was detected in three samples, with the highest concentration exhibited in sample 16-MW05 (4J µg/L). No phenol concentrations were above State and/or Federal standards. Naphthalene was detected in sample 16-MW05 at a concentration of 6J µg/L (below State and/or Federal standards). Bis(2-ethylhexyl)phthalate was detected in 4 of 6 groundwater samples at concentrations ranging from 1J µg/L (16-MW02 and 16-MW05) to 5J µg/L (16-MW03). The concentrations of bis(2-ethylhexyl)phthalate were less than 10 times the maximum concentration detected in QA/QC blanks; therefore, this compound is considered a laboratory contaminant.

No pesticides or PCBs were detected in the shallow groundwater.

The eight inorganics detected in the shallow groundwater samples were barium, calcium, iron, lead, magnesium, manganese, sodium and zinc. Only iron, at a concentration of 712 µg/L, was detected above the State and/or Federal standards. Total metal concentrations were one or two orders of magnitude less than base background levels.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 4-13. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained from each well, which are representative of groundwater conditions following purging, pH values ranged from 5.35 to 5.81 s.u., specific conductance values ranged from 53 to 245 micromhos/cm, and temperature values ranged from 16.7 to 20.5° C. Turbidity values were all recorded as less than or equal to 10 nephelometric turbidity units (NTU). A turbidity reading of less than 5 NTU is considered to be non-visible to the human eye. The USEPA Region IV research into low-flow purging considers a reading of 10 NTU as satisfactory for well stabilization criteria. Specific conductance values are well within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978). All values for pH are below the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.). Field parameters for pH and specific conductance were comparable to values obtained at other sites at MCB Camp Lejeune.

4.4.2.2 Round Two

Positive detection summary tables for full TCL organics and TAL metals (total) are presented in Tables 4-14 and 4-15, respectively.

No volatile organics were detected during this sampling round. The semivolatile naphthalene was detected at concentrations of 4J µg/L or 5J µg/L in all 6 wells. Naphthalene was not detected above State and/or Federal standards. Bis(2-ethylhexyl)phthalate was detected at concentrations ranging from 1J µg/L (16-MW03) to 5J µg/L (16-MW04). The phthalate concentrations were less than 10 times the maximum concentration detected in QA/QC blanks; therefore, it is considered a laboratory contaminant.

Aluminum, barium, calcium, iron, magnesium, manganese, potassium and sodium were detected during the second round of groundwater sampling and analysis. Iron was the only metal detected above State and/or Federal standards. Total metal concentrations were one or two orders of magnitude less than base background levels.

Groundwater field parameter results for pH and temperature are presented in Table 4-16. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Only pH and temperature were measured for the second sampling round because volatiles were the constituents of concern as identified in the first sampling round, and other field measurement instruments were unavailable. Reviewing the last readings obtained from each well, which are representative of groundwater conditions following purging, pH values ranged from 4.70 to 5.33 s.u. and temperature values ranged from 15.6 to 19.2° C. All values for pH are below the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.). Values for pH were comparable to values obtained during the Round One sampling.

4.4.3 Surface Water Investigation

Five surface water samples were collected from Northeast Creek. Positive detection summary tables for organics and metals are presented in Tables 4-17 and 4-18, respectively.

4-Methyl-2-pentanone and 1,1,2,2-tetrachloroethane were the only volatile organics detected. No NCWQS or Federal AWQC is established for 4-methyl-2-pentanone. 1,1,2,2-Tetrachloroethane was detected at a concentration (2 µg/L) above the AWQC of 0.17 µg/L at location 16-NC-SW05. The NCWQS established for 1,1,2,2-tetrachloroethane (10.8 µg/L) is greater than the detected concentration of this compound in Northeast Creek.

The only semivolatile organic detected was bis(2-ethylhexyl)phthalate at a concentration of 10J µg/L in sample 16-NC-SW05, one-quarter mile downstream from the site. This concentration is above the Federal AWQC criteria established for this phthalate. Bis(2-ethylhexyl)phthalate was detected in QA/QC blanks collected as part of the surface water and sediment investigations at a maximum concentration of 6 µg/L. The detected concentration of this phthalate ester in sample 16-NC-SW05 is less than 10 times the maximum QA/QC concentration; therefore, it is considered a laboratory contaminant.

No pesticides or PCBs were detected in the surface water samples from Northeast Creek.

Arsenic was the only metal detected above the Federal AWQC. Arsenic was detected at four of the five sampling locations. The upgradient location did not exhibit arsenic. Metal concentrations in surface water were generally one order of magnitude greater than base upgradient levels. Magnesium and potassium were detected at two orders of magnitude, and sodium was detected three orders of magnitude greater than base upgradient levels. Inorganics antimony, beryllium, cadmium, cobalt, copper, mercury, nickel, selenium, thallium and zinc were not detected.

4.4.4 Sediment Investigation

Ten sediment samples were collected from the five sampling locations in Northeast Creek. These samples were collected from depths of 0 to 6 inches and 6 to 12 inches. Positive detection summary tables for full TCL organics and TAL metals are presented as Tables 4-19 and 4-20, respectively.

Carbon disulfide was detected in one sediment sample (16-NC-SD03, 0 to 6 inches) at a concentration of 2J µg/kg. Toluene was detected in sample 16-NC-SD04 (0 to 6 inches) at a concentration of 1J µg/kg and in sample 16-NC-SD02 (0 to 6 inches) at a concentration of 2J µg/kg. No NOAA Effects Range Criteria are established for carbon disulfide and toluene.

No semivolatile organics or pesticides/PCBs were detected in sediment samples from Northeast Creek.

For the inorganics, only silver, detected in sample 16-NC-SD01 (0 to 6 inches) at a concentration of 1.2 mg/kg, was above a NOAA Effects Range Criteria (ER-L). Metal concentrations were within an order of magnitude or less of base upgradient levels.

4.4.5 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) samples were collected during the soil, groundwater, surface water and sediment investigations. These samples included trip blanks, field blanks, equipment rinsate blanks, and duplicate samples. Analytical results of the field duplicates are provided in Appendix J and other field QA/QC (e.g. rinsate blanks, trip blanks, etc.) results are provided in Appendix K.

Organics detected in QA/QC samples include acetone, methylene chloride, chloroform, 2-butanone, bis(2-ethylhexyl)phthalate, chloromethane, 1,2-dichloroethane, bromodichloromethane, and dibromochloromethane. Acetone was detected in 7 of 9 samples at concentrations ranging from 5J µg/L to 14 µg/L. Methylene chloride was detected in 8 of 9 QA/QC samples with concentrations ranging from 2J µg/L to 10J µg/L. Eight of 23 TAL metals were detected in QA/QC samples.

A field blank (274-FB01) collected from the potable water source (fire hydrant at Camp Johnson) used for decontamination of heavy equipment exhibited levels of chloromethane (5J µg/L), methylene chloride (8J µg/L), acetone (12 µg/L), 1,2-dichloroethene (2J µg/L) and 2-butanone (6J µg/L). This field blank also contained levels of inorganics.

4.5 Extent of Contamination

4.5.1 Soils

4.5.1.1 Surface Soil

Figure 4-1 presents the positive detections of volatiles, semivolatiles, pesticides and PCBs in surface soil at Site 16.

Toluene, acetone, and methylene chloride were the only volatiles detected in the surface soil. Methylene chloride concentrations and one acetone concentration were detected at levels less than 10 times the maximum concentrations detected in QA/QC blanks, classifying them as laboratory contaminants. The acetone concentrations above QA/QC blanks were exhibited in monitoring well borings 16-MW04 and 16-MW06. Monitoring well boring 16-MW04 exhibited the highest concentration of acetone. This location is outside the boundaries of the burn dump as identified from aerial photographs. The source of the acetone at this location is unknown. Toluene was detected at three locations, all within the boundary of the burn dump, at low levels. Toluene was not detected in QA/QC blanks. No specific source for the toluene has been identified at the site. The toluene detected in the surface soil may be associated with historical records indicating the disposal of waste oils at the site.

PAH constituents were the most widely detected semivolatiles in surface soil. No PAHs were detected in QA/QC blanks. The PAHs were detected within the boundaries of the burn dump and may be attributed to the past burning operations. Phthalate esters were also detected in the surface soil. Bis(2-ethylhexyl)phthalate was the only phthalate detected in QA/QC blanks. Maximum phthalate concentrations were detected in the western area of the burn dump and in the surface drainage area southeast of the site. The concentrations and distribution of the phthalates indicates that they may result from former activities at the burn dump. Bis(2-ethylhexyl)phthalate was also detected in background boring 16-BB-SB01, northwest of the site.

Pesticides were detected throughout the burn dump as well as off site locations. Highest concentrations were detected within the existing open area of the burn dump. Concentrations are similar to base wide concentrations from the historical use of pesticides at Camp Lejeune (Water and Air Research, 1983). Aroclor 1254 was detected within the boundary of the burn dump and the surface drainage area. Historical records do not indicate the disposal of PCBs at the site; however, oils disposed of at the site may have contained PCBs which would account for the presence of these compounds.

Inorganics were detected in all areas of the site. Figure 4-2 presents the concentrations of inorganics above base background levels detected in the surface soil at Site 16. Concentrations detected above base background levels were widespread, in site and background boring locations. The locations with the highest number of detected inorganics above base background were in the northern portion of the site, and north/northwest and west of the burn dump. The high concentration of lead observed at location 16-BD-SB05 is localized, as the confirmatory samples collected at 10-foot centers from this location did not exhibit high concentrations of lead.

4.5.1.2 Subsurface Soil

Figure 4-3 presents the positive detections of volatiles, semivolatiles, pesticides and PCBs in subsurface soil at Site 16.

Acetone and bromomethane were the only volatiles detected in the subsurface soil. Acetone was detected in 12 of 32 samples, with the highest concentrations exhibited in the central and southern portions of the site. Acetone was detected more frequently in the subsurface soil than the surface soil, indicating its occurrence may be related to past activities at the site. Bromomethane was detected at a concentration of 1J µg/kg at location 16-BD-06 (13 to 15 feet). It was not detected in the QA/QC blanks. No specific source for the bromomethane has been identified.

Maximum PAH concentrations were detected at location 16-BD-SB10 at a depth of 5 to 7 feet. This was an area where treated poles were found during test pit excavations. No semivolatiles were detected in the surface soil at this location. Phthalate esters were detected at concentrations frequently similar to those detected in the surface soil. The phthalates were detected in the northern and southern portions of the site. 1,4-Dichlorobenzene and 1,2,4-trichlorobenzene were detected at locations 16-MW02 and 16-BD-SB12 east of the site. No historical records indicate a source for these chlorinated solvents; however, their occurrence may be attributed to former activities at the site.

Pesticides were primarily detected in the eastern area of the site within the surface drainage area. Concentrations of pesticides in the subsurface soil were less than an order of magnitude different than concentrations detected in the surface soil. The occurrence of pesticides may be attributed to the documented historical usage of pesticides at Camp Lejeune (Water and Air Research, 1983). Aroclor 1254 was detected in two locations within the surface drainage area at concentrations one to two orders of magnitude less than those in the surface soil. As with the surface soil, the detected concentrations of PCBs may be attributed to the disposal of waste oils at the site, which may have contained PCBs.

The only inorganics detected in the subsurface soil above base background levels were barium, lead and manganese in sample 16-SDA-SB03 (3 to 5 feet), and zinc in samples 16-BD-SB05 (13 to

15 feet), 16-SDA-SB01 (3 to 5 feet) and 16-SDA-SB03 (3 to 5 feet). Figure 4-4 presents the detected inorganics above base background levels in subsurface soil at Site 16.

4.5.2 Groundwater

4.5.2.1 Round One

Figure 4-5 presents the positive detections of organics in the shallow groundwater at Site 16 for Round One.

Benzene was the only volatile detected in the shallow groundwater above State and/or Federal standards. Benzene was detected in well 16-MW05. Benzene was not detected in either surface or subsurface soils. Monitoring well 16-MW05 is located in the area where treated poles were found. This may be a localized source, due to the use of fuels as a carrier for wood treating chemicals during the treatment process.

No semivolatiles, pesticides or PCBs were detected in the shallow groundwater for Round One above State and/or Federal standards.

Iron was the only TAL total metal detected above Federal and/or State standards, refer to Figure 4-6. It was detected in well 16-MW03 near Northeast Creek. As previously stated, iron is a common naturally occurring inorganic in groundwater at MCB, Camp Lejeune. Total metal concentrations were similar (same order of magnitude) to dissolved metal concentrations, supporting the conclusion that suspended solids in samples contribute to total metal concentrations, thus biasing results.

4.5.2.2 Round Two

No organics were detected above State and/or Federal standards during Round Two sampling at Site 16.

Iron was the only TAL total metal detected above State and/or Federal standards (refer to Figure 4-7). It was detected in well 16-MW03, as during the first sampling round but at a lesser concentration. As stated for Round One, this elevated iron concentration could be naturally occurring in groundwater.

4.5.3 Surface Water

1,1,2,2-Tetrachloroethane was detected above Federal AWQC criteria in Northeast Creek (refer to Figure 4-8). Due to the distance the sample location is away from the site (one-quarter mile downstream), it is likely that the site is not the source of the contamination. In addition, this contaminant was not detected in on-site soil or groundwater.

Arsenic was the only metal detected in surface water at Site 16 above State and/or Federal standards (refer to Figure 4-9). Due to the upgradient surface water location being non-detect for arsenic, the site may be the source of arsenic detected in Northeast Creek. Arsenic was detected in the surface soil one order of magnitude greater than base surface soil background levels. A specific source for the arsenic in the surface soil is unknown; however, arsenic is a component of some pesticides and the historic usage of pesticides at the base may contribute to the elevated levels detected in the surface soil. Runoff from the open area of the burn dump at Site 16 could then transport the arsenic to Northeast Creek.

4.5.4 Sediment

No organics were detected above NOAA Effects Range Criteria in Northeast Creek.

Silver was the only metal detected above NOAA criteria in Northeast Creek (refer to Figure 4-10). Location 16-NC-SD01, located one-quarter mile upgradient of the site, exhibited the silver concentration above standards. It would not appear that the site is the source of the detected silver concentration in Northeast Creek.

4.6 Summary

PAH constituents were the most frequently detected semivolatiles and exhibited the greatest concentrations in soil. These constituents are most likely associated with past burning operations that were conducted at the site. PAH constituents detected in the site surface and subsurface soils were not detected in background/control samples from the three background soil boring locations at Site 16. The presence of these constituents may be attributed to past site activities due to the absence of these constituents in the background/control samples, and to the treated poles and roofing shingles encountered in the trenches in the area of borings 16-BD-SB10 and 16-BD-SB08. Pesticides were detected in surface and subsurface soils at low levels over most of the site. These concentrations are due to the historical usage of pesticides at the Base. PCBs were detected in isolated locations at Site 16. These contaminants may be related to site activities, due to the reported disposal of oils and lubricants at the site. Benzene was the only organic detected in the shallow groundwater at the site in Round One in one well. Benzene was not detected during the second sampling round. Few organics were detected in the surface water and sediment samples. Those detected in the surface water above Federal and/or State standards were detected downstream from the site.

Inorganics were detected in all media at Site 16. Metal concentrations were greater in site surface soil than in base background surface soil. No specific source has been identified for the elevated metal concentrations in the surface soil; however, it may be the result of the variety of materials burned at the site. Iron was detected in shallow groundwater above State and Federal standards. Iron has been shown to be a naturally occurring metal in shallow groundwater at MCB, Camp Lejeune. Concentrations of iron in shallow groundwater at Site 16 were two to three orders of magnitude less than at other sites at MCB, Camp Lejeune (refer to Appendix G).

4.7 References

Baker. 1994. Baker Environmental, Inc. Remedial Investigation/Feasibility Study Project Plans, Operable Unit No. 8 (Site 16), Operable Unit No. 11 (Sites 7 and 80), and Operable Unit No. 12 (Site 3), MCB Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia. September 1994.

Greenhorne & O'Mara, Inc. 1992. Preliminary Draft Report Wellhead Monitoring Study Engineering Study 92-34. Prepared for the Department of the Navy Civil Branch. December 1992.

Pagenkopt, Gordon K. 1978. Introduction to Natural Water Chemistry. Marcel Dekker, Inc.

USEPA. 1988. United States Environmental Protection Agency. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-89/004.

USEPA. 1989(a). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-002. December 1989.

USEPA. 1989(b). United States Environmental Protection Agency. Exposure Factors Handbook. Office of Health and Environmental Assessment. Washington, D.C. EPA/600/8-89-043. May 1989.

USEPA. 1991. United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.

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

SECTION 4.0 TABLES

TABLE 4-1

SUMMARY OF SITE BACKGROUND AND BASE BACKGROUND INORGANIC LEVELS IN SURFACE SOIL
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO - 0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	1,710 - 3,630	17.7 - 9,570
Antimony	ND	0.33 - 8
Arsenic	ND	0.065 - 3.9
Barium	4.1 - 7.4	0.65 - 20.8
Beryllium	ND - 0.23	0.02 - 0.26
Cadmium	ND - 1	0.04 - 0.6
Calcium	96.8 - 227	4.25 - 10,700
Chromium	ND - 3.3	0.33 - 12.5
Cobalt	ND	0.185 - 2.355
Copper	ND	0.5 - 87.2
Iron	1,260 - 2,150	69.7 - 9,640
Lead	5.2 - 10.2	0.47 - 142
Magnesium	42.9 - 99.1	2.55 - 610
Manganese	5.5 - 7.4	0.87 - 66
Mercury	ND	0.01 - 0.08
Nickel	ND	0.6 - 3.55
Potassium	ND	1 - 416
Selenium	ND	0.075 - 1.3
Silver	ND	0.0435 - 4.3
Sodium	25.2 - 35.9	4.7 - 126
Vanadium	3.1 - 5.4	0.305 - 18.2
Zinc	ND - 22.1	0.3 - 28.3

ND = Not Detected

TABLE 4-2

SUMMARY OF SITE BACKGROUND AND BASE BACKGROUND INORGANIC LEVELS IN SUBSURFACE SOIL
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO - 0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	888 - 2,330	16.9 - 11,000
Antimony	ND	0.355 - 6.9
Arsenic	ND	0.033 - 15.4
Barium	ND - 3.8	0.65 - 22.6
Beryllium	ND	0.01 - 0.31
Cadmium	ND	0.155 - 1.2
Calcium	74.2 - 290	4.75 - 4,410
Chromium	2.4 - 4.7	0.65 - 66.4
Cobalt	ND	0.175 - 7
Copper	ND	0.47 - 9.5
Iron	1,150 - 1,870	63.3 - 90,500
Lead	2.4 - 3.8	0.465 - 21.4
Magnesium	35.7 - 115	2.85 - 852
Manganese	2.4 - 5	0.395 - 19.9
Mercury	ND	0.01 - 0.68
Nickel	ND	0.45 - 4.7
Potassium	ND - 228	1.05 - 1,250
Selenium	ND	0.085 - 2.4
Silver	ND	0.175 - 1
Sodium	ND - 29.8	5.4 - 141
Vanadium	3.9 - 4.9	0.34 - 69.4
Zinc	ND - 15	0.32 - 26.6

ND = Not Detected

TABLE 4-3

SUMMARY OF BASE-WIDE UPSTREAM BACKGROUND LEVELS OF INORGANICS IN SURFACE WATER
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Total Metals	Average (µg/L)	Minimum Positive Detect (µg/L)	Maximum Positive Detect (µg/L)
Aluminum	803.4	178	1350
Antimony	NA	ND	ND
Arsenic	NA	ND	ND
Barium	17.9	13.4	27.2
Beryllium	NA	ND	ND
Cadmium	1.5	3	3
Calcium	13,383.7	600	41,600
Chromium	NA	ND	ND
Cobalt	3.7	8	8
Copper	12.7	4	129
Cyanide	NA	ND	ND
Iron	900.6	413	1,460
Lead	2.6	1.17	10.4
Magnesium	1,138	588	2,410
Manganese	13.4	6.2	40
Mercury	0.1	0.52	0.52
Nickel	105.1	1,380	1,380
Potassium	776.8	341	2,210
Selenium	NA	ND	ND
Silver	NA	ND	ND
Sodium	7,835.7	3,930	22,100
Thallium	NA	ND	ND
Vanadium	4.4	1.9	10
Zinc	18	18	111

NA - Not Applicable
ND - Not Detected

TABLE 4-4

SUMMARY OF BASE-WIDE UPSTREAM BACKGROUND LEVELS OF INORGANICS IN SEDIMENT
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Total Metals	Average (mg/kg)	Minimum Positive Detect (mg/kg)	Maximum Positive Detect (mg/kg)
Aluminum	4,800.8	351	9,090
Antimony	NA	ND	ND
Arsenic	0.6	0.702	1.6
Barium	15.5	5.2	37.1
Beryllium	0.2	0.13	0.86
Cadmium	0.4	0.54	1.3
Calcium	2,626.4	216	22,200
Chromium	4.7	2.42	10
Cobalt	1	0.6	1.3
Copper	2,424.1	0.43	53,200
Iron	2,268.6	262	6,940
Lead	22.5	1	314
Magnesium	200.5	21.5	852
Manganese	6.4	1.96	23
Mercury	NA	ND	ND
Nickel	2.4	2.8	5.97
Potassium	157.2	81.1	457
Selenium	0.9	0.862	2.9
Silver	0.7	7.3	7.3
Sodium	130.6	73.6	491
Thallium	0.4	0.29	0.31
Vanadium	6.3	3.3	15.7
Zinc	49.2	12	926

NA - Not Applicable
ND - Not Detected

TABLE 4-5

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Surface Soil	Volatile Organic Compounds	Methylene chloride	NE	NE	6J	15J	16-MW05-00	3/29	NA	NA	
		Acetone	NE	NE	11J	1200	16-MW04-00	3/29	NA	NA	
		Toluene	NE	NE	1J	4J	16-BD-SB14-00	3/29	NA	NA	Central
	Semivolatile Organic Compounds	Phenol	NE	NE	70J	70J	16-BD-SB09-00	1/29	NA	NA	Western
		1,4 Dichlorobenzene	NE	NE	43J	43J	16-BD-SB13-00	1/29	NA	NA	Surface Drainage Area
		Naphthalene	NE	NE	36J	36J	16-MW06-00	1/29	NA	NA	Southern
		2-Methylnaphthalene	NE	NE	67J	67J	16-MW06-00	1/29	NA	NA	Southern
		Phenanthrene	NE	NE	52J	99J	16-MW06-00	3/29	NA	NA	Western/Southwestern
		Anthracene	NE	NE	100NJ	100NJ	16-MW06-00	1/29	NA	NA	Southern
		Fluoranthene	NE	NE	46J	46J	16-BD-SB13-00	1/29	NA	NA	Surface Drainage Area
		Pyrene	NE	NE	39J	110J	16-BD-SB13-00	3/29	NA	NA	Scattered
		Butyl Benzyl phthalate	NE	NE	64J	64J	16-BD-SB16-00	1/29	NA	NA	Southern
		Benzo(a)anthracene	NE	NE	43J	43J	16-BD-SB09-00	1/29	NA	NA	Western
		Chrysene	NE	NE	43J	70J	16-MW06-00	4/29	NA	NA	Southern
		bis(2-Ethylhexyl)phthalate	NE	NE	37J	490	16-BD-SB16-00	6/29	NA	NA	Scattered
		Benzo (b)fluoranthene	NE	NE	54J	88J	16-BD-SB13-00	2/29	NA	NA	Scattered
		Benzo (k) fluoranthene	NE	NE	84J	84J	16-BD-SB13-00	1/29	NA	NA	Surface Drainage Area
		Benzo (a) pyrene	NE	NE	42J	130J	16-BD-SB16-00	2/29	NA	NA	Scattered
		Indeno (1,2,3-cd) pyrene	NE	NE	52J	52J	16-BD-SB16-00	1/29	NA	NA	Southern
		Benzo (g,h,i) perylene	NE	NE	92J	92J	16-BD-SB16-00	1/29	NA	NA	Southern

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
Surface Soil (Cont.)	Pesticides/ PCBs				(µg/kg)	(µg/kg)					
		delta-BHC	NE	NE	4.7	4.7	16-BD-SB13-00	1/29	NA	NA	Surface Drainage Area
		Aldrin	NE	NE	3.4J	3.4J	16-BD-SB09-00	1/29	NA	NA	Western
		Dieldrin	NE	NE	5.6	77J	16-BD-SB09-00	10/29	NA	NA	Scattered
		4,4'-DDE	NE	NE	5	440	16-BD-SB05-00	26/29	NA	NA	Scattered
		Endrin	NE	NE	6.5	14J	16-BD-SB16-00	3/29	NA	NA	Southwestern
		Endosulfan II	NE	NE	1.9J	26J	16-BD-SB13-00	8/29	NA	NA	Scattered
		4,4'-DDD	NE	NE	2.6J	120	16-BD-SB05-00	20/29	NA	NA	Widespread
		Endosulfan Sulfate	NE	NE	4.8J	4.8J	16-SDA-SB03-00	1/29	NA	NA	Northern
		4,4'-DDT	NE	NE	3.8	540J	16-BD-SB05-00	24/29	NA	NA	Widespread
		Methoxychlor	NE	NE	4.6J	4.6J	16-SDA-SB04-00	1/29	NA	NA	Western
		Endrin ketone	NE	NE	4.2	9.9	16-BD-SB09-00	2/29	NA	NA	Western
		Endrin aldehyde	NE	NE	4.6	29	16-BD-SB16-00	9/29	NA	NA	Scattered
		alpha-Chlordane	NE	NE	3.1J	120	16-BD-SB13-00	11/29	NA	NA	Scattered
		gamma-Chlordane	NE	NE	1.6J	72J	16-BD-SB13-00	9/29	NA	NA	Scattered
		Aroclor-1254	NE	NE	41	2,100	16-BD-SB13-00	13/29	NA	NA	Scattered
		Aroclor-1260	NE	NE	50J	210J	16-BD0SB05-00	2/29	NA	NA	Scattered

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
Surface Soil (Cont.)				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NA	17.7 - 9,570	866J	18,500J	16-BD-SB05-00	33/33	NA	10	North/northwest
		Arsenic	NA	0.065 - 3.9	2.3	24.7J	16-BD-SB01-00	21/33	NA	11	Scattered
		Barium	NA	0.65 - 20.8	3	334	16-BD-SB05-00	33/33	NA	9	Scattered
		Beryllium	NA	0.02 - 0.26	0.24	0.49	16-BD-SB09-00	6/33	NA	2	Western
		Cadmium	NA	0.04 - 0.6	1.8	9.6	16-BD-SB05-00	2/33	NA	2	Scattered
		Calcium	NA	4.25 - 10,700	66.4J	112,000J	16-BD-SB16-00	29/33	NA	6	Scattered
		Chromium	NA	0.33 - 12.5	2.2	43.2J	16-BD-SB05-00	31/33	NA	3	Scattered
		Cobalt	NA	0.185 - 2.355	6.3	6.3	16-BD-SB05-00	1/33	NA	1	Northwest
		Copper	NA	0.5 - 87.2	2.2J	543J	16-BD-SB05-00	28/33	NA	2	Scattered
		Iron	NA	69.7 - 9,640	470	69,700	16-BD-SB05-00	28/33	NA	3	Scattered
		Lead	NA	0.47 - 142	3.8J	5,210J	16-BD-SB05-00	32/33	NA	2	Central to Northwest
		Magnesium	NA	2.55 - 610	32.5	2,520	16-BD-SB05-00	27/33	NA	1	Northwest
		Manganese	NA	0.87 - 66	2.8J	1,030J	16-BD-SB05-00	29/33	NA	1	Scattered
		Mercury	NA	0.01 - 0.08	0.11J	14	16-SDA-SB01-00	9/33	NA	9	Scattered
		Nickel	NA	0.6 - 3.55	24.4	24.4	16-BD-SB05-00	1/33	NA	1	Northwest
		Potassium	NA	1 - 416	113	475	16-BD-SB08-00	14/33	NA	1	Central
		Selenium	NA	0.075 - 1.3	1.1	6	16-BD-SB05-00	8/33	NA	5	Scattered
		Silver	NA	0.0435 - 4.3	1.2	3.1	16-BD-SB05-00	2/33	NA	0	--
		Sodium	NA	4.7 - 126	26.8	63.4	16-MW02-00	15/33	NA	0	--
		Thallium	NA	--	2.1	3.6	16-BD-SB05-00	2/33	NA	--	--
		Vanadium	NA	0.305 - 18.2	2.3J	45.4	16-BD-SB05-00	31/33	NA	2	Scattered
		Zinc	NA	0.3 - 28.3	14.2J	4,350J	16-BD-SB05-00	21/33	NA	13	Scattered

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Sub-surface Soils	Volatile Organic Compounds	Bromomethane	NE	NE	1J	1J	16-BD-SB06-07	1/32	NA	NA	Northern
		Acetone	NE	NE	42J	900J	16-BD-SB14-05	12/32	NA	NA	8 exceed 10x maximum blank concentrtion
	Semivolatile Organic Compounds	1,4-Dichlorobenzene	NE	NE	50J	67J	16-BD-SB12-02	2/32	NA	NA	Northeast
		1,2,4-Trichlorobenzene	NE	NE	45J	66J	16-BD-SB12-02	2/32	NA	NA	Northeast
		Naphthalene	NE	NE	88J	88J	16-BD-SB10-03	1/32	NA	NA	Central
		2-Methyl-naphthalene	NE	NE	77J	77J	16-BD-SB10-03	1/32	NA	NA	Central
		Acenaphthene	NE	NE	51J	290J	16-BD-SB10-03	3/32	NA	NA	Central to Northeast
		Dibenzofuran	NE	NE	310J	310J	16-BD-SB10-03	1/32	NA	NA	Central
		Fluorene	NE	NE	680	680	16-BD-SB10-03	1/32	NA	NA	Central
		Pentachlorophenol	NE	NE	38NJ	94J	16-BD-SB02-07	3/32	NA	NA	Northwest and Northeast
		Phenanthrene	NE	NE	2,200	2,200	16-BD-SB10-03	1/32	NA	NA	Central
		Anthracene	NE	NE	380	380	16-BD-SB10-03	1/32	NA	NA	Central
		Carbazole	NE	NE	180J	180J	16-BD-SB10-03	1/32	NA	NA	Central
		di-n-butyl-phthalate	NE	NE	270J	270J	16-BD-SB10-03	1/32	NA	NA	Central
		Fluoranthene	NE	NE	1,200	1,200	16-BD-SB10-03	1/32	NA	NA	Central
		Pyrene	NE	NE	670J	670J	16-BD-SB10-03	1/32	NA	NA	Central
		Benzo(a)anthracene	NE	NE	160J	160J	16-BD-SB10-03	1/32	NA	NA	Central
		Chrysene	NE	NE	160J	160J	16-BD-SB10-03	1/32	NA	NA	Central
		bis(2-Ethylhexyl)phthalate	NE	NE	58J	71J	16-MW05-08	2/32	NA	NA	Central to Southwest
		di-n-octyl-phthalate	NE	NE	46J	46J	16-MW06-06	1/32	NA	NA	Central
		Bebzi(b)fluoranthene	NE	NE	57J	57J	16-BD-SB10-03	1/32	NA	NA	Central

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
Sub-surface Soils (Cont.)	Semivolatile Organic Compounds (Cont.)				(µg/kg)	(µg/kg)					
		Benzo(k)fluoranthene	NE	NE	58J	58J	16-BD-SB10-03	1/32	NA	NA	Central
		Benzo(a)pyrene	NE	NE	38J	38J	16-BD-SB10-03	1/32	NA	NA	Central
	Pesticides/ PCBs	4,4'-DDE	NE	NE	7.6	36	16-BD-SB05-07	3/32	NA	NA	Northwest
		Endosulfan II	NE	NE	7.1J	7.1J	16-SDA-SB03-02	1/32	NA	NA	Surface Drainage Area
		4,4-DDD	NE	NE	52J	52J	16-BD-SB05-07	1/32	NA	NA	Northwest
		4,4'-DDT	NE	NE	37J	630	16-BD-SB05-07	2/32	NA	NA	Northwest and Surface Drainage Area
		alpha-chlordane	NE	NE	3.8	3.8	16-BD-SB13-02	1/32	NA	NA	Surface Drainage Area
		gamma-chlordane	NE	NE	2.4J	2.5J	16-BD-SB13-02	2/32	NA	NA	Surface Drainage Area
		Aroclor-1254	NE	NE	40	45	16-BD-SB13-02	2/32	NA	NA	Northwest and Surface Drainage Area

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
Sub-surface Soils (Cont.)				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	16.9 - 11,000	315J	7,650J	16-SDA-SB03-02	31/32	NA	0[1]	--
		Arsenic	NE	0.033 - 15.4	2.5J	2.5J	16-BD-SB10-03	1/32	NA	0	--
		Barium	NE	0.65 - 22.6	1.2	36.5	16-SDA-SB03-02	25/32	NA	1	Surface Drainage Area
		Beryllium	NE	0.01 - 0.31	0.21	0.21	16-BD-SB20-06	1/32	NA	0	--
		Calcium	NE	4.75 - 4,410	31.7	1,400	16-BD-SB13-02	24/32	NA	0	--
		Chromium	NE	0.65 - 66.4	2.4	7.9	16-BD-SB19-03	24/32	NA	0	--
		Copper	NE	0.47 - 9.5	2.3J	3.4J	16-SDA-SB03-02	5/32	NA	0	--
		Iron	NE	63.3 - 90,500	268	7,830	16-SDA-SB03-02	25/32	NA	0	--
		Lead	NE	0.465 - 21.4	1.1J	68J	16-SDA-SB03-02	26/32	NA	1	Surface Drainage Area
		Magnesium	NE	2.85 - 852	13.7	237	16-MW06-06	25/32	NA	0	--
		Manganese	NE	0.395 - 19.9	0.63J	38.1J	16-SDA-SB03-02	25/32	NA	1	Surface Drainage Area
		Mercury	NE	0.01 - 0.68	0.1J	0.28	16-MW05-08	3/32	NA	0	--
		Potassium	NE	1.05 - 1,250	194	370	16-BD-SB19-03	9/32	NA	0	--
		Selenium	NE	0.085 - 2.4	1.2	1.2	16-MW01-01	1/32	NA	0	--
		Sodium	NE	5.4 - 141	22.7	34.7	16-BD-SB20-06	9/32	NA	0	--
		Vanadium	NE	0.34 - 69.4	2.4	14.1	16-BD-SB19-03	16/32	NA	0	--
		Zinc	NE	0.32 - 26.6	4.9J	399J	16-SDA-SB01-02	11/32	NA	3	Northwest and Surface Drainage Area

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Ground-water Round 1	Volatile Organic Compounds	Benzene	5.0	1.0	37	37	16-MW05-01	1/6	1	1	Central
		Ethylbenzene	700	29	1J	1J	16-MW05-01	1/6	0	0	--
		Phenol	NE	300	1J	4J	16-MW05-01	3/6	0	0	Central/Southeast
		Naphthalene	NE	21	6J	6J	16-MW05-01	1/6	0	0	Central
		bis(2-Ethylhexyl)phthalate	6.0	3.0	1J	5J	16-MW03-01	4/6	0	1	East/Southeast of Burn Dump
	Inorganics	Barium	2,000	2,000	24.4J	77.9	16-MW03-01	6/6	0	0	--
		Calcium	NE	NE	370	13,400	16-MW03-01	6/6	NA	NA	--
		Iron	300$^{(2)}$	300	712	712	16-MW03-01	1/6	1	1	East/Southeast of Burn Dump
		Lead	15$^{(3)}$	15	3.2J	3.2J	16-MW04-01	1/6	0	0	--
		Magnesium	NE	NE	1,020	5,090	16-MW03-01	6/6	NA	NA	--
		Manganese	50$^{(2)}$	50	9.8J	31.6J	16-MW05-01	4/6	0	0	--
		Sodium	NE	NE	2,480	16,400	16-MW04-01	6/6	NA	NA	--
		Zinc	5,000$^{(2)}$	2,100	80.5	80.5	16-MW02-01	1/6	0	0	--
Ground-water Round 2	Semi-Volatiles	Naphthalene	NE	21	4J	5J	16-MW01-02 16-MW02-02 16-MW03-02	6/6	NA	0	Widespread
		bis(2-ethylhexyl)phthalate	6.0	3.0	1J	5J	16-MW04-02	3/6	0	1	Scattered
	Inorganics	Aluminum	NE	NE	274	300	16-MW02-02	2/6	NA	NA	Scattered
		Barium	2,000	2,000	25J	54.1J	16-MW05-02	6/6	0	0	Widespread
		Calcium	NE	NE	728	6,540	16-MW03-02	5/6	NA	NA	Widespread
		Iron	300$^{(2)}$	300	410	410	16-MW03-02	1/6	1	1	East/Southeast of Burn Dump
		Magnesium	NE	NE	1,380	3,130	16-MW03-02	6/6	NA	NA	Widespread
		Manganese	50$^{(2)}$	50	11.4J	24.6J	16-MW-05-02	2/6	0	0	Scattered
		Potassium	NE	NE	1,270	1,290	16-MW06-02	3/6	NA	NA	Scattered
		Sodium	NE	NE	2,240	14,500	16-MW04-02	6/6	NA	NA	Widespread

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
			AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
Surface Water	Volatile Organic Compounds	4-Methyl-2-pentanone	NE	NE	7J	7J	16-NC-SW05	1/5	NA	NA	--
		1,1,2,2-Tetrachloroethane	0.17	10.8	2J	2J	16-NC-SW05	1/5	1	0	
	Semivolatile Organic Compounds	bis(2-Ethylhexyl)phthalate	1.8	NE	10J	10J	16-NC-SW05	1/5	1	NA	
	Inorganics	Aluminum	NE	NE	4,210J	12,300J	16-NC-SW05	5/5	NA	NA	--
		Arsenic	0.018	NE	2.2J	3.1J	16-NC-SW03	4/5	4	NA	--
		Barium	2,000	NE	22.9	30.4	16-NC-SW05	5/5	0	NA	--
		Calcium	NE	NE	154,000J	173,000J	16-NC-SW04	5/5	NA	NA	--
		Chromium	NE	NE	15.6	15.6	16-NC-SW05	1/5	NA	NA	--
		Iron	300	NE	2,780J	6,650J	16-NC-SW05	5/5	0	NA	--
		Lead	NE	NE	5.5J	13.7	16-NC-SW05	5/5	NA	NA	--
		Magnesium	NE	NE	542,000	615,000	16-NC-SW04	5/5	NA	NA	--
		Manganese	4	NE	17.2	24.4	16-NC-SW05	5/5	0	NA	--
		Potassium	NE	NE	169,000	188,000	16-NC-SW04	5/5	NA	NA	--
		Silver	NE	NE	6.4	8.9	16-NC-SW01	5/5	NA	NA	--
		Sodium	NE	NE	4,240,000J	4,740,000J	16-NC-SW04	5/5	NA	NA	--
		Vanadium	NE	NE	19.6	19.6	16-NC-SW05	1/5	NA	NA	--

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination					
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	No. of Detections Above Comparison Criteria	No. of Dectections Above Comparison Criteria	Distribution
			NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
Sediments	Volatile Organic Compounds	Carbon Disulfide	NE	NE	2J	2J	16-NC-SD03-06	1/10	NA	NA	--
		Toluene	NE	NE	1J	2J	16-NC-SD02-06	2/10	NA	NA	--
			(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
	Inorganics	Aluminum	NE	NE	1,380J	7,460J	16-NC-SD05-612	10/10	NA	NA	--
		Arsenic	8.2	70	0.8J	4.7J	16-NC-SD05-612	8/10	0	0	--
		Barium	NE	NE	1.9	10.8	16-NC-SD02-612	10/10	NA	NA	--
		Beryllium	NE	NE	0.27	0.33	16-NC-SD05-612	4/10	NA	NA	--
		Calcium	NE	NE	87.4	1,220	16-NC-SD01-06	10/10	NA	NA	--
		Chromium	81	370	3.9	21.2	16-NC-SD05-612	10/10	0	0	--
		Cobalt	NE	NE	2.4	3.1	16-NC-SD05-612	3/10	NA	NA	--
		Iron	NE	NE	336J	9,960J	16-NC-SD05-612	10/10	NA	NA	--
		Lead	46.7	218	2.3J	6J	16-NC-SD01-612	10/10	0	0	--
		Magnesium	NE	NE	504	618	16-NC-SD05-612	3/10	NA	NA	--
		Manganese	NE	NE	1.7	10.5	16-NC-SD05-612	10/10	NA	NA	--
		Silver	1	3.7	1.2	1.2	16-NC-SD01-06	1/10	[illegible]	0	--
		Sodium	NE	NE	170	1,320	16-NC-SD02-06	10/10	NA	NA	--
		Vanadium	NE	NE	3.6	29.9	16-NC-SD01-06	10/10	NA	NA	--
		Zinc	150	410	1.9J	46.4J	16-NC-SD04-06	10/10	0	0	--

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

(1) Detections compared to maximum base background concentration
(2) SMCL = Secondary Maximum Contaminant Level
(3) Action Level
(4) Shaded Boxes indicated detections above comparison criteria

NE = No Criteria Established
NA = Not Applicable
J - estimated value
NJ - tentatively identified compound estimated value
ARAR - Applicable Relevant Appropriate Requirement
MCL - maximum contaminant level
NCWQS - North Carolina Water Quality Standard
AWQC - Ambient Water Quality Criteria
µg/L - microgram per liter (ppb)
µg/kg - microgram per kilogram (ppb)
mg/kg - milligram per kilogram (ppm)
NOAA ER-L - National Oceanic Atmospheric Administration Effective Range-Low
NOAA ER-M - National Oceanic Atmospheric Administration Effective Range-Median
"--" = undefined

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB01-00	16-BD-SB02-00	16-BD-SB03-00	16-BD-SB04-00	16-BD-SB05-00	16-BD-SB06-00	16-BD-SB07-00	16-BD-SB08-00
Laboratory Sample ID:		AC4115	AC4111	AC4571	AC4198	AC4186	AC4182	AC4576	AC4581
Date Sampled:		10/19/94	10/19/94	10/20/94	10/19/94	10/18/94	10/18/94	10/20/94	10/20/94
	UNITS								
VOLATILES									
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	ND	ND	ND	ND	ND	1 J
SEMIVOLATILES									
Phenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	39 J	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	42 J	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB01-00	16-BD-SB02-00	16-BD-SB03-00	16-BD-SB04-00	16-BD-SB05-00	16-BD-SB06-00	16-BD-SB07-00	16-BD-SB08-00
Laboratory Sample ID:		AC4115	AC4111	AC4571	AC4198	AC4186	AC4182	AC4576	AC4581
Date Sampled:		10/19/94	10/19/94	10/20/94	10/19/94	10/18/94	10/18/94	10/20/94	10/20/94
PESTICIDES/PCBs									
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	7.3	ND	ND	ND	ND
4,4'-DDE	UG/KG	59	69 J	5	21	440	35 J	120	56
Endrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	6.4	ND	ND	ND	ND	9.3 J	ND	ND
4,4'-DDD	UG/KG	55 J	5.6 J	ND	5.3	120	ND	21 J	11 J
Endosulfan sulfate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	140 J	88 J	3.8	38	540 J	ND	160 J	49 J
Methoxychlor	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	ND	4.2	ND	ND	ND	ND
Endrin aldehyde	UG/KG	9.2 J	ND	ND	ND	ND	13	ND	ND
alpha-Chlordane	UG/KG	8.7	ND	ND	ND	ND	25 J	ND	3.5
gamma-Chlordane	UG/KG	ND	ND	ND	ND	6.1	3.7 J	ND	1.6 J
Aroclor 1254	UG/KG	460 J	ND	ND	ND	ND	1200	ND	130
Aroclor 1260	UG/KG	ND	ND	ND	ND	210 J	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB09-00	16-BD-SB10-00	16-BD-SB11-00	16-BD-SB12-00	16-BD-SB13-00	16-BD-SB14-00	16-BD-SB15-00	16-BD-SB16-00
Laboratory Sample ID:		AC4144	AC4172	AC4136	AC4586	AC4592	AC4121	AC4194	AC4126
Date Sampled:		10/18/94	10/18/94	10/18/94	10/20/94	10/20/94	10/19/94	10/19/94	10/18/94
	UNITS								
VOLATILES									
Methylene chloride	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	11 J	ND
Toluene	UG/KG	2 J	ND	ND	ND	ND	4 J	ND	ND
SEMIVOLATILES									
Phenol	UG/KG	70 J	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND	43 J	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/KG	56 J	ND	ND	ND	ND	ND	ND	52 J
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	46 J	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	110 J	ND	ND	63 J
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	64 J
Benzo[a]anthracene	UG/KG	43 J	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	47 J	ND	ND	ND	68 J	ND	ND	43 J
bis(2-Ethylhexyl)phthalate	UG/KG	43 J	ND	ND	ND	ND	ND	ND	490
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	88 J	ND	ND	54 J
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	84 J	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	130 J
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	52 J
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	92 J

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB09-00	16-BD-SB10-00	16-BD-SB11-00	16-BD-SB12-00	16-BD-SB13-00	16-BD-SB14-00	16-BD-SB15-00	16-BD-SB16-00
Laboratory Sample ID:		AC4144	AC4172	AC4136	AC4586	AC4592	AC4121	AC4194	AC4126
Date Sampled:		10/18/94	10/18/94	10/18/94	10/20/94	10/20/94	10/19/94	10/19/94	10/18/94
<u>PESTICIDES/PCBs</u>									
delta-BHC	UG/KG	ND	ND	ND	ND	4.7	ND	ND	ND
Aldrin	UG/KG	3.4 J	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	77 J	ND	ND	ND	11 J	ND	28	22 J
4,4'-DDE	UG/KG	81	150 J	75	14	94 J	71 J	21	70
Endrin	UG/KG	6.5	ND	ND	ND	ND	7 J	ND	14 J
Endosulfan II	UG/KG	ND	ND	ND	ND	26 J	10 J	ND	15
4,4'-DDD	UG/KG	31	46 J	8.3	ND	17 J	22 J	2.6 J	19 J
Endosulfan sulfate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	130	150 J	46	5.5 J	40 J	46 J	16	140 J
Methoxychlor	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	UG/KG	9.9	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	8.5 J	ND	ND	21	19 J	ND	29
alpha-Chlordane	UG/KG	ND	9.4 J	ND	ND	120	19	ND	36
gamma-Chlordane	UG/KG	ND	3.8 J	ND	ND	72 J	6.1 J	ND	18 J
Aroclor 1254	UG/KG	190 J	380 J	ND	ND	2100	870	ND	1100
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB17-00	16-BD-SB18-00	16-BD-SB19-00	16-BD-SB20-00	16-MW02-00	16-MW04-00	16-MW05-00	16-MW06-00
Laboratory Sample ID:		AC4190	AC4608	AC4604	AC4848	AC4567	AC4102	AC4857	AC4862
Date Sampled:		10/19/94	10/20/94	10/20/94	10/20/94	10/19/94	10/19/94	10/21/94	10/21/94
	UNITS								
VOLATILES									
Methylene chloride	UG/KG	ND	ND	ND	6 J	ND	ND	15 J	8 J
Acetone	UG/KG	ND	ND	ND	ND	ND	1200	ND	200
Toluene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES									
Phenol	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	36 J
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	67 J
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	99 J
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	100 NJ
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	ND	70 J
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	44 J	ND	ND	80 J	120 J
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB17-00	16-BD-SB18-00	16-BD-SB19-00	16-BD-SB20-00	16-MW02-00	16-MW04-00	16-MW05-00	16-MW06-00
Laboratory Sample ID:		AC4190	AC4608	AC4604	AC4848	AC4567	AC4102	AC4857	AC4862
Date Sampled:		10/19/94	10/20/94	10/20/94	10/20/94	10/19/94	10/19/94	10/21/94	10/21/94
<u>PESTICIDES/PCBs</u>									
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	5.6	ND	18	ND	ND	ND	7.4 J
4,4'-DDE	UG/KG	38	230	ND	35	9.2	ND	23	46
Endrin	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND	ND	ND	3.6 J
4,4'-DDD	UG/KG	35	13	ND	ND	ND	ND	3.8	18 J
Endosulfan sulfate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	120	130 J	3.8 J	ND	8.1 J	ND	ND	37 J
Methoxychlor	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	4.6	ND	ND	ND	6.4 J
alpha-Chlordane	UG/KG	ND	ND	9.5	ND	ND	ND	ND	5.3
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	2.8 J
Aroclor 1254	UG/KG	ND	65 J	ND	41	ND	ND	ND	140
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND	ND	ND	50 J

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-SDA-SB01-00	16-SDA-SB02-00	16-SDA-SB03-00	16-SDA-SB04-00
Laboratory Sample ID:		AC4116	AC4132	AC4158	AC4162
Date Sampled:		10/18/94	10/18/94	10/18/94	10/18/94
	UNITS				
VOLATILES					
Methylene chloride	UG/KG	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	ND	ND
SEMIVOLATILES					
Phenol	UG/KG	ND	ND	ND	ND
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	37 J	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND
Indeno[1,2,3-cd]pyrene	UG/KG	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-6 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-SDA-SB01-00	16-SDA-SB02-00	16-SDA-SB03-00	16-SDA-SB04-00
Laboratory Sample ID:		AC4116	AC4132	AC4158	AC4162
Date Sampled:		10/18/94	10/18/94	10/18/94	10/18/94
PESTICIDES/PCBs					
delta-BHC	UG/KG	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	25	9.2
4,4'-DDE	UG/KG	66	21	91	10
Endrin	UG/KG	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	16 J	1.9 J
4,4'-DDD	UG/KG	18 J	3.9 J	11 J	ND
Endosulfan sulfate	UG/KG	ND	ND	4.8 J	ND
4,4'-DDT	UG/KG	79	21 J	90 J	6.8
Methoxychlor	UG/KG	ND	ND	ND	4.6 J
Endrin ketone	UG/KG	ND	ND	ND	ND
Endrin aldehyde	UG/KG	8.7	ND	ND	ND
alpha-Chlordane	UG/KG	6.4	3.1 J	ND	ND
gamma-Chlordane	UG/KG	3.4 J	ND	ND	ND
Aroclor 1254	UG/KG	260 J	110	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-BD-SB01-00	16-BD-SB02-00	16-BD-SB03-00	16-BD-SB04-00	16-BD-SB05-00	16-BD-SB06-00	16-BD-SB07-00	16-BD-SB08-00
Laboratory Sample ID:		AC4115	AC4111	AC4571	AC4198	AC4186	AC4182	AC4576	AC4581
Date Sampled:		10/19/94	10/19/94	10/20/94	10/19/94	10/18/94	10/18/94	10/20/94	10/20/94
	UNITS								
Aluminum	MG/KG	1700 J	1550 J	1170	2030 J	18500 J	5090 J	3870	6880
Arsenic	MG/KG	24.7 J	5.1 J	4.5	10.8 J	9.1 J	3.4 J	4.9	4.9
Barium	MG/KG	15.3	7.8	19.3	31.5 J	334	14.9	11.5	12.3
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	MG/KG	ND	ND	ND	ND	9.6	ND	ND	ND
Calcium	MG/KG	729 J	310 J	1300	228 J	18300 J	890 J	10700	24100
Chromium	MG/KG	3.5 J	ND	2.2	4.3 J	43.2 J	5.8 J	10.7	13.5
Cobalt	MG/KG	ND	ND	ND	ND	6.3	ND	ND	ND
Copper	MG/KG	11.2 J	5.1 J	6	5.7 J	543 J	3.5 J	6.5	5
Iron	MG/KG	4620	7120	4010	4320 J	69700	3720	4520	12500
Lead	MG/KG	15.4 J	6.7 J	28.2	8.1 J	5210 J	12.6 J	94.9	10.3
Magnesium	MG/KG	94.1	47.5	91.7	71.9 J	2520	149	ND	401
Manganese	MG/KG	4.8 J	2.8 J	8	3.1 J	1030 J	9.1 J	18.4	22.8
Mercury	MG/KG	0.12 J	ND	ND	ND	0.34 J	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	24.4	ND	ND	ND
Potassium	MG/KG	ND	ND	205	313	351	280	ND	475
Selenium	MG/KG	1.7	ND	ND	1.3	6	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	3.1	ND	ND	ND
Sodium	MG/KG	ND	ND	49.5	ND	ND	ND	43.5	49.8
Thallium	MG/KG	ND	ND	ND	ND	3.6	ND	ND	ND
Vanadium	MG/KG	9.2	4.8	3.8	8 J	45.4	8.4	8.3	22.4
Zinc	MG/KG	19.9 J	ND	29	ND	4350 J	ND	34.8	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-BD-SB09-00	16-BD-SB10-00	16-BD-SB11-00	16-BD-SB12-00	16-BD-SB13-00	16-BD-SB14-00	16-BD-SB15-00	16-BD-SB16-00
Laboratory Sample ID:		AC4144	AC4172	AC4136	AC4586	AC4592	AC4121	AC4194	AC4126
Date Sampled:		10/18/94	10/18/94	10/18/94	10/20/94	10/20/94	10/19/94	10/19/94	10/18/94
	UNITS								
Aluminum	MG/KG	1570	4760 J	3840	3640	1920	3590 J	3420 J	2810
Arsenic	MG/KG	8.2	7.2 J	ND	ND	ND	5.2 J	ND	2.3
Barium	MG/KG	36.3	28.9 J	11	7.1	53.5	32.3	7.6	42.7
Beryllium	MG/KG	0.49	0.24	ND	ND	ND	0.45	ND	ND
Cadmium	MG/KG	ND	ND	ND	ND	1.8	ND	ND	ND
Calcium	MG/KG	ND	14700 J	ND	4030	78400	43400 J	275 J	112000 J
Chromium	MG/KG	5	9.9 J	4.2	5	12.6	7.7 J	2.9 J	11.1
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	7.7	40.8 J	3.2	ND	73.5	32.7 J	2.2 J	88.8
Iron	MG/KG	ND	7900 J	ND	3250	2890	6430	ND	ND
Lead	MG/KG	9.4	200 J	8.2	6.4	69.6	77.7 J	8.8 J	33
Magnesium	MG/KG	ND	296 J	ND	132	317	341	98.3	ND
Manganese	MG/KG	ND	61.7 J	ND	6.8	22.7	65 J	10.1 J	37.6
Mercury	MG/KG	ND	0.11 J	ND	ND	2.6	0.36 J	ND	1.5
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	224	262	ND	ND	ND	ND
Selenium	MG/KG	2	1.2	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	1.2	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	34.7	62.3	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	8.7	12.5	6.1	7.4	4	8.8	4.6	4.2
Zinc	MG/KG	ND	201 J	69.5 J	ND	335	130 J	ND	193 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-BD-SB17-00	16-BD-SB18-00	16-BD-SB19-00	16-BD-SB20-00	16-MW02-00	16-MW03-00	16-MW04-00	16-MW05-00
Laboratory Sample ID:		AC4190	AC4608	AC4604	AC4848	AC4567	AC4178	AC4102	AC4857
Date Sampled:		10/19/94	10/20/94	10/20/94	10/20/94	10/19/94	10/18/94	10/19/94	10/21/94
	UNITS								
Aluminum	MG/KG	4470 J	2740	2660	2370 J	3040	4590 J	866 J	6680 J
Arsenic	MG/KG	2.6 J	ND	ND	ND	3.1	ND	ND	9.5
Barium	MG/KG	9.9	9.4	8.2	11.2	36.7	20.6	3	18.1
Beryllium	MG/KG	ND	ND	ND	0.25	ND	ND	ND	ND
Cadmium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	2130 J	7330	244	7660 J	2590	126 J	66.4 J	755 J
Chromium	MG/KG	6.1 J	2.6	2.7	3.3 J	6.4	3.6 J	ND	9.2 J
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	3.3 J	4	ND	7.1	13.3	ND	ND	19.5
Iron	MG/KG	5220	2050	3110	2280 J	2710	1970	470	12200 J
Lead	MG/KG	7.5 J	10.4	8.7	13.8 J	45.3	3.8 J	ND	60.1 J
Magnesium	MG/KG	112	112	80.6	116	180	133	32.5	281
Manganese	MG/KG	6.7 J	11.3	8.5	15.8 J	26.5	21.4 J	6.6 J	20.6 J
Mercury	MG/KG	ND	ND	ND	ND	0.25	ND	ND	0.43
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	214	ND	ND	ND	296	ND	ND	247 J
Selenium	MG/KG	ND	ND	ND	1.1	ND	ND	ND	1.4
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	26.8	45.8	40.7	63.4	ND	ND	39.5
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	10.8	5.8	5.2	4.7	8.5	2.9	ND	17.6
Zinc	MG/KG	29.2 J	17.9	ND	82.7 J	73.8	ND	ND	51.1 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-MW06-00	16-SDA-SB01-00	16-SDA-SB02-00	16-SDA-SB03-00	16-SDA-SB04-00
Laboratory Sample ID:		AC4862	AC4116	AC4132	AC4158	AC4162
Date Sampled:		10/21/94	10/18/94	10/18/94	10/18/94	10/18/94
	UNITS					
Aluminum	MG/KG	2200 J	5030	1380	5170 J	2640 J
Arsenic	MG/KG	ND	3.4	ND	3.2 J	ND
Barium	MG/KG	13.4	18	6.9	23.7	11.5 J
Beryllium	MG/KG	0.25	ND	ND	0.25	ND
Cadmium	MG/KG	ND	ND	ND	ND	ND
Calcium	MG/KG	7120 J	ND	ND	324 J	150 J
Chromium	MG/KG	4.6 J	9.4	4.5	7.1 J	2.5 J
Cobalt	MG/KG	ND	ND	ND	ND	ND
Copper	MG/KG	8.7	13.4	5.5	3.9 J	ND
Iron	MG/KG	2350 J	6650	ND	4950	1450 J
Lead	MG/KG	14 J	18	11	96.9 J	7.8 J
Magnesium	MG/KG	88.4	ND	ND	149	64.4 J
Manganese	MG/KG	13.9 J	ND	ND	16.8 J	22.5 J
Mercury	MG/KG	ND	14	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	1.8	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND
Sodium	MG/KG	31.2	ND	ND	ND	ND
Thallium	MG/KG	ND	ND	ND	ND	2.1
Vanadium	MG/KG	4.1	11.2	3.7	11.5	2.3 J
Zinc	MG/KG	27.8 J	ND	ND	36.7 J	14.2 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-7a
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8
SITE 16 - CONFIRMATIONAL SURFACE SOILS
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-PBA-SB01-00	16-PBA-SB02-00	16-PBA-SB03-00	16-PBA-SB04-00
Laboratory Sample ID:		AH3883	AH3884	AH3885	AH3886
Date Sampled:		12/13/95	12/13/95	12/13/95	12/13/95
	UNITS				
Aluminum	MG/KG	5350	4830	2290	4660
Arsenic	MG/KG	5.5	7.5	4.1	6.8
Barium	MG/KG	16.8	11.8	7.8	12.7
Calcium	MG/KG	8340	3220	555	736
Chromium	MG/KG	7.8	7.2	4.1	7.3
Copper	MG/KG	8.2	7.8	4.1	9.2
Iron	MG/KG	7030	7330	4080	8160
Lead	MG/KG	20.5	12.3	9.5	12.6
Magnesium	MG/KG	324	202	135	126
Manganese	MG/KG	10.8	8.7	5.6	7.2
Potassium	MG/KG	175	159	113	158
Sodium	MG/KG	61.9	45.3	30	35.8
Vanadium	MG/KG	15.4	14.4	ND	12.7
Zinc	MG/KG	15.2	12.6	8.2	10.4
Moisture	%	9.99	11.22	10.59	11.71

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB02-07	16-BD-SB05-07	16-BD-SB06-07	16-BD-SB07-04	16-BD-SB10-03	16-BD-SB12-02	16-BD-SB13-02	16-BD-SB14-05
Laboratory Sample ID:		AC4113	AC4188	AC4184	AC4578	AC4174	AC4589	AC4594	AC4596
Date Sampled:		10/19/94	10/18/94	10/18/94	10/20/94	10/18/94	10/20/94	10/20/94	10/19/94
	UNITS								
VOLATILES									
Bromomethane	UG/KG	ND	ND	1 J	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	300	ND	100 J	310	290 J	ND	900 J
SEMIVOLATILES									
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND	ND	67 J	ND	ND
1,2,4-Trichlorobenzene	UG/KG	ND	ND	ND	ND	ND	66 J	ND	ND
Naphthalene	UG/KG	ND	ND	ND	ND	88 J	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	77 J	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	290 J	51 J	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	310 J	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	680	ND	ND	ND
Pentachlorophenol	UG/KG	94 J	ND	ND	ND	ND	38 NJ	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	ND	2200	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	380	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND	180 J	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	270 J	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	1200	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	670 J	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	160 J	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	160 J	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
di-n-Octylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	57 J	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	58 J	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	38 J	ND	ND	ND

UG/KG - milligram per kilogram
J - value is estimated
ND - not detected
NJ - estimated/tentative identification

16SBSLOP.XLS

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB02-07	16-BD-SB05-07	16-BD-SB06-07	16-BD-SB07-04	16-BD-SB10-03	16-BD-SB12-02	16-BD-SB13-02	16-BD-SB14-05
Laboratory Sample ID:		AC4113	AC4188	AC4184	AC4578	AC4174	AC4589	AC4594	AC4596
Date Sampled:		10/19/94	10/18/94	10/18/94	10/20/94	10/18/94	10/20/94	10/20/94	10/19/94
	UNITS								
PESTICIDES/PCBs									
4,4'-DDE	UG/KG	ND	36	ND	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	52 J	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	630	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	3.8	ND
gamma-Chlordane	UG/KG	ND	2.4 J	ND	ND	ND	ND	2.5 J	ND
Aroclor 1254	UG/KG	ND	ND	ND	ND	ND	ND	45	ND

UG/KG - milligram per kilogram
J - value is estimated
ND - not detected
NJ - estimated/tentative identification

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB16-05	16-BD-SB17-05	16-BD-SB18-06	16-BD-SB19-03	16-BD-SB20-06	16-MW01-01	16-MW02-03	16-MW05-08
Laboratory Sample ID:		AC4128	AC4192	AC4610	AC4606	AC4850	AC4140	AC4569	AC4860
Date Sampled:		10/18/94	10/19/94	10/20/94	10/20/94	10/20/94	10/18/94	10/19/94	10/21/94
	<u>UNITS</u>								
<u>VOLATILES</u>									
Bromomethane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	UG/KG	760	210	42 J	85 J	630	ND	86	190
<u>SEMIVOLATILES</u>									
1,4-Dichlorobenzene	UG/KG	ND	ND	ND	ND	ND	ND	50 J	ND
1,2,4-Trichlorobenzene	UG/KG	ND	ND	ND	ND	ND	ND	45 J	ND
Naphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND	ND	ND	70 J	ND
Dibenzofuran	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	UG/KG	ND	ND	ND	ND	ND	ND	52 NJ	ND
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	58 J	ND	ND	71 J
di-n-Octylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - milligram per kilogram
J - value is estimated
ND - not detected
NJ - estimated/tentative identification

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-BD-SB16-05	16-BD-SB17-05	16-BD-SB18-06	16-BD-SB19-03	16-BD-SB20-06	16-MW01-01	16-MW02-03	16-MW05-08
Laboratory Sample ID:		AC4128	AC4192	AC4610	AC4606	AC4850	AC4140	AC4569	AC4860
Date Sampled:		10/18/94	10/19/94	10/20/94	10/20/94	10/20/94	10/18/94	10/19/94	10/21/94
	UNITS								
PESTICIDES/PCBs									
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND	7.6	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Aroclor 1254	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND

UG/KG - milligram per kilogram
J - value is estimated
ND - not detected
NJ - estimated/tentative identification

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-MW06-06	16-SDA-SB01-02	16-SDA-SB03-02
Laboratory Sample ID:		AC4864	AC4124	AC4160
Date Sampled:		10/21/94	10/18/94	10/18/94
	UNITS			
VOLATILES				
Bromomethane	UG/KG	ND	ND	ND
Acetone	UG/KG	ND	ND	ND
SEMIVOLATILES				
1,4-Dichlorobenzene	UG/KG	ND	ND	ND
1,2,4-Trichlorobenzene	UG/KG	ND	ND	ND
Naphthalene	UG/KG	ND	ND	ND
2-Methylnaphthalene	UG/KG	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND
Dibenzofuran	UG/KG	ND	ND	ND
Fluorene	UG/KG	ND	ND	ND
Pentachlorophenol	UG/KG	ND	ND	ND
Phenanthrene	UG/KG	ND	ND	ND
Anthracene	UG/KG	ND	ND	ND
Carbazole	UG/KG	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND
di-n-Octylphthalate	UG/KG	46 J	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND

UG/KG - milligram per kilogram
J - value is estimated
ND - not detected
NJ - estimated/tentative identification

TABLE 4-8 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-MW06-06	16-SDA-SB01-02	16-SDA-SB03-02
Laboratory Sample ID:		AC4864	AC4124	AC4160
Date Sampled:		10/21/94	10/18/94	10/18/94
	UNITS			
PESTICIDES/PCBs				
4,4'-DDE	UG/KG	ND	ND	10
Endosulfan II	UG/KG	ND	ND	7.1 J
4,4'-DDD	UG/KG	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	37 J
alpha-Chlordane	UG/KG	ND	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND
Aroclor 1254	UG/KG	ND	40	ND

UG/KG - milligram per kilogram
J - value is estimated
ND - not detected
NJ - estimated/tentative identification

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-BD-SB01-06	16-BD-SB02-07	16-BD-SB03-07	16-BD-SB04-06	16-BD-SB05-07	16-BD-SB06-07	16-BD-SB07-04
Laboratory Sample ID:		AC4119	AC4113	AC4574	AC4100	AC4188	AC4184	AC4578
Date Sampled:		10/19/94	10/19/94	10/20/94	10/19/94	10/18/94	10/18/94	10/20/94
	UNITS							
Aluminum	MG/KG	355 J	2180 J	ND	445 J	731 J	655 J	814
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	1.2	3.7	ND	1.6	2.8	2.1	ND
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	40.1 J	57.2 J	31.7	ND	273 J	103 J	149
Chromium	MG/KG	ND	3.8 J	ND	ND	2.6 J	ND	2.4
Copper	MG/KG	ND	ND	ND	ND	2.3 J	ND	ND
Iron	MG/KG	587	595	612	354	1060	508	430
Lead	MG/KG	1.1 J	3.4 J	5.4	ND	7.2 J	ND	2.1
Magnesium	MG/KG	13.7	90.3	33.4	14.8	59.4	26	43.7
Manganese	MG/KG	0.63 J	3.3 J	1.6	0.87 J	9.8 J	1.7 J	2.7
Mercury	MG/KG	ND	ND	ND	0.1 J	ND	ND	ND
Potassium	MG/KG	ND	221	ND	ND	ND	ND	209
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	ND	ND	ND	ND	2.5	ND	ND
Zinc	MG/KG	ND	ND	ND	ND	43.6 J	13.5 J	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-BD-SB08-06	16-BD-SB09-05	16-BD-SB10-03	16-BD-SB10-07	16-BD-SB11-06	16-BD-SB12-02	16-BD-SB13-02
Laboratory Sample ID:		AC4583	AC4146	AC4174	AC4176	AC4138	AC4589	AC4594
Date Sampled:		10/20/94	10/18/94	10/18/94	10/18/94	10/18/94	10/20/94	10/20/94
	UNITS							
Aluminum	MG/KG	561	690	2910 J	315 J	659	1110	2050
Arsenic	MG/KG	ND	ND	2.5 J	ND	ND	ND	ND
Barium	MG/KG	4.3	ND	5.8	1.5	ND	3.4	9.2
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	113	ND	500 J	57.6 J	ND	751	1400
Chromium	MG/KG	2.7	ND	3.8 J	2.6 J	2.4	ND	ND
Copper	MG/KG	ND	ND	2.3 J	ND	ND	ND	2.7
Iron	MG/KG	558	ND	2370	756	ND	787	1280
Lead	MG/KG	2.4	1.7	4.1 J	ND	1.4	2.3	3.1
Magnesium	MG/KG	37.1	ND	59.7	19.9	ND	52	46.2
Manganese	MG/KG	1.5	ND	2.3 J	1.5 J	ND	5.7	2.7
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	0.13
Potassium	MG/KG	291	ND	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	30.6	ND	ND	ND	ND	ND	33.8
Vanadium	MG/KG	ND	ND	5.6	ND	ND	ND	2.4
Zinc	MG/KG	ND	ND	ND	ND	ND	ND	21.8

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-BD-SB14-05	16-BD-SB15-06	16-BD-SB16-05	16-BD-SB17-05	16-BD-SB18-06	16-BD-SB19-03	16-BD-SB20-06	16-MW01-01
Laboratory Sample ID:		AC4596	AC4196	AC4128	AC4192	AC4610	AC4606	AC4850	AC4140
Date Sampled:		10/19/94	10/19/94	10/18/94	10/19/94	10/20/94	10/20/94	10/20/94	10/18/94
	UNITS								
Aluminum	MG/KG	692	1730 J	1130	1680 J	1810	4840	3420 J	2720
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	ND	5.4	ND	4.1	5	8.7	6.8	6.1
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	0.21	ND
Calcium	MG/KG	114	66.6 J	ND	261 J	53.2	205	175 J	ND
Chromium	MG/KG	ND	3.4 J	2.5	4.9 J	3.5	7.9	6.9 J	3
Copper	MG/KG	ND	ND	ND	2.9 J	ND	ND	ND	ND
Iron	MG/KG	268	823	ND	971	1610	6760	3280 J	ND
Lead	MG/KG	2.1	ND	1.8	ND	3.5	4.5	4.7 J	4.5
Magnesium	MG/KG	23.6	113	ND	112	130	193	211	ND
Manganese	MG/KG	5.4	2.7 J	ND	3.7 J	2.3	3.7	4.6 J	ND
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	194	260	370	308 J	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	1.2
Sodium	MG/KG	22.7	ND	ND	ND	27.6	34.1	34.7	ND
Vanadium	MG/KG	ND	ND	3.1	3.2	4.8	14.1	8.1	3.8
Zinc	MG/KG	ND	14.3 J	ND	ND	ND	ND	8.9 J	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-MW01-04	16-MW02-03	16-MW03-02	16-MW04-03	16-MW05-08	16-MW06-06	16-SDA-SB01-02	16-SDA-SB02-02
Laboratory Sample ID:		AC4142	AC4569	AC4180	AC4104	AC4860	AC4864	AC4124	AC4134
Date Sampled:		10/18/94	10/19/94	10/18/94	10/19/94	10/21/94	10/21/94	10/18/94	10/18/94
	UNITS								
Aluminum	MG/KG	1220	2350	1000 J	3350 J	699 J	2930 J	4140	1900
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Barium	MG/KG	ND	4.6	2.4	5.4	3.1	6.6	6.9	7.1
Beryllium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	ND	88.9	51.4 J	36.6 J	82.9 J	362 J	ND	ND
Chromium	MG/KG	4.3	4.1	3 J	7 J	2.4 J	6.5 J	5.5	2.6
Copper	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Iron	MG/KG	ND	319	1720	5710	816 J	1380 J	ND	ND
Lead	MG/KG	3.1	4.5	ND	5.4 J	3.2 J	3.7 J	4.7	2.5
Magnesium	MG/KG	ND	83.7	69.6	236	43.4	237	ND	ND
Manganese	MG/KG	ND	3.2	1.5 J	3.9 J	1.7 J	5.5 J	ND	ND
Mercury	MG/KG	ND	ND	ND	ND	0.28	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	290	ND	229 J	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	25.4	ND	ND	32.5	29.7	ND	ND
Vanadium	MG/KG	5.6	ND	3.1	7.2	ND	6.2	8.4	2.6
Zinc	MG/KG	ND	ND	ND	17.2 J	9.6 J	4.9 J	399 J	ND

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-SDA-SB03-02	16-SDA-SB04-02
Laboratory Sample ID:		AC4160	AC4168
Date Sampled:		10/18/94	10/18/94
	UNITS		
Aluminum	MG/KG	7650 J	737 J
Arsenic	MG/KG	ND	ND
Barium	MG/KG	36.5	3.8
Beryllium	MG/KG	ND	ND
Calcium	MG/KG	477 J	214 J
Chromium	MG/KG	5.5 J	3.3 J
Copper	MG/KG	3.4 J	ND
Iron	MG/KG	7830	729
Lead	MG/KG	68 J	2.2 J
Magnesium	MG/KG	185	38.1
Manganese	MG/KG	38.1 J	4 J
Mercury	MG/KG	ND	ND
Potassium	MG/KG	ND	ND
Selenium	MG/KG	ND	ND
Sodium	MG/KG	ND	ND
Vanadium	MG/KG	8.8	ND
Zinc	MG/KG	81 J	13.2 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-10
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-MW02-01	16-MW03-01	16-MW05-01	16-MW06-01
Laboratory Sample ID:		AD1488	AD1485	AD1167	AD1491
Date Sampled:		11/30/94	11/29/94	11/29/94	11/30/94
	UNITS				
VOLATILES					
Benzene	UG/L	ND	ND	37	ND
Ethylbenzene	UG/L	ND	ND	1 J	ND
SEMIVOLATILES					
Phenol	UG/L	ND	2 J	4 J	1 J
Naphthalene	UG/L	ND	ND	6 J	ND
bis(2-Ethylhexyl)phthalate	UG/L	1 J	5 J	1 J	2 J

UG/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-11
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL TOTAL METALS

Client Sample ID:		16-MW01-01	16-MW02-01	16-MW03-01	16-MW04-01	16-MW05-01	16-MW06-01
Laboratory Sample ID:		AD1636	AD1489	AD1486	AD1633	AD1168	AD1492
Date Sampled:		11/30/94	11/30/94	11/29/94	11/30/94	11/29/94	11/30/94
	UNITS						
Barium	UG/L	27.2 J	50.9	77.9	24.7 J	53	24.4 J
Calcium	UG/L	3160	6200	13400	1460	7770	370
Iron	UG/L	ND	ND	712	ND	ND	ND
Lead	UG/L	ND	ND	ND	3.2 J	ND	ND
Magnesium	UG/L	1610	1870	5090	1020	1210	1510
Manganese	UG/L	ND	23.1 J	28.9 J	ND	31.6 J	9.8 J
Sodium	UG/L	3230	7090	15600	16400	6000	2480
Zinc	UG/L	ND	80.5	ND	ND	ND	ND

UG/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-12
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL DISSOLVED METALS

Client Sample ID:		16-MW01D-01	16-MW02D-01	16-MW03D-01	16-MW04D-01	16-MW05D-01	16-MW06D-01
Laboratory Sample ID:		AD1657	AD1503	AD1502	AD1656	AD1169	AD1504
Date Sampled:		11/30/94	11/30/94	11/29/94	11/30/94	11/29/94	11/30/94
	UNITS						
Barium	UG/L	28.4 J	41.1	75.8	19.3 J	44.3	11.9 J
Calcium	UG/L	3930	5840 J	13600 J	1640	6990	558 J
Copper	UG/L	ND	ND	ND	ND	18.6	ND
Iron	UG/L	ND	ND	588 J	ND	ND	ND
Magnesium	UG/L	1890	1730	5050	1030	1160	1350 J
Manganese	UG/L	12.4 J	21.3 J	30.2 J	ND	ND	8.2 J
Sodium	UG/L	3890	6470 J	15500 J	16600	5610	2430 J

UG/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-13

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No. / Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Field Parameters					
			Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)
16-MW01	25.36	1.6	2.5	67	21	5.65	-	53
11/30/94			4.5	140	17.5	5.57	17.4	10
			5	81	18	5.54	18.3	4.5
			6	69	18	5.54	17.4	3.4
			7	75	18	5.54	17.4	2
16-MW02	18.9	2.3	0.9	106	22	5.71	18.1	2.2
11/30/94			2	109	20.5	5.63	18.3	1.0
			3	117	19.5	5.56	18	0.53
16-MW03	20.06	1.5	0	254	18	5.49	18.2	>100
11/29/94			1.5	248	19	5.42	18.8	>100
			3	249	20	5.33	19.2	93
			4	248	19	5.37	18.8	33
			5	237	19	5.41	18.8	26
			6	240	19.5	5.33	19.3	10
			7	246	19.5	5.36	18.9	15
			8	245	19.6	5.35	19.1	10
			9	245	19.5	5.35	19.3	10
16-MW04	19.85	1.4	1.4	150	18	5.47	18.1	23
11/30/94			2.9	132	21	5.43	18.2	11.5
			3.9	135	21	5.41	17.8	4.8
			5.4	138	18	5.81	14.2	2.6
			7.1	130	21	5.49	17.9	1.5
16-MW05	34.1	2.6	2.3	123	19.5	6.04	18.8	90
11/29/94			2.7	111	20	5.95	20.7	21
			3.7	122	20	5.97	20.5	4.5
			4.5	119	21	5.81	20.5	2.0
16-MW06	33.56	2.74	3.25	53	22.8	5.48	16.7	5
11/30/94			4.5	58	18	5.34	17.1	14
			6.3	58	18	-	-	1
			5	53	22.5	5.41	16.7	0.7

(1) Measurements taken from top of PVC Casing.

TABLE 4-14
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
GROUNDWATER-ROUND 2
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-MW01-02	16-MW02-02	16-MW03-02	16-MW04-02	16-MW05-02	16-MW06-02
Laboratory Sample ID:		AE8475	AE8479	AE8477	AE8481	AE8480	AE8482
Date Sampled:		02/03/95	02/03/95	02/03/95	02/03/95	02/04/95	02/04/95
	UNITS						
SEMIVOLATILES							
Naphthalene	UG/L	5 J	5 J	5 J	4 J	4 J	4 J
bis(2-Ethylhexyl)phthalate	UG/L	ND	ND	1 J	5 J	2 J	ND

UG/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-15
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
GROUNDWATER-ROUND 2
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL TOTAL METALS

Client Sample ID:		16-MW01-02	16-MW02-02	16-MW03-02	16-MW04-02	16-MW05-02	16-MW06-02
Laboratory Sample ID:		AE8475	AE8479	AE8477	AE8481	AE8480	AE8482
Date Sampled:		02/03/95	02/03/95	02/03/95	02/03/95	02/04/95	02/04/95
	UNITS						
Aluminum	UG/L	ND	300	ND	ND	274	ND
Barium	UG/L	26.1 J	50.7 J	50.1 J	44.1 J	54.1 J	25 J
Calcium	UG/L	1240	4330	6540	728	3820	ND
Iron	UG/L	ND	ND	410	ND	ND	ND
Magnesium	UG/L	1490	2110	3130	1860	1380	1590
Manganese	UG/L	ND	11.4 J	ND	ND	24.6 J	ND
Potassium	UG/L	ND	1280	ND	ND	1270	1290
Sodium	UG/L	3280	7310	10500	14500	3730	2240

UG/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-16

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)(1)	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)
16-MW01	25.21	2.1	0	-	-	4.7	15.6	-
3/29/95			2	-	-	4.78	15.9	-
			4	-	-	4.83	16	-
			6	-	-	4.91	15.9	-
16-MW02	17.86	2.4	0	-	-	5	16.5	-
3/29/95			3	-	-	4.98	16.7	-
			6	-	-	5	16.5	-
			7	-	-	5	16.4	-
16-MW03	20.05	1.7	0	-	-	5	16.4	-
3/29/95			2.5	-	-	5.42	18.8	-
			5	-	-	5.33	19.2	-
16-MW04	-	-	0	-	-	4.68	15.2	-
3/29/95			2.5	-	-	4.68	15.2	-
			5	-	-	4.70	15.6	-
16-MW05	33.95	3.0	0	-	-	4.79	17.3	-
3/29/95			6	-	-	4.73	17.5	-
			16	-	-	4.79	17.7	-
16-MW06	33.55	3.29	0	-	-	4.78	17.7	-
3/29/95			3	-	-	4.85	17.8	-
			6	-	-	4.86	17.5	-
			9	-	-	4.90	17.9	-

(1) Measurements taken from top of PVC Casing.

Note: Only pH and temperature measurements taken due to instruments being in use. All samples looked clear at end of purging. Samples not analyzed for dissolved metals.

TABLE 4-17
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
NORTHEAST CREEK SURFACE WATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-NC-SW05
Laboratory Sample ID:		AB1976
Date Sampled:		6/26/94
	UNITS	
VOLATILES		
4-Methyl-2-pentanone	UG/L	7 J
1,1,2,2-Tetrachloroethane	UG/L	2 J
SEMIVOLATILES		
bis(2-Ethylhexyl)phthalate	UG/L	10 J

UG/L - microgram per liter
J - value is estimated

TABLE 4-18
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
NORTHEAST CREEK SURFACE WATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		16-NC-SW01	16-NC-SW02	16-NC-SW03	16-NC-SW04	16-NC-SW05
Laboratory Sample ID:		AB1969	AB1972	AB1975	AB1987	AB1978
Date Sampled:		6/27/94	6/27/94	6/26/94	6/26/94	6/26/94
	UNITS					
Aluminum	UG/L	4210 J	4560 J	4880 J	5550 J	12300 J
Arsenic	UG/L	ND	2.2 J	3.1 J	2.6 J	2.9 J
Barium	UG/L	22.9	23.2	25.8	26.7	30.4
Calcium	UG/L	161000 J	154000 J	165000 J	173000 J	165000 J
Chromium	UG/L	ND	ND	ND	ND	15.6
Iron	UG/L	2780 J	3380 J	3410 J	3590 J	6650 J
Lead	UG/L	6	7 J	5.8 J	5.5 J	13.7
Magnesium	UG/L	542000	542000	570000	615000	552000
Manganese	UG/L	19.3	21.2	19.3	17.2	24.4
Potassium	UG/L	175000	169000	179000	188000	179000
Silver	UG/L	8.9	8.4	8.8	8.6	6.4
Sodium	UG/L	4250000 J	4240000 J	4430000 J	4740000 J	4270000 J
Vanadium	UG/L	ND	ND	ND	ND	19.6

UG/L - microgram per liter
J - value is estimated
ND - not detected

TABLE 4-19
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
NORTHEAST CREEK SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		16-NC-SD02-06	16-NC-SD03-06	16-NC-SD04-06
Laboratory Sample ID:		AB2045	AB2036	AB2042
Date Sampled:		6/27/94	6/26/94	6/26/94
	UNITS			
VOLATILES				
Carbon Disulfide	UG/KG	ND	2 J	ND
Toluene	UG/KG	2 J	ND	1 J

UG/KG - microgram per kilogram
J - value is estimated
ND - not detected

TABLE 4-20
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
NORTHEAST CREEK SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

	Client Sample ID:	16-NC-SD01-06	16-NC-SD01-612	16-NC-SD02-06	16-NC-SD02-612	16-NC-SD03-06	16-NC-SD03-612	16-NC-SD04-06
	Laboratory Sample ID:	AB2049	AB2027	AB2046	AB2025	AB2037	AB2019	AB2043
	Date Sampled:	6/27/94	6/27/94	6/27/94	6/27/94	6/26/94	6/26/94	6/26/94
	UNITS							
Aluminum	MG/KG	2150 J	6700 J	1760 J	3570 J	1620 J	1400 J	1380 J
Arsenic	MG/KG	1.5 J	1.2 J	0.8 J	ND	3.6 J	2.8 J	3.8 J
Barium	MG/KG	3.4	7.5	5.5	10.8	1.9	3.3	3.5
Beryllium	MG/KG	0.3	0.27	ND	ND	ND	ND	ND
Calcium	MG/KG	1220	434	341	192	87.4	93.8	124
Chromium	MG/KG	10	11.2	3.9	3.9	8.9	4.2	10.1 J
Cobalt	MG/KG	2.4	ND	ND	ND	ND	ND	ND
Iron	MG/KG	9110 J	4520 J	1290 J	336 J	8470 J	2500 J	8730 J
Lead	MG/KG	4.5 J	6 J	3.2 J	4.8 J	5.3 J	2.3 J	3.2 J
Magnesium	MG/KG	ND	504	ND	ND	ND	ND	ND
Manganese	MG/KG	4.1	7.8	3.8	4.8	6.1	1.7	1.9
Silver	MG/KG	1.2	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	710	671	1320	334	622	568	646 J
Vanadium	MG/KG	29.9	11.8	3.6	4.3	11.6	4.7	19.2 J
Zinc	MG/KG	4.7 J	2.8 J	2 J	2.7 J	5.6 J	1.9 J	46.4 J

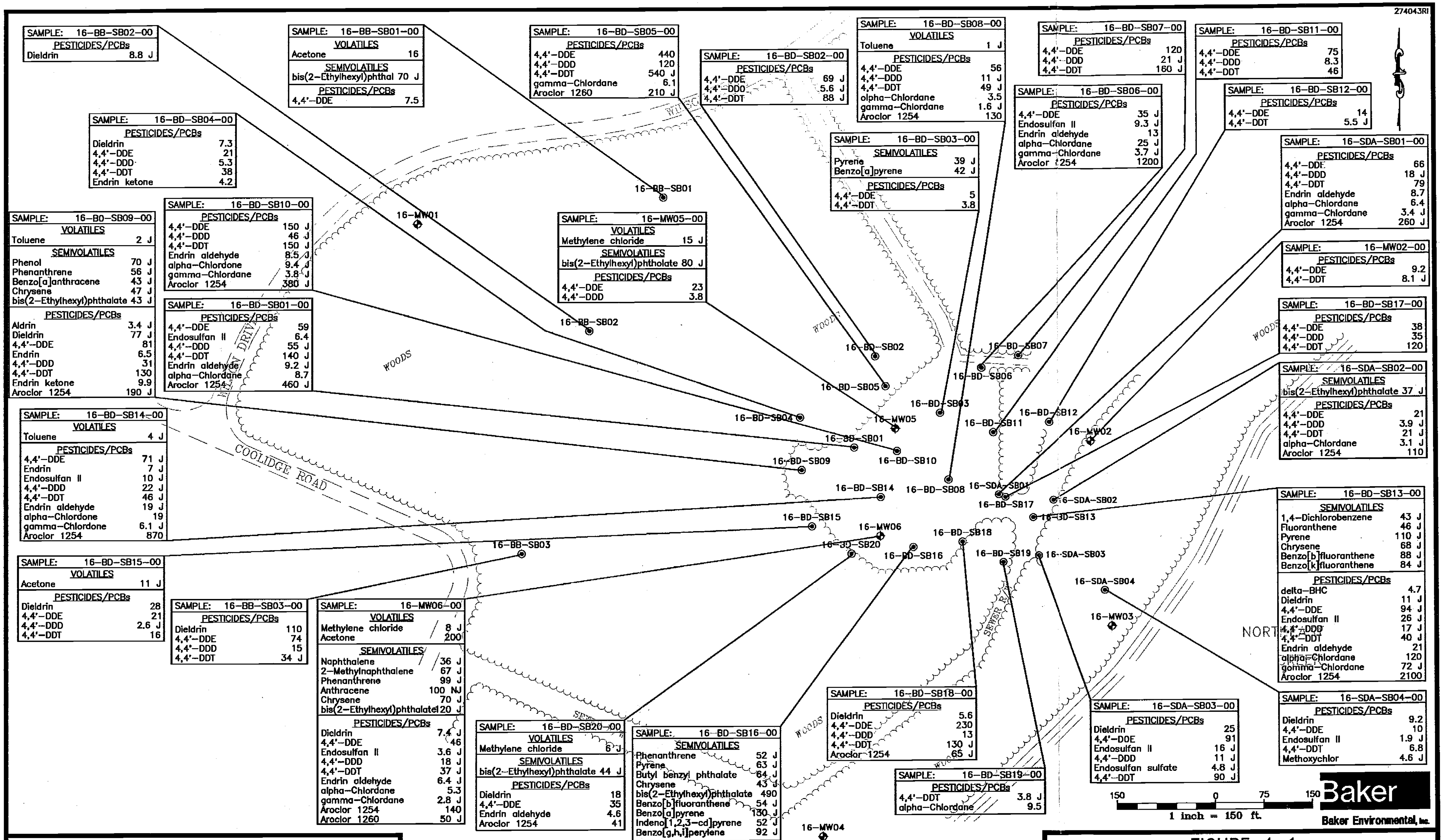
MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

TABLE 4-20 (continued)
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 8 (SITE 16)
NORTHEAST CREEK SEDIMENT
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

	Client Sample ID:	16-NC-SD04-612	16-NC-SD05-06	16-NC-SD05-612
	Laboratory Sample ID:	AB2013	AB2031	AB2015
	Date Sampled:	6/26/94	6/26/94	6/26/94
	UNITS			
Aluminum	MG/KG	4160 J	6150 J	7460 J
Arsenic	MG/KG	ND	1.3 J	4.7 J
Barium	MG/KG	10.5	7.8	10.3
Beryllium	MG/KG	ND	0.29	0.33
Calcium	MG/KG	114	103	90.5
Chromium	MG/KG	7.1	16.4	21.2
Cobalt	MG/KG	ND	2.6	3.1
Iron	MG/KG	1460 J	6630 J	9960 J
Lead	MG/KG	5.5 J	5.2 J	4.6 J
Magnesium	MG/KG	ND	606	618
Manganese	MG/KG	10.4	10.4	10.5
Silver	MG/KG	ND	ND	ND
Sodium	MG/KG	170	429	402
Vanadium	MG/KG	5	14.3	16.7
Zinc	MG/KG	2.5 J	3.9 J	3.6 J

MG/KG - milligram per kilogram
J - value is estimated
ND - not detected

SECTION 4.0 FIGURES



SAMPLE:	16-BB-SB02-00
PESTICIDES/PCBs	
Dieldrin	8.8 J

SAMPLE:	16-BB-SB01-00
VOLATILES	
Acetone	16
SEMIVOLATILES	
bis(2-Ethylhexyl)phthal	70 J
PESTICIDES/PCBs	
4,4'-DDE	7.5

SAMPLE:	16-BD-SB05-00
PESTICIDES/PCBs	
4,4'-DDE	440
4,4'-DDD	120
4,4'-DDT	540 J
gamma-Chlordane	6.1
Aroclor 1260	210 J

SAMPLE:	16-BD-SB02-00
PESTICIDES/PCBs	
4,4'-DDE	69 J
4,4'-DDD	5.6 J
4,4'-DDT	88 J

SAMPLE:	16-BD-SB08-00
VOLATILES	
Toluene	1 J
PESTICIDES/PCBs	
4,4'-DDE	56
4,4'-DDD	11 J
4,4'-DDT	49 J
alpha-Chlordane	3.5
gamma-Chlordane	1.6 J
Aroclor 1254	130

SAMPLE:	16-BD-SB07-00
PESTICIDES/PCBs	
4,4'-DDE	120
4,4'-DDD	21 J
4,4'-DDT	160 J

SAMPLE:	16-BD-SB11-00
PESTICIDES/PCBs	
4,4'-DDE	75
4,4'-DDD	8.3
4,4'-DDT	46

SAMPLE:	16-BD-SB06-00
PESTICIDES/PCBs	
4,4'-DDE	35 J
Endosulfan II	9.3 J
Endrin aldehyde	13
alpha-Chlordane	25 J
gamma-Chlordane	3.7 J
Aroclor 1254	1200

SAMPLE:	16-BD-SB12-00
PESTICIDES/PCBs	
4,4'-DDE	14
4,4'-DDT	5.5 J

SAMPLE:	16-BD-SB04-00
PESTICIDES/PCBs	
Dieldrin	7.3
4,4'-DDE	21
4,4'-DDD	5.3
4,4'-DDT	38
Endrin ketone	4.2

SAMPLE:	16-BD-SB03-00
SEMIVOLATILES	
Pyrene	39 J
Benzo[a]pyrene	42 J
PESTICIDES/PCBs	
4,4'-DDE	5
4,4'-DDT	3.8

SAMPLE:	16-SDA-SB01-00
PESTICIDES/PCBs	
4,4'-DDE	66
4,4'-DDD	18 J
4,4'-DDT	79
Endrin aldehyde	8.7
alpha-Chlordane	6.4
gamma-Chlordane	3.4 J
Aroclor 1254	260 J

SAMPLE:	16-B0-SB09-00
VOLATILES	
Toluene	2 J
SEMIVOLATILES	
Phenol	70 J
Phenanthrene	56 J
Benzo[a]anthracene	43 J
Chrysene	47 J
bis(2-Ethylhexyl)phthalate	43 J
PESTICIDES/PCBs	
Aldrin	3.4 J
Dieldrin	77 J
4,4'-DDE	81
Endrin	6.5
4,4'-DDD	31
4,4'-DDT	130
Endrin ketone	9.9
Aroclor 1254	190 J

SAMPLE:	16-BD-SB10-00
PESTICIDES/PCBs	
4,4'-DDE	150 J
4,4'-DDD	46 J
4,4'-DDT	150 J
Endrin aldehyde	8.5 J
alpha-Chlordone	9.4 J
gamma-Chlordane	3.8 J
Aroclor 1254	380 J

SAMPLE:	16-MW05-00
VOLATILES	
Methylene chloride	15 J
SEMIVOLATILES	
bis(2-Ethylhexyl)phtholate	80 J
PESTICIDES/PCBs	
4,4'-DDE	23
4,4'-DDD	3.8

SAMPLE:	16-MW02-00
PESTICIDES/PCBs	
4,4'-DDE	9.2
4,4'-DDT	8.1 J

SAMPLE:	16-BD-SB01-00
PESTICIDES/PCBs	
4,4'-DDE	59
Endosulfan II	6.4
4,4'-DDD	55 J
4,4'-DDT	140 J
Endrin aldehyde	9.2 J
alpha-Chlordane	8.7
Aroclor 1254	460 J

SAMPLE:	16-BD-SB17-00
PESTICIDES/PCBs	
4,4'-DDE	38
4,4'-DDD	35
4,4'-DDT	120

SAMPLE:	16-SDA-SB02-00
SEMIVOLATILES	
bis(2-Ethylhexyl)phthalate	37 J
PESTICIDES/PCBs	
4,4'-DDE	21
4,4'-DDD	3.9 J
4,4'-DDT	21 J
alpha-Chlordane	3.1 J
Aroclor 1254	110

SAMPLE:	16-BD-SB14-00
VOLATILES	
Toluene	4 J
PESTICIDES/PCBs	
4,4'-DDE	71 J
Endrin	7 J
Endosulfan II	10 J
4,4'-DDD	22 J
4,4'-DDT	46 J
Endrin aldehyde	19 J
alpha-Chlordone	19
gamma-Chlordone	6.1 J
Aroclor 1254	870

SAMPLE:	16-BD-SB13-00
SEMIVOLATILES	
1,4-Dichlorobenzene	43 J
Fluoranthene	46 J
Pyrene	110 J
Chrysene	68 J
Benzo[b]fluoranthene	88 J
Benzo[k]fluoranthene	84 J
PESTICIDES/PCBs	
delta-BHC	4.7
Dieldrin	11 J
4,4'-DDE	94 J
Endosulfan II	26 J
4,4'-DDD	17 J
4,4'-DDT	40 J
Endrin aldehyde	21
alpha-Chlordane	120
gomma-Chlordane	72 J
Aroclor 1254	2100

SAMPLE:	16-BD-SB15-00
VOLATILES	
Acetone	11 J
PESTICIDES/PCBs	
Dieldrin	28
4,4'-DDE	21
4,4'-DDD	2.6 J
4,4'-DDT	16

SAMPLE:	16-BB-SB03-00
PESTICIDES/PCBs	
Dieldrin	110
4,4'-DDE	74
4,4'-DDD	15
4,4'-DDT	34 J

SAMPLE:	16-MW06-00
VOLATILES	
Methylene chloride	8 J
Acetone	200
SEMIVOLATILES	
Naphthalene	36 J
2-Methylnaphthalene	67 J
Phenanthrene	99 J
Anthracene	100 NJ
Chrysene	70 J
bis(2-Ethylhexyl)phthalate	120 J
PESTICIDES/PCBs	
Dieldrin	7.4 J
4,4'-DDE	46
Endosulfan II	3.6 J
4,4'-DDD	18 J
4,4'-DDT	37 J
Endrin aldehyde	6.4 J
alpha-Chlordane	5.3
gamma-Chlordane	2.8 J
Aroclor 1254	140
Aroclor 1260	50 J

SAMPLE:	16-BD-SB18-00
PESTICIDES/PCBs	
Dieldrin	5.6
4,4'-DDE	230
4,4'-DDD	13
4,4'-DDT	130 J
Aroclor 1254	65 J

SAMPLE:	16-SDA-SB04-00
PESTICIDES/PCBs	
Dieldrin	9.2
4,4'-DDE	10
Endosulfan II	1.9 J
4,4'-DDT	6.8
Methoxychlor	4.6 J

SAMPLE:	16-SDA-SB03-00
PESTICIDES/PCBs	
Dieldrin	25
4,4'-DOE	91
Endosulfan II	16 J
4,4'-DDD	11 J
Endosulfan sulfate	4.8 J
4,4'-DDT	90 J

SAMPLE:	16-BD-SB20-00
VOLATILES	
Methylene chloride	6 J
SEMIVOLATILES	
bis(2-Ethylhexyl)phthalate	44 J
PESTICIDES/PCBs	
Dieldrin	18
4,4'-DDE	35
Endrin aldehyde	4.6
Aroclor 1254	41

SAMPLE:	16-BD-SB16-00
SEMIVOLATILES	
Phenanthrene	52 J
Pyrene	63 J
Butyl benzyl phthalate	64 J
Chrysene	43 J
bis(2-Ethylhexyl)phthalate	490
Benzo[b]fluoranthene	54 J
Benzo[a]pyrene	130 J
Indeno[1,2,3-cd]pyrene	52 J
Benzo[g,h,i]perylene	92 J
PESTICIDES/PCBs	
Dieldrin	22 J
4,4'-DDE	70
Endrin	14 J
Endosulfan II	15
4,4'-DDD	19 J
4,4'-DDT	140 J
Endrin aldehyde	29
alpha-Chlordane	36
gamma-Chlordane	18 J
Aroclor 1254	1100

SAMPLE:	16-BD-SB19-00
PESTICIDES/PCBs	
4,4'-DDT	3.8 J
alpha-Chlordane	9.5

SAMPLE:	16-MW04-00
VOLATILES	
Acetone	1200

LEGEND

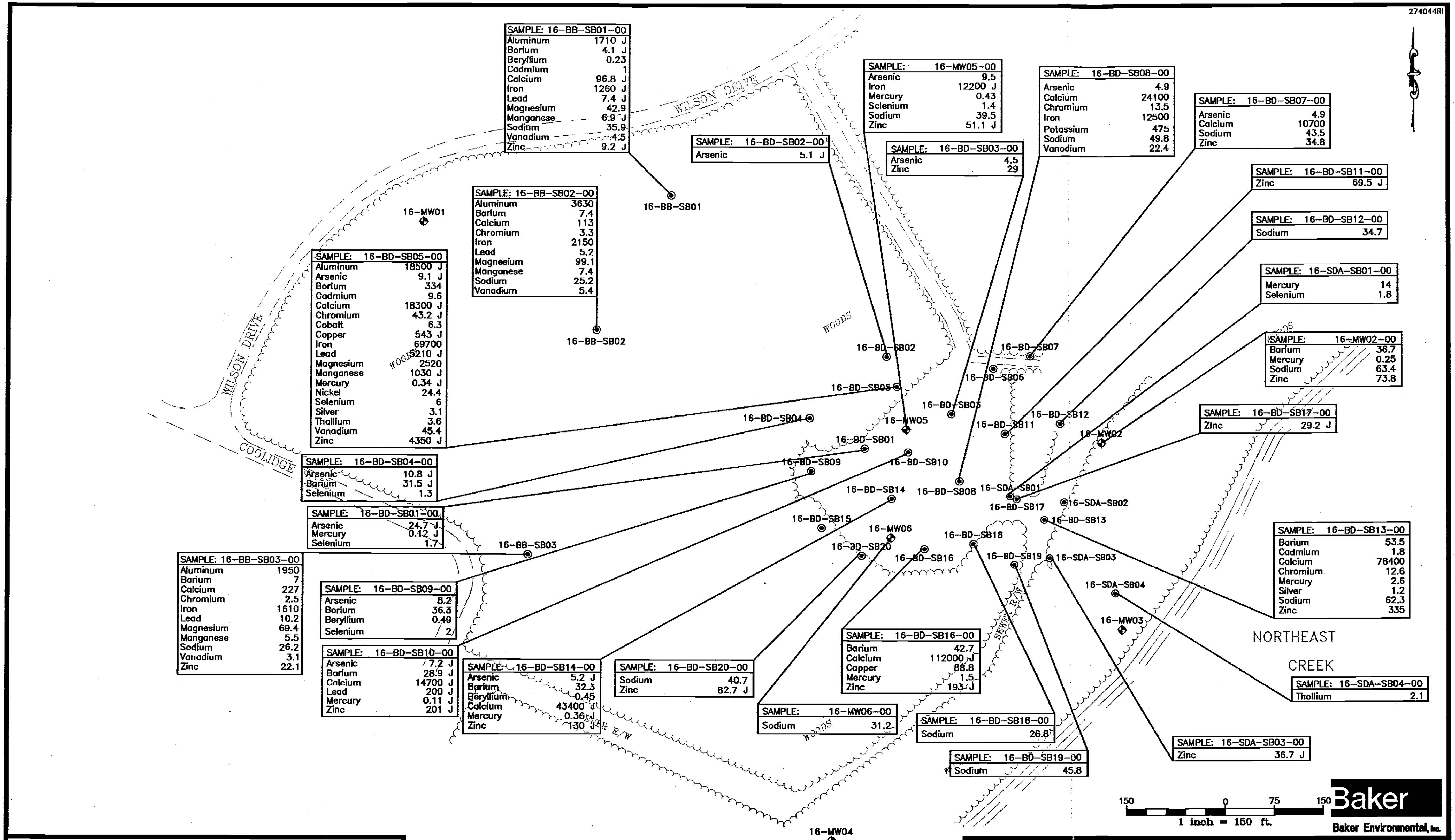
16-MW01 ⊕	MONITORING WELL LOCATION
16-BD-SB01 ◉	SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-1
POSITIVE DETECTIONS OF ORGANICS IN SURFACE SOILS AT SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q162

274044RI



SAMPLE:	16-BB-SB01-00
Aluminum	1710 J
Borium	4.1 J
Beryllium	0.23
Cadmium	1
Calcium	96.8 J
Iron	1260 J
Lead	7.4 J
Magnesium	42.9
Manganese	6.9 J
Sodium	35.9
Vanadium	4.5
Zinc	9.2 J

SAMPLE:	16-MW05-00
Arsenic	9.5
Iron	12200 J
Mercury	0.43
Selenium	1.4
Sodium	39.5
Zinc	51.1 J

SAMPLE:	16-BD-SB08-00
Arsenic	4.9
Calcium	24100
Chromium	13.5
Iron	12500
Potassium	475
Sodium	49.8
Vanodium	22.4

SAMPLE:	16-BD-SB07-00
Arsenic	4.9
Calcium	10700
Sodium	43.5
Zinc	34.8

SAMPLE:	16-BD-SB02-00
Arsenic	5.1 J

SAMPLE:	16-BD-SB03-00
Arsenic	4.5
Zinc	29

SAMPLE:	16-BD-SB11-00
Zinc	69.5 J

SAMPLE:	16-BB-SB02-00
Aluminum	3630
Barium	7.4
Calcium	113
Chromium	3.3
Iron	2150
Lead	5.2
Magnesium	99.1
Manganese	7.4
Sodium	25.2
Vanadium	5.4

SAMPLE:	16-BD-SB12-00
Sodium	34.7

SAMPLE:	16-BD-SB05-00
Aluminum	18500 J
Arsenic	9.1 J
Borium	334
Cadmium	9.6
Calcium	18300 J
Chromium	43.2 J
Cobalt	6.3
Copper	543 J
Iron	69700
Lead	5210 J
Magnesium	2520
Manganese	1030 J
Mercury	0.34 J
Nickel	24.4
Selenium	6
Silver	3.1
Thallium	3.6
Vanadium	45.4
Zinc	4350 J

SAMPLE:	16-SDA-SB01-00
Mercury	14
Selenium	1.8

SAMPLE:	16-MW02-00
Barium	36.7
Mercury	0.25
Sodium	63.4
Zinc	73.8

SAMPLE:	16-BD-SB17-00
Zinc	29.2 J

SAMPLE:	16-BD-SB04-00
Arsenic	10.8 J
Barium	31.5 J
Selenium	1.3

SAMPLE:	16-BD-SB01-00
Arsenic	24.7 J
Mercury	0.12 J
Selenium	1.7

SAMPLE:	16-BB-SB03-00
Aluminum	1950
Barium	7
Calcium	227
Chromium	2.5
Iron	1610
Lead	10.2
Magnesium	69.4
Manganese	5.5
Sodium	26.2
Vanadium	3.1
Zinc	22.1

SAMPLE:	16-BD-SB13-00
Barium	53.5
Cadmium	1.8
Calcium	78400
Chromium	12.6
Mercury	2.6
Silver	1.2
Sodium	62.3
Zinc	335

SAMPLE:	16-BD-SB09-00
Arsenic	8.2
Borium	36.3
Beryllium	0.49
Selenium	2

SAMPLE:	16-BD-SB16-00
Barium	42.7
Calcium	112000 J
Capper	88.8
Mercury	1.5
Zinc	193 J

SAMPLE:	16-BD-SB10-00
Arsenic	7.2 J
Barium	28.9 J
Calcium	14700 J
Lead	200 J
Mercury	0.11 J
Zinc	201 J

SAMPLE:	16-BD-SB14-00
Arsenic	5.2 J
Barium	32.3
Beryllium	0.45
Calcium	43400 J
Mercury	0.36 J
Zinc	130 J

SAMPLE:	16-BD-SB20-00
Sodium	40.7
Zinc	82.7 J

SAMPLE:	16-SDA-SB04-00
Thollium	2.1

SAMPLE:	16-MW06-00
Sodium	31.2

SAMPLE:	16-BD-SB18-00
Sodium	26.8

SAMPLE:	16-SDA-SB03-00
Zinc	36.7 J

SAMPLE:	16-BD-SB19-00
Sodium	45.8

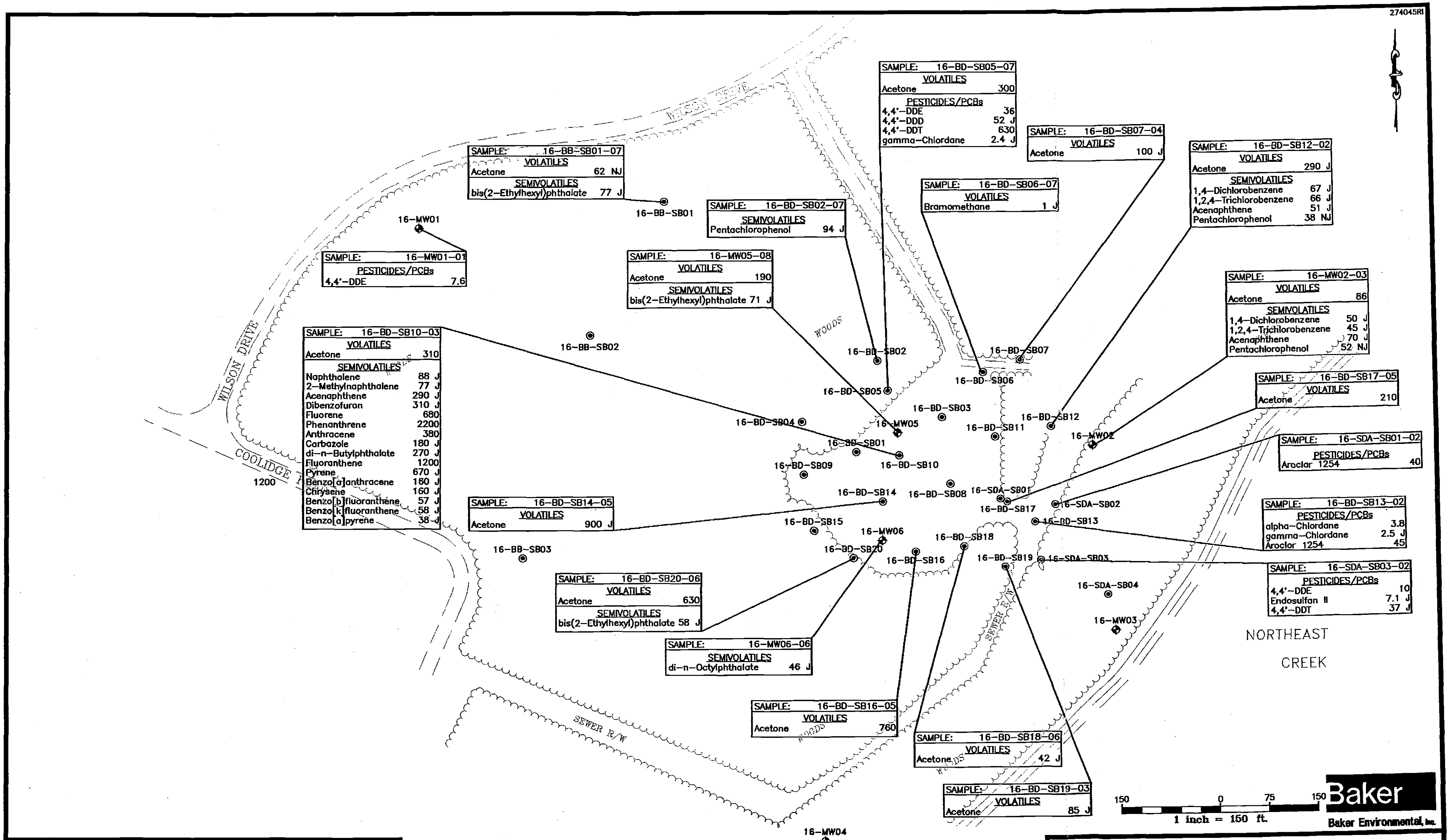
LEGEND

16-MW01 ⊕	MONITORING WELL LOCATION
16-BD-SB01 ◉	SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MILLIGRAMS PER KILOGRAM (mg/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-2
POSITIVE DETECTIONS OF INORGANICS IN SURFACE SOILS ABOVE BASE BACKGROUND LEVELS AT SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q172

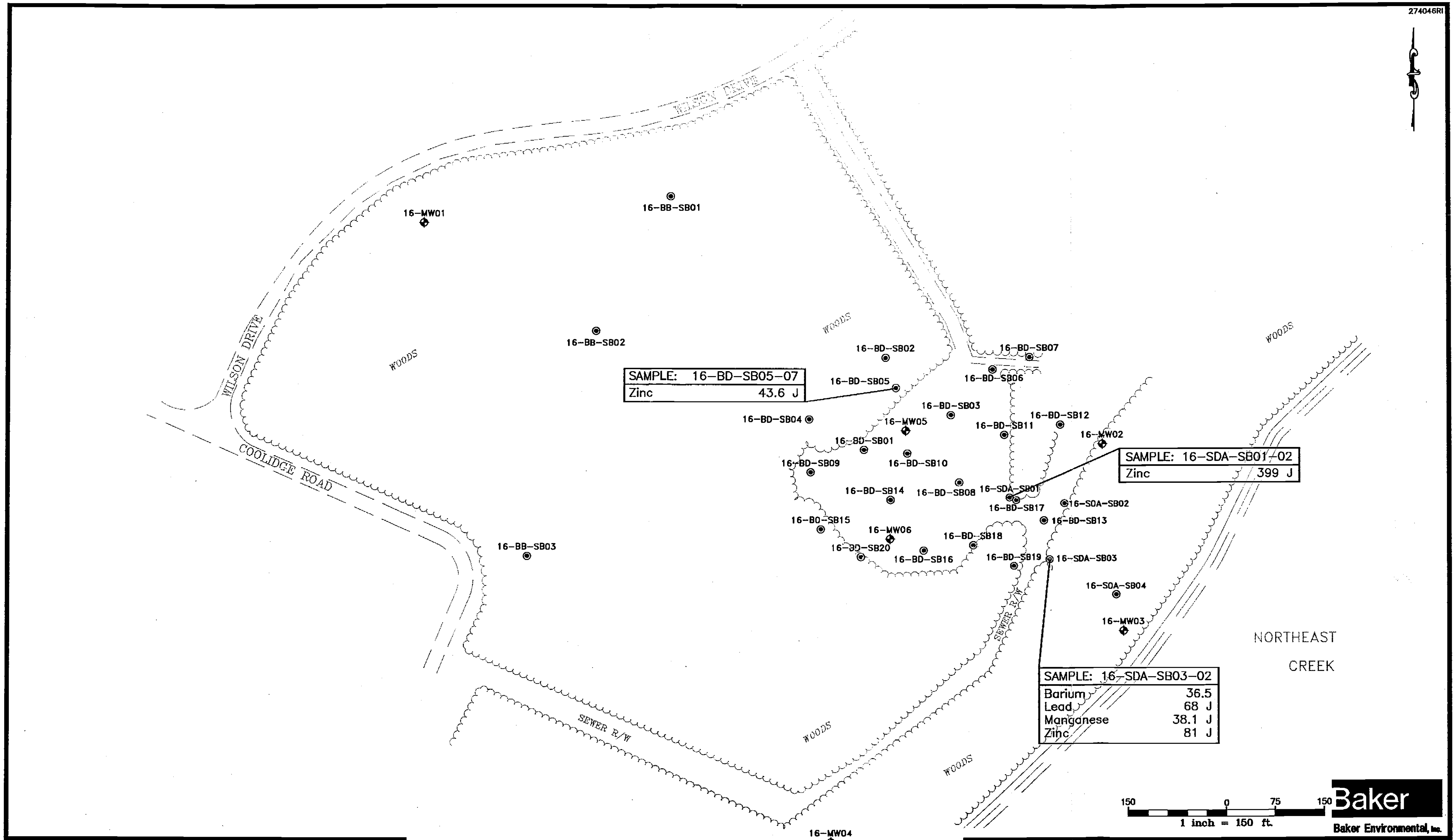


LEGEND

16-MW01	MONITORING WELL LOCATION
16-BD-SB01	SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-3
POSITIVE DETECTIONS OF ORGANICS IN SUBSURFACE SOILS AT
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SAMPLE:	16-BD-SB05-07
Zinc	43.6 J

SAMPLE:	16-SDA-SB01-02
Zinc	399 J

SAMPLE:	16-SDA-SB03-02
Barium	36.5
Lead	68 J
Manganese	38.1 J
Zinc	81 J

Baker

Baker Environmental, Inc.

LEGEND

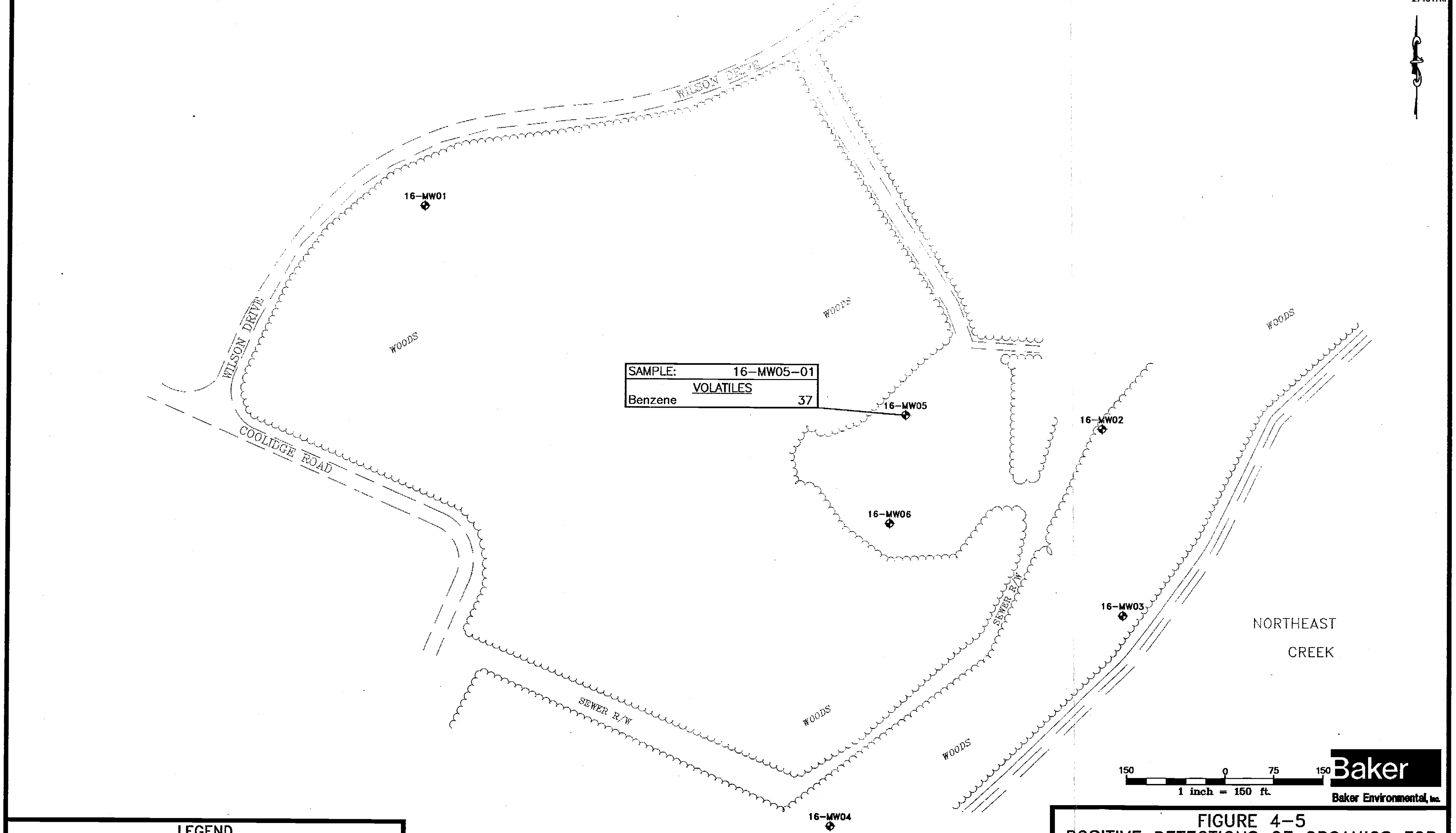
16-MW01 ⊕ MONITORING WELL LOCATION

16-BD-SB01 ◉ SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MILLIGRAMS PER KILOGRAM (mg/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-4
POSITIVE DETECTIONS OF INORGANICS IN SUB-SURFACE SOILS ABOVE BASE BACKGROUND LEVELS
AT SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q192



SAMPLE:	16-MW05-01
VOLATILES	
Benzene	37

LEGEND

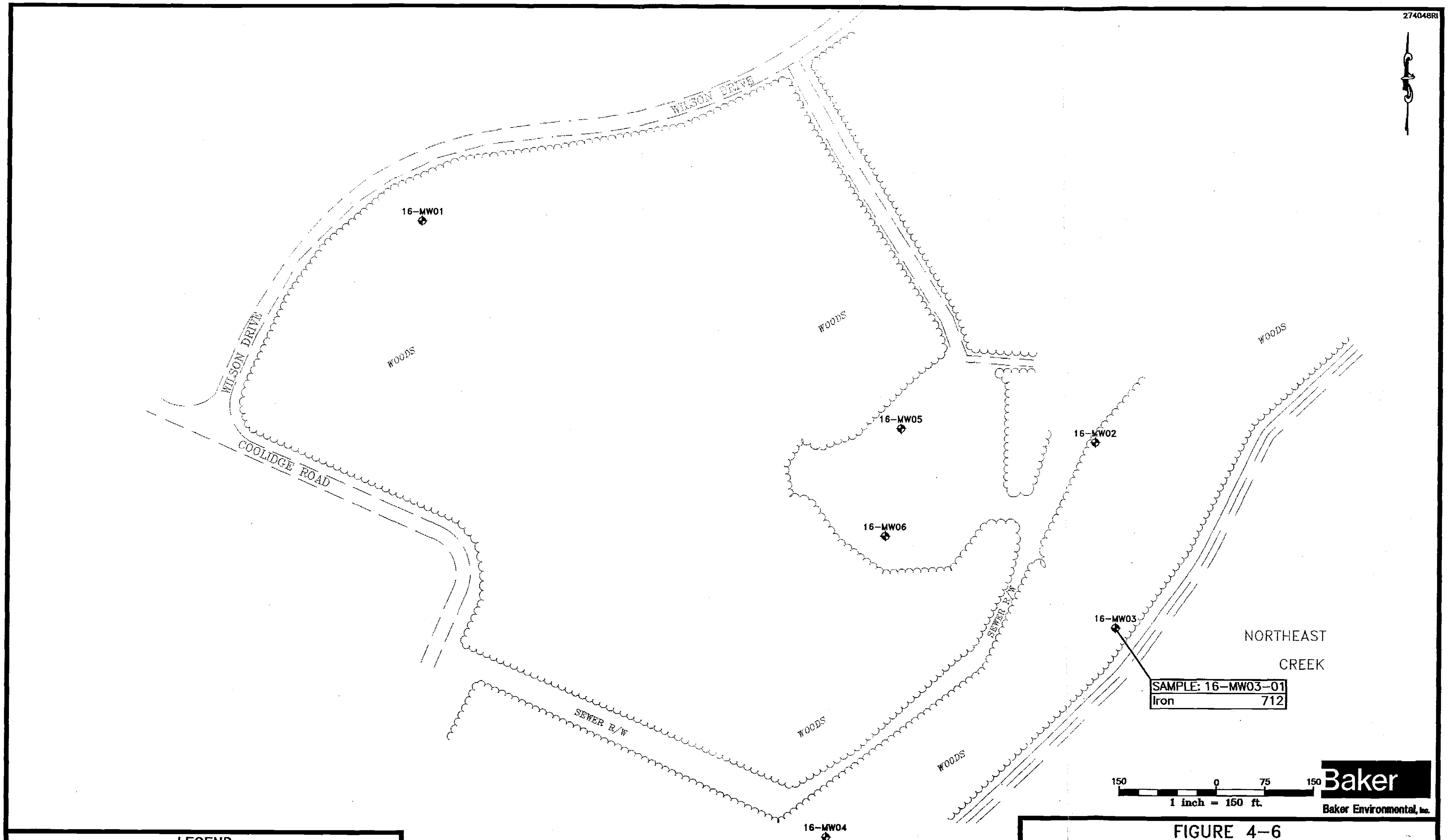
16-MW01 MONITORING WELL LOCATION

NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-5
POSITIVE DETECTIONS OF ORGANICS FOR ROUND ONE ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS AT SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q20Z

274048RI



SAMPLE: 16-MW03-01	
Iron	712

Baker

Baker Environmental, Inc.

LEGEND

16-MW01 ⊕ MONITORING WELL LOCATION

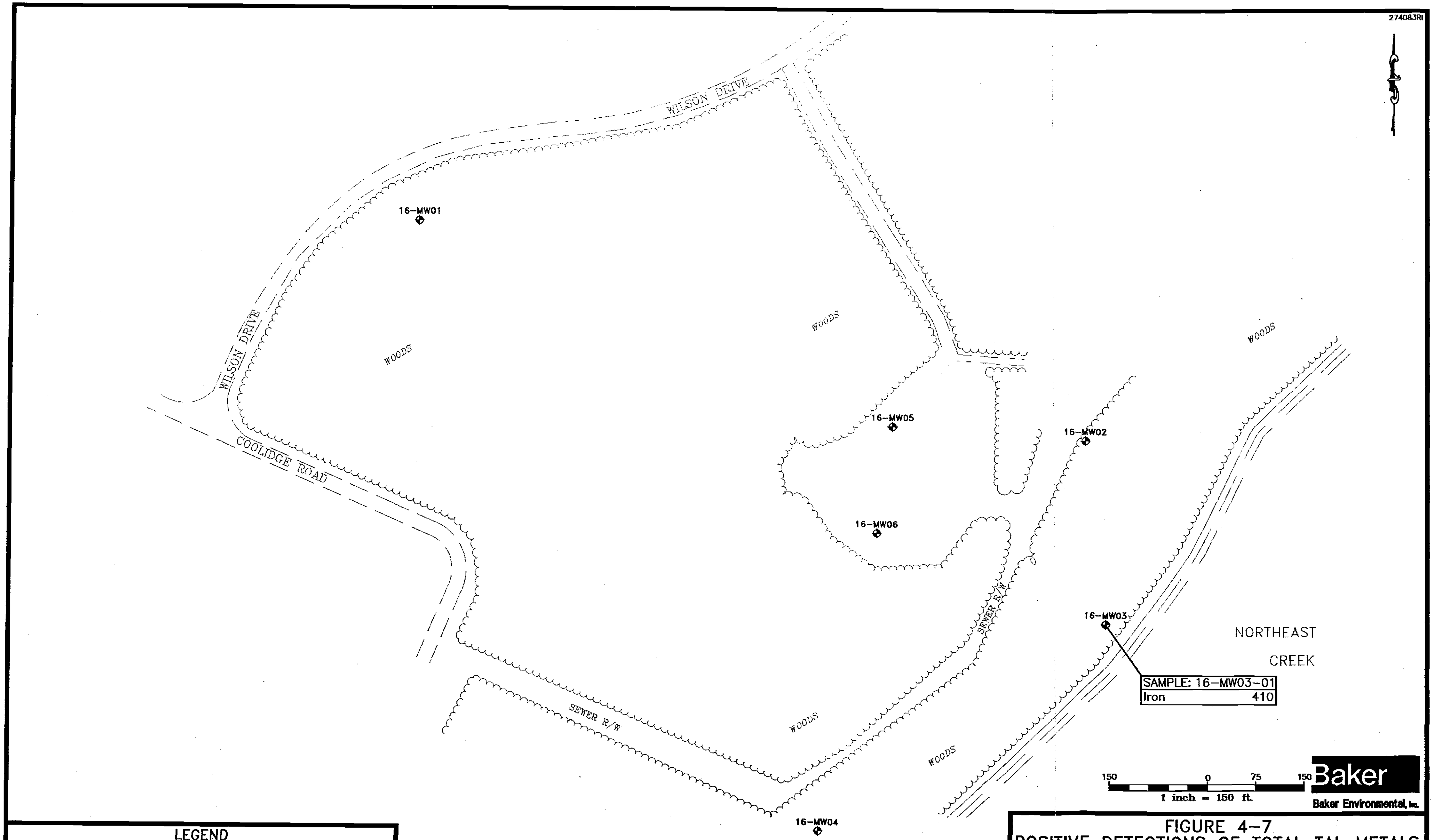
NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-6
POSITIVE DETECTIONS OF TOTAL TAL METALS FOR ROUND ONE ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS AT SITE 16 - MONTFORD POINT BURN DUMP

REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q212



LEGEND

16-MW01 MONITORING WELL LOCATION

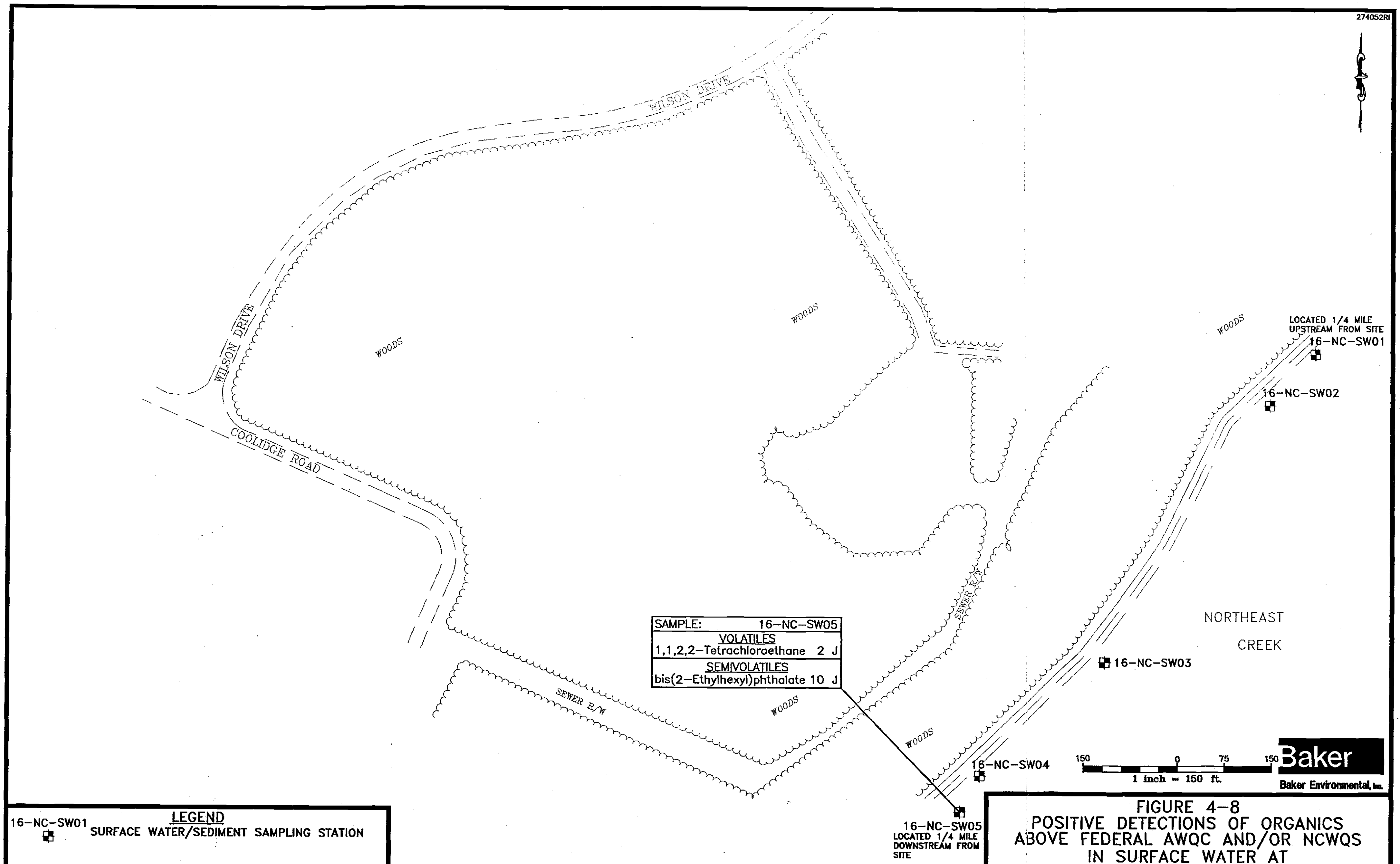
NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-7
POSITIVE DETECTIONS OF TOTAL TAL METALS FOR ROUND TWO ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS AT SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q222

274052RI



SAMPLE:	16-NC-SW05
VOLATILES	
1,1,2,2-Tetrachloroethane	2 J
SEMIVOLATILES	
bis(2-Ethylhexyl)phthalate	10 J

LEGEND

16-NC-SW01 ⊞ SURFACE WATER/SEDIMENT SAMPLING STATION

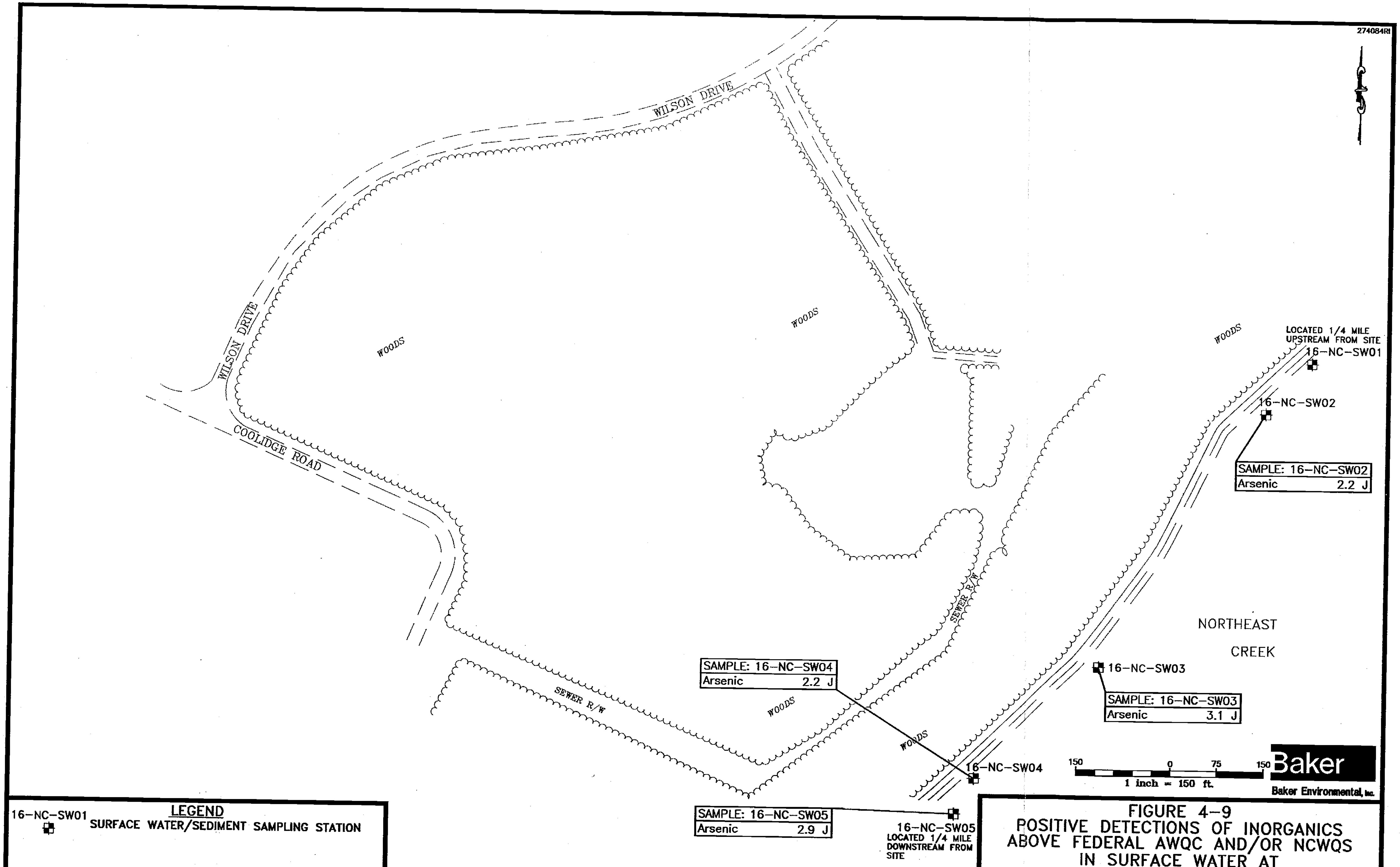
NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

Baker
Baker Environmental, Inc.

FIGURE 4-8
POSITIVE DETECTIONS OF ORGANICS ABOVE FEDERAL AWQC AND/OR NCWQS IN SURFACE WATER AT
SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274084RI



Baker

Baker Environmental, Inc.

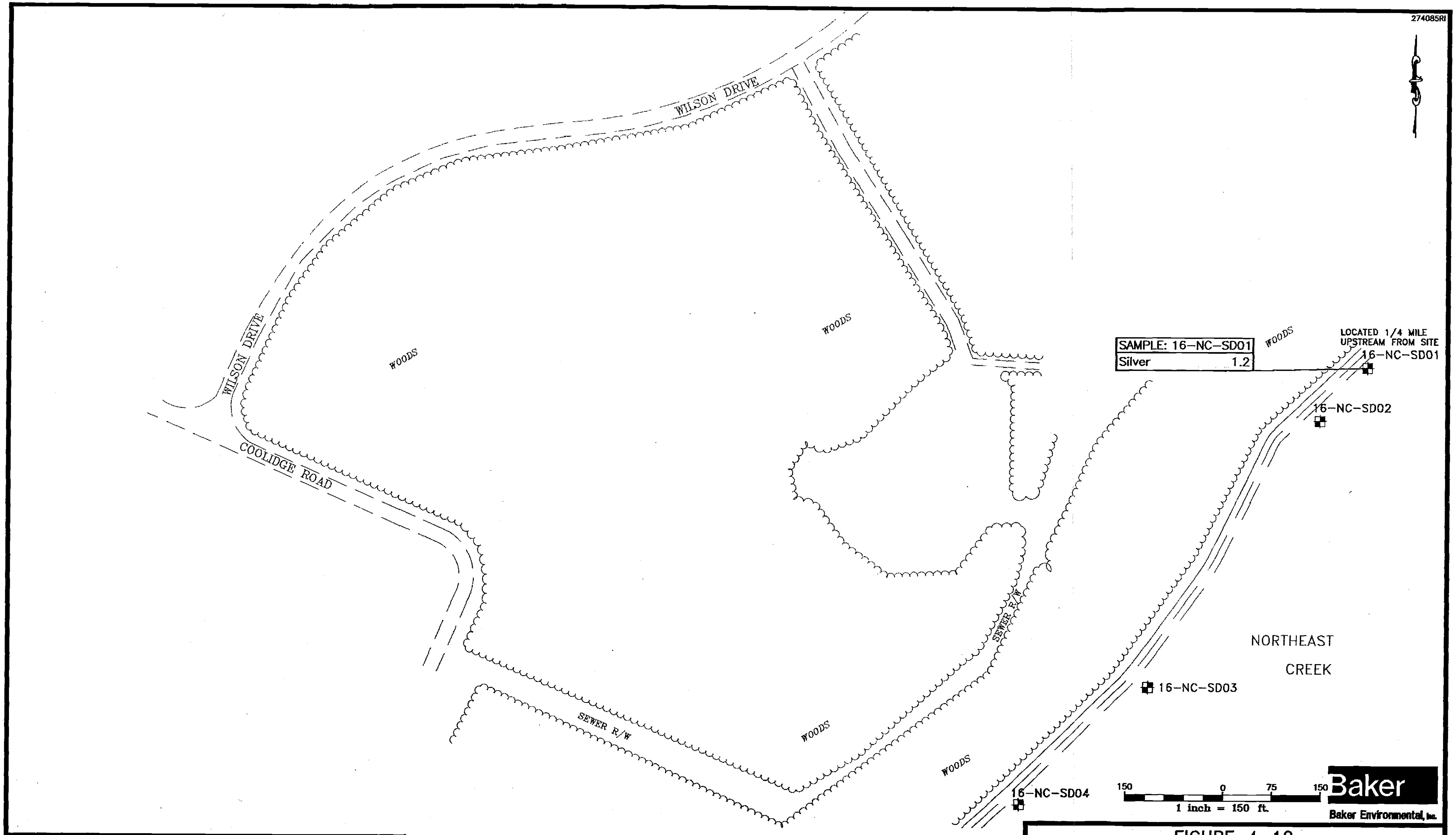
LEGEND

16-NC-SW01 ⊞ SURFACE WATER/SEDIMENT SAMPLING STATION

NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MICROGRAMS PER LITER (ug/L).

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-9
POSITIVE DETECTIONS OF INORGANICS
ABOVE FEDERAL AWQC AND/OR NCWQS
IN SURFACE WATER AT
SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

16-NC-SW01 ⊞ SURFACE WATER/SEDIMENT SAMPLING STATION

NOTE:
-SAMPLE CONCENTRATIONS REPORTED IN MILLIGRAMS PER KILOGRAM (ug/kg).
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 4-10
POSITIVE DETECTIONS OF INORGANICS
ABOVE FEDERAL AWQC AND/OR NCWQS
IN SEDIMENT AT
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

5.0 CONTAMINANT FATE AND TRANSPORT

The potential for a contaminant to migrate and persist in an environmental medium is critical when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. The environmental mobility of a chemical is influenced by its physical and chemical properties, the physical characteristics of the site, and the site chemistry. This section presents a discussion of the various physical and chemical properties of contaminants detected at Operable Unit (OU) No. 8, Site 16, and their fate and transport through the environment.

5.1 Chemical and Physical Properties Impacting Fate and Transport

Table 5-1 presents the physical and chemical properties associated with the organic contaminants detected during this investigation. These properties determine the inherent environmental mobility and fate of a contaminant. These properties include:

- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Organic carbon adsorption coefficient (sediment partition)
- Specific gravity
- Henry's Law constant
- Mobility index

A discussion of the environmental significance of each of these properties follows.

Vapor pressure provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. Volatilization can be important when evaluating groundwater and subsurface soils, particularly when selecting remedial technologies. Vapor pressure for monocyclic aromatics are generally higher than vapor pressures for polyaromatic hydrocarbons (PAHs). Contaminants with higher vapor pressures (e.g., volatile organic compounds [VOCs]) will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures (e.g., inorganics).

The rate at which a contaminant is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble contaminants (e.g., VOCs) are usually more readily leached than less soluble contaminants (e.g., inorganics). The water solubilities indicate that the volatile organic contaminants including monocyclic aromatics are usually several orders-of-magnitude more soluble than PAHs. Consequently, highly soluble compounds such as the chlorinated VOCs will migrate at a faster rate than less water soluble compounds.

The octanol/water partition coefficient (K_{ow}) is the ratio of the chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment. Specifically, a linear relationship between octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been established (Lyman et al., 1982). The coefficient is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available.

The organic carbon adsorption coefficient (K_{oc}) indicates the tendency of a chemical to adhere to soil particles organic carbon. The solubility of a chemical in water is inversely proportional to the K_{oc}. Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities. For example, contaminants such as PAHs are relatively immobile in the environment and are preferentially bound to the soil. These compounds are not subject to aqueous transport to the extent of compounds with higher water solubilities. Erosional properties of surface soils may, however, enhance the mobility of these bound soils contaminants.

Specific gravity is the ratio of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a contaminant will have a tendency to "float" or "sink" (as an immiscible liquid) in water if it exceeds its corresponding water solubility.

Vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. These two parameters can be used to estimate an equilibrium concentration of a contaminant in the water phase and in the air directly above the water. This can be expressed as Henry's Law Constant.

A quantitative assessment of mobility has been developed that uses water solubility (S), vapor pressure (VP), and organic carbon partition coefficient (K_{oc}) (Laskowski, 1983). This value is referred to as the Mobility Index (MI). It is defined as:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI is presented by Ford and Gurba (1984):

Relative MI	Mobility Description
> 5	extremely mobile
0 to 5	very mobile
-5 to 0	slightly mobile
-10 to -5	immobile
<-10	very immobile

The relative mobilities of many inorganic constituents is presented in Table 5-1.

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 16, the following potential contaminant transport pathways have been identified.

- Off-site atmospheric deposition of windblown dust.
- Leaching of sediment contaminants to surface water.
- Migration of contaminants in surface water.
- Leaching of soil contaminants to groundwater.
- Migration of groundwater contaminants.
- Surface soil run-off from Site 16.

Contaminants released to the environment could also undergo the following during transportation:

- Physical transformations: volatilization, precipitation
- Chemical transformations: photolysis, hydrolysis, oxidation, reduction
- Biological transformation: biodegradation
- Accumulation in one or more media

The following paragraphs describe the potential transport pathways listed above.

5.2.1 Off-Site Deposition of Windblown Dust

Wind can act as a contaminant transport pathway agent by eroding exposed soil and exposed sediment and blowing it off site. This is influenced by: wind velocity, the grain size/density of the soil/sediment particles and the amount of vegetative cover over the soil or sediment. Wind also may have acted as a transport agent during station-wide pesticide spraying.

Most of the site is flat and currently cleared, the other areas are comprised of pine trees. There is an opening in the wooded area in the southeast corner of the study area which leads to Northeast Creek. Consequently, this transport pathway may be significant at this site.

5.2.2 Leaching of Sediment Contaminants to Surface Water

When in contact with surface water, contaminants attached to sediment particles can disassociate from the sediment particle into surface water. Hydrophobic contaminants present in surface water also can be removed from the water column by sediment. Typically, an equilibrium between sediment concentrations and surface water concentrations is established in an aquatic system over time. This is primarily influenced by the physical and chemical properties of the contaminant, (i.e., water solubility, K_{oc}) and the physical and chemical properties of the sediment particle (i.e., grain size, f_{oc}).

The Northeast Creek lies approximately 400 feet southeast from the boundary of the burn dump. A few VOCs and inorganics were detected both in the surface water and sediments.

5.2.3 Leaching of Soil Contaminants to Groundwater

Contaminants that adhere to soil particles or have accumulated in soil pore spaces can leach and migrate vertically to the groundwater due to precipitation. The rate and extent of this migration is influenced by the depth to the water table, amount of precipitation, rate of infiltration, the physical and chemical properties of the soil, and the physical and chemical properties of the contaminant.

Groundwater samples were collected from shallow monitoring wells at Site 16. The groundwater analytical results can be compared to soil sample analytical results to determine if contaminants detected in soil have migrated or may migrate in the future, to underlying groundwater. These results were discussed in detail in Section 4.0, Nature and Extent of Contamination.

A few VOCs were detected in groundwater samples collected during the initial round which differed from those detected in the surface soil. This may be due to a number of reasons, including:

- VOCs in soil may have degraded, decomposed, or volatilized out of the soil column over time.
- The VOC contamination in groundwater may be from an off-site source.
- The source of VOC contamination, either contaminated soil of material disposed on site, may have been removed.
- The VOC source may be unrelated to the site, or a result of sampling or laboratory introduction.

Contaminants detected in Site 16 soil samples such as PAHs were not detected in groundwater samples, suggesting that these compounds have not leached to groundwater. Considering the physical and chemical properties of PAHs and their "moderately immobile" nature (Table 5-1), this is expected.

5.2.4 Migration of Groundwater Contaminants

Contaminants leaching from soils to underlying groundwater can migrate as dissolved constituents in groundwater in the direction of groundwater flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) advection, movement caused by flow of groundwater; (2) dispersion, movement caused by irregular mixing of waters during advection; and (3) retardation, principally chemical mechanisms which occur during advection. Subsurface transport of the immiscible contaminants is governed by a set of factors different from those of dissolved contaminants.

Advection

Advection is the process which most strongly influences the migration of dissolved organic solutes. Groundwater, under water table aquifer conditions (i.e., unconfined aquifer), generally flows from regions of the subsurface where the water table is under a higher head (i.e., recharge areas) to regions of where the water table is under a lower head (i.e., discharge areas). Hydraulic gradient is the term used to describe the magnitude of this force (i.e., the slope of the water table). The gradient typically follows the topography for shallow, uniform sandy aquifers which are commonly found in coastal regions. In general, groundwater flow velocities, in sandy aquifers, under natural gradient conditions are probably between 10 meters/year to 100 meters/year (32.8 to 328 feet/year) (Lyman, et al., 1982).

Thus, when monitoring wells or small supply wells in silty sand aquifers are located hundreds of thousands of meters downgradient of a contaminated source, the average travel time for the groundwater to flow from the source to the well point is typically on the order of decades. This site is very close to Northeast Creek where the groundwater may discharge to the surface water; therefore, this transport pathway may be significant at this site.

Dispersion

Dispersion results from two basic processes, molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes results in diffusion of solutes from a zone of high concentration to a lower concentration. Dispersion and spreading during transport result in the dilution of contaminants (maximum concentration of contaminant decreases with distance from the source). For simple hydrogeological systems, the spreading is reported to be proportional to the flow rate. Spreading is largely scale dependent. Furthermore, dispersion in the direction of flow is often observed to be markedly greater than dispersion in the directions transverse (perpendicular) to the flow. Because detailed studies to determine dispersive characteristics at the site were not conducted, longitudinal and transverse dispersivities are estimated based on similar hydrogeological systems (Mackay, et al., 1985).

Chemical Mechanisms

Some dissolved contaminants may interact with the aquifer solids encountered along the flow path through adsorption, partitioning, ion exchange, and other processes. The interactions result in the contaminant distribution between aqueous phase and aquifer solids, diminution of concentrations in the aqueous phase, and retardation of the movement of the contaminant relative to groundwater flow. The higher the fraction of the contaminant sorbed, the more retarded its transport. Certain halogenated organic solvents sorption is affected by hydrophobility (antipathy for dissolving in water) and the fraction of solid organic matter in the aquifer solids (organic carbon content). If the aquifer is homogeneous, sorption of hydrophobic organic solute should be constant in space and time. If the sorptive interaction is at equilibrium and completely reversible, the solute should move at a constant average velocity equal to the groundwaters average velocity divided by the retardation factor.

Organic contaminants can be transformed into other organic compounds by a complex set of chemical and biological mechanisms. The principal classes of chemical reactions that can affect organic contaminants in water are hydrolysis and oxidation. However, it is believed that most chemical reactions occurring in the groundwater zone are likely to be slow compared with transformations mediated by microorganisms. Certain organic groundwater contaminants can be biologically transformed by microorganisms attached to solid surfaces within the aquifer. Factors which affect the rates of biotransformation of organic compounds include: water temperature and pH, the number of species of microorganisms present, the concentration of substrate, and presence of microbial toxicants and nutrients, and the availability of electron acceptors. Transformation of a toxic organic solute is no assurance that it has been converted to harmless or even less harmless hazardous products. Biotransformation of common groundwater contaminants, such as trichloroethene (TCE), 1,1,1-trichloroethane (TCA), and tetrachloroethene (PCE), can result in the formation of such intermediates as vinyl chloride and 1,1-dichloroethene(Mackay, et al., 1985).

The interaction of non-ionic organic compounds with solid phases can also be used to predict the fate of the highly nonpolar organic contaminants (i.e., 4,4'-DDT, PCBs). Sorptive binding is proportional to the organic content of the sorbent. Sorption of non-ionic organic pesticides can be attributed to an active fraction of the soil organic matter (Lyman et al., 1982). The uptake of neutral organics by soils results from their partitioning to the solutes aqueous solubility and to its liquid-liquid (e.g., octanol-water) partition coefficient (Chiou, 1979). Currently, literature information is available on the interrelation of soil organic properties to the binding of pesticides, herbicides, and high molecular weight pollutants such as PCBs. Organic matrices in natural systems that have varying origins, degrees of humification, and degrees of association with inorganic matrices exhibit dissimilarities in their ability to sorb non-ionic organic contaminants.

The soils and sediments formed or deposited on the land surface can act as a reservoir for inorganic contaminants. Soils contain surface-active mineral and humic constituents involved in reactions that affect metal retention. The surfaces of fine-grained soil particles are very chemically active. The surface soils can be negatively charged, positively charged or electronically neutral.

Opposite charged metallic counterions from solutions in soils (i.e., groundwater) are attracted to these charged surfaces. The relative proportions of ions attracted to these various sites depends on the degree of acidity or alkalinity of the soil, on its mineralogical composition, and on its content of organic matter. The extent of adsorption depends on either the respective charges on the adsorbing surface and the metallic cation.

In addition to these adsorption reactions, precipitation of new mineral phases also may occur if the chemical composition of the soil solution becomes supersaturated with respect to the insoluble precipitates. Of the probable precipitates, the most important of these phases are hydroxides, carbonates, and sulfides. The precipitation of hydroxide minerals is important for metals such as iron and aluminum, the precipitation of carbonate minerals is significant for calcium and barium, and the precipitation of sulfide minerals dominates the soil chemistry of zinc, cadmium, and mercury. A number of precipitates may form if metals are added to soils the concentration of metal in solution will be controlled, at equilibrium, by the solid phase that results in the lowest value of the activity of the metallic ion in solution (Evans, 1989).

Table 5-2 presents the general processes which influence the aquatic fate of contaminants at Site 16; these processes include: sorption, volatilization, biodegradation, photolysis, hydrolysis, and bioaccumulation. For organic priority pollutants, consulting the rates contained in this table concerning the relative importance of aquatic processes for the fate of each compound, may aid in the elimination of unimportant processes.

5.2.5 Surface Soil Run-Off

Water can erode exposed soil and sediment particles during precipitation events. This is influenced by site topography, amount of precipitation, soil/sediment particle size/density and cohesion, and vegetative cover.

The topography of Site 16 is relatively flat, with a slight slope to the southeast. Overland drainage is in the southeast direction. This relatively flat topography would reduce the potential runoff. The Northeast Creek is approximately 400 feet southeast from the boundary of the burn dump. Therefore, surface runoff in the far southeastern portion of the site most probably will drain towards Northeast Creek. Surface soil and sediment analytical results indicated that surface soil runoff may not be an active pathway for the transport of contaminants off-site. PAHs, pesticides and PCBs were detected in the surface soils which were not detected in the sediment or the surface water.

The following paragraphs summarize the site-specific fate and transport data for some contaminants of potential concern at Site 16.

5.2.6 Migration of Contaminants in Surface Water

Contaminants leaching from soils to surface water can migrate as dissolved constituents in surface water in the direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) movement caused by the flow of surface water, (2) movement caused by irregular mixing of water, and (3) chemical mechanisms occurring during the movement of surface water. As stated earlier, sediment particles can disassociate from the sediment into surface water and migrate by one of the aforementioned methods.

The Northeast Creek lies approximately 400 feet southeast of the boundary of the burn dump. Therefore, this transport pathway may be significant at this site.

5.3 Fate and Transport Summary

The following paragraphs summarize the contaminant group fate and transport data for contaminants detected in media collected at Site 16.

5.3.1 Volatile Organic Compounds

VOCs (i.e., methylene chloride, acetone, toluene, bromomethane, benzene, ethylbenzene, and 1,1,2,2-tetrachloroethane) tend to be mobile in environmental media as indicated by their presence in groundwater and their corresponding MI values. Their environmental mobility is a function of high water solubilities, high vapor pressures, low K_{ow} and K_{oc} values, and high mobility indices.

Without a continuing source, VOCs do not generally tend to persist in environmental media because photolysis, oxidation, and biodegradation figure significantly in their removal.

5.3.2 Polynuclear Aromatic Hydrocarbons (PAHs)

Low water solubilities, high K_{ow} and K_{oc} indicate a strong tendency for PAHs to adsorb to soils. Of the PAHs, fluoranthene, is probably the best marker compound, since it is consistently the most abundant of the PAHs measured and provides the strongest correlation with total PAH values. Benzo(g,h,i)perylene is usually the most abundant compound in soils with low PAH values but becomes less important with increasing total PAH values. Other PAH are anthracene, benzo(a)anthracene, chrysene, pyrene, fluorene, benzo(g,h,i)perylene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, naphthalene, and phenanthrene. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint. An exception is naphthalene, which is considered only slightly immobile because of somewhat higher water solubility (Jones, et al., 1989).

PAHs generally lack adequate vapor pressures to be transmitted via vaporization and subsequent airborne transport. However, surface and shallow surface soil particles containing PAHs could potentially be subject to airborne transport and subsequent deposition, especially during mechanical disturbances such as vehicle traffic or digging (Jones, et al., 1989).

PAHs are somewhat persistent in the environment. In general their persistence increases with increasing ring numbers. Photolysis and oxidation may be important removal mechanisms in surface waters and surficial soils, while biodegradation could be an important fate process in groundwater, surface soils or deeper soils. PAHs are ubiquitous in nature.

5.3.3 Pesticides/Polychlorinated Biphenyls

Pesticides/PCBs are persistent and immobile contaminants in environmental media. Pesticides travel at varying rates through soil, mainly due to their affinity for soil surfaces. The soil sorption coefficient (K_d) is the distribution of a pesticide between soil and water. In general, the K_d values are higher for high organic carbon soil than for low organic carbon soils. Therefore, soils with high K_d values will retain pesticides (i.e., 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD). As evidenced by the ubiquitous nature of 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD, volatilization is an important transport process from soils and waters.

PCBs have low vapor pressures, low water solubilities, and high K_{oc} and K_{ow} values. Adsorption of these contaminants to soil and sediment is the major fate of these contaminants in the environment.

5.3.4 Inorganics

Inorganics can be found as solid complexes at ambient temperature and pressure in soils at the site. Inorganic ions exist in pure solutions as hydrated ions. Groundwater, as opposed to a pure solution, is a highly complex chemical system which is heavily influenced by the mineralogy of the substrate. Factors affecting the transport of inorganics in saturated soils are interactive and far more complex and numerous than those affecting the transport of organic contaminants.

The most complicated pathway for inorganic contaminants is migration in subsurface soils and groundwaters, where oxidation reduction potential (Eh) and pH play critical roles. Table 5-3 presents an assessment of relative inorganic environmental mobilities as a function of Eh and pH. pH in the soils at Site 16 range from relatively neutral to slightly alkaline, therefore, inorganics in the subsurface soil should be relatively immobile.

Transport of inorganic species in groundwater is mainly a function of the inorganic's solubility in solution under the chemical conditions of the soil-solution matrix. The inorganic must be dissolved (i.e. in solution) for leaching and transport by advection with the groundwater to occur. Generally, dynamic and reversible processes control solubility and transport of the dissolved metal ions. Such process include precipitation/dissolution, adsorption/desorption, and ion exchange.

Inorganics could be sorbed onto colloidal materials, theoretically increasing their inherent mobility in saturated porous media. It is important to note, however, that colloids themselves are not mobile in most soil/water systems.

Inorganics such as arsenic and chromium depend upon speciation to influence their mobility. Speciation varies with the chemistry of the environmental medium and temporal factors. These variables make the site-specific mobility of an inorganic constituent difficult to assess.

5.4 References

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for Alpha-, Beta-, Gamma-, and Delta- Hexachlorocyclohexane. U.S. Environmental Protection Agency. December 1988.

Agency for Toxic Substances and Disease Registry, U.S. Department of Health Services. Toxicological Profile for p,p'-DDT, p,p'-DDE and p,p'-DDD. April 1989.

Agency of Toxic Substances and Disease Registry. U.S. Public Health Service. Toxicological Profile for Selected PCBs (Aroclor -1260, -1254, -1248, -1242, -1232, -1221 and -1016). U.S. Environmental Protection Agency, Atlanta, Georgia. June 1989.

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for Naphthalene and 2-Methylnaphthalene. February 1990.

Agency for Toxic Substances and Disease Registry. U.S. Department of Human and Health Services. Public Health Service. Toxicological Profile for Aldrin/Dieldrin (Draft for Public Comment). Atlanta, Georgia. February 1992.

Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. Toxicological Profile for Endosulfan. April 1993

Chiou, C.T., L.J. Peters, and V.H. Freed, 1979. "A Physical Concept of Soil-Water Equilibra for Non-Ionic Organic Compounds." Science. Vol. 206, pp. 831-832.

Clement Associates Inc. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites, Final Report. September 1985.

Evans, 1989.

Ford and Gurba. 1984. Methods of Determining Relative Contaminant Mobilities and Migration Pathways Using Physical-Chemical Data.

Howard, Philip H. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Lewis Publishers. Chelsea, Michigan. 1991.

Jones, et al., 1989.

Laskowski, D.A., C.A. Goring, P.S. McCall and R.L. Swann. 1983. "Terrestrial Environment Risk Analysis for Chemicals, "Environmental Risk Analysis for Chemicals, R.A. Conways, ed., Van Nostrand Reinhold Company, New York, New York.

Lyman, W.J., W.F. Rechl, and D.H. Rosenblatt. 1982. Handbook of Chemical Property Estimation Methods. McGraw-Hill, Inc., New York.

Mackay, P.M., P.V. Roberts, and J.A. Cherry. 1985. "Transport of Organic Contaminants in Groundwater." Environmental Science and Technology. Vol. 19, No. 5, pp. 384-392.

Montgomery, J.H., and L.M. Welkon. Groundwater Chemicals Desk Reference. Lewis Publishers. Chelsea, Michigan. 1980.

SCDM, 1992. Superfund Chemical Data Matrix. Office of Solid Waste and Emergency Response. January 1992.

SPHEM, 1986 U.S. Environmental Protection Agency, 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response. Washington, D.C. October 1986. EPA 540/1-86-060.

Swartzbaugh, et al. 1992. "Remediating Sites Contaminated with Heavy Metals." Hazardous Materials Control, November/December, 1992.

U.S. Environmental Protection Agency, 1985. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Office of Solid Waste and Remedial Response. Washington, D.C. September 1985.

U.S. Environmental Protection Agency. September 1985. Water quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater - Part I. EPA 160-6-85/022a.

U.S. Environmental Protection Agency, 1986. Health and Environmental Effects Profile for Carbazole. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development. Cincinnati, OH. April 1986. EPA/600/X-86/334.

Verscheuren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Company, New York, 1983.

Versar. 1991. Remedial Investigation Interim Report, Naval Weapons Station, Yorktown, Virginia.

SECTION 5.0 TABLES

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES FOR ORGANIC CHEMICALS OF POTENTIAL CONCERN
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{oc}	Log K_{ow}	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index
Volatiles: Methylene Chloride	4.4 x 10^{+02}(1)	1.3 x 10^{+04}(1)	1.54(2)	1.3(1)	1.327(15)	2.2 x 10^{-03}(1)	5.2
Acetone	2.3 x 10^{+02}(1)	1.0 x 10^{+06}(1)	0.34(2)	-0.24(2)	0.791(14)	3.9 x 10^{-05}(1)	8.0
Toluene	2.8 x 10^{+01}(1)	5.3 x 10^{+02}(1)	2.48(2)	2.7(1)	0.867(14)	6.6 x 10^{-03}(1)	1.7
Bromomethane	1.6 x 10^{+03}(1)	1.5 x 10^{+04}(1)	--	1.2(1)	--	6.2 x 10^{-03}(1)	--
Benzene	9.5 x 10^{+01}(1)	1.8 x 10^{+03}(1)	1.92(2)	2.1(1)	0.879(14)	5.6 x 10^{-03}(1)	3.3
Ethylbenzene	9.6(1)	1.7 x 10^{+02}(1)	3.04(2)	3.2(1)	0.867(14)	8.4 x 10^{-03}(1)	0.2
Carbon Disulfide	3.6 x 10^{+02}(1)	1.2 x 10^{+03}(1)	1.73(2)	2.0(2)	1.263(14)	3.0 x 10^{-02}(1)	3.9
2-Methyl-2-pentanone	6(14)	1.9 x 10^{+04}(14)	1.47-2.29(14)	1.68(14)	0.8017(14)	4.15 x 10^{-05}(16)	3.6-2.8
1,1,2,2-Tetrachloroethane	6.1(1)	3.0 x 10^{+03}(1)	2.07(2)	2.6(1)	1.60(14)	4.6 x 10^{-04}(1)	2.2
Semivolatiles: Phenol	3.5 x 10^{-01}(1)	8.3 x 10^{+04}(1)	1.15(2)	1.5(1)	1.07(14)	3.3 x 10^{-07}(1)	3.3
1,4-Dichlorobenzene	1.0(1)	8.1 x 10^{+01}(1)	3.23(2)	3.4(1)	1.458(14)	2.4 x 10^{-03}(1)	-1.3
1,2,4-Trichlorobenzene	2.9 x 10^{-01}(1)	4.9 x 10^{+01}(1)	3.96(2)	4.3(1)	--	1.4 x 10^{-03}(1)	-2.8
Naphthalene	8.5 x 10^{-02}(1)	3.1 x 10^{+01}(1)	2.97(10)	3.6(1)	1.152(14)	4.8 x 10^{-04}(1)	-2.5
2-Methylnaphthalene	--	insoluble	3.03	3.6	1.0058(14)	--	--
Acenaphthene	1.5 x 10^{-03}(3)	3.47(3)	1.25(3)	3.97(3)	0.994(14)	1.5 x 10^{-04}(3)	2.5
Dibenzofuran	--	10(6)	3.9-4.1(6)	4.12-4.31(6)	1.0886(6)	--	--
Fluorene	1 x 10^{-02}(3)	1.69(3)	3.65(3)	4.18(3)	--	1.29 x 10^{-03}(3)	-5.4
Pentachlorophenol	2.4 x 10^{-08}(1)	2.0 x 10^{-03}(1)	4.72(2)	5.9(1)	1.978(14)	2.4 x 10^{-08}(1)	-15
Phenanthrene	9.6 x 10^{-04}(3)	1.0(3)	4.2(3)	4.46(3)	1.025(14)	2.25 x 10^{-04}(3)	-7.2
Fluoranthene	5.0 x 10^{-06}(3)	0.26(3)	4.64(3)	5.33(3)	--	5.12 x 10^{-06}(3)	-10.5
Anthracene	2.4 x 10^{-04}(3)	0.045(3)	4.20(3)	4.45(3)	1.25(14)	1.25 x 10^{-03}(3)	-9.2
Carbazole	7.0 x 10^{-04}(4)	1.2(4)	--	3.72(4)	1.1(4)	--	--

TABLE 5-1 (continued)

PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS OF POTENTIAL CONCERN
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{oc}	Log K_{ow}	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index
Di-n-butylphthalate	7.3×10^{-05}(1)	11(1)	5.23(2)	5.2(1)	1.0465(14)	--	-8.3
Pyrene	2.5×10^{-06}(3)	0.14(3)	4.64(3)	5.32(3)	--	4.75×10^{-06}(3)	-11.1
Butyl benzyl phthalate	8.3×10^{-06}(1)	2.7(1)	4.78(14)	4.9(3)	1.1(14)	1.3×10^{-06}(3)	-9.4
Benzo(a)anthracene	2.2×10^{-08}(3)	5.7×10^{-03}(3)	5.34(3)	5.61(3)	--	7.34×10^{-07}(3)	-15.2
Chrysene	6.3×10^{-09}(3)	1.8×10^{-03}(3)	5.34(3)	5.61(3)	1.274(14)	1.05×10^{-06}(3)	-16.3
Bis(2-ethylhexyl)phthalate	9.8×10^{-06}(1)	0.34(1)	8.73(2)	5.1(1)	0.99(14)	1.5×10^{-05}(1)	-14.2
Di-n-octylphthalate	2.6×10^{-06}(1)	3(1)	9.2(2)	9.2(1)	0.99(14)	--	-14.3
Benzo(b)fluoranthene	5×10^{-07}(3)	1×10^{-03}(3)	--	6.08(3)	--	1.66×10^{-04}(3)	--
Benzo(k)fluoranthene	5×10^{-07}(3)	5.5×10^{-04}(3)	--	6.08(3)	--	3.02×10^{-04}(3)	--
Benzo(a)pyrene	5.6×10^{-09}(3)	3.8×10^{-03}(3)	--	6.08(3)	1.274(14)	4.89×10^{-07}(3)	--
Indeno(1,2,3-cd)pyrene	1×10^{-10}(3)	5×10^{-04}(3)	--	6.51(3)	--	6.0×10^{-10}(3)	--
Benzo(g,h,i)perylene	1×10^{-10}(3)	3×10^{-04}(3)	--	6.51(3)	--	1.21×10^{-07}(3)	--
Pesticides/PCBs: delta-BHC	3.5×10^{-05}(1)	3.1(1)	3.5(5)	2.5-4.14(6)	1.87(14)	4.3×10^{-07}(1)	-7.5
Aldrin	1.4×10^{-04}(7)	0.2(7)	4.69(7)	3.01(7)	--	3.2×10^{-04}(7)	-9.2
Dieldrin	7.8×10^{-07}(7)	0.18(7)	3.87(7)	4.55(7)	1.75(14)	1.51×10^{-05}(7)	-10.7
4,4'-DDE	6.5×10^{-06}(9)	0.12(8)	6.6(8)	7(8)	--	2.1×10^{-05}(1)	-12.7
Endrin	3×10^{-06}(11)	2.5×10^{-04}(11)	3.92(6)	4.56(11)	--	7.5×10^{-06}(11)	-13
Endosulfan II**	1×10^{-05}(11)	0.51(11)	3.31(6)	3.83(11)	--	1.1×10^{-05}(11)	-8.6
4,4'-DDD	1×10^{-06}(9)	0.16(8)	5.9(8)	6.2(8)	--	4×10^{-06}(1)	-12.7
Endosulfan Sulfate	1×10^{-05}(12)	440(1)	3.37(6)	3.66(6)	--	2.1×10^{-03}(1)	-5.7
4,4'-DDT	1.9×10^{-07}(9)	0.0034(8)	5.4(8)	6.19(8)	--	8.3×10^{-06}(1)	-14.6
Methoxychlor	1.4×10^{-06}(11)	1×10^{-01}(1)	--	4.8(1)	--	1.6×10^{-05}(1)	--
Endrin Aldehyde***	3×10^{-06}(11)	2.5×10^{-04}(11)	3.92(6)	4.56(11)	--	7.52×10^{-06}(11)	-13

TABLE 5-1 (continued)

PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS OF POTENTIAL CONCERN
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{oc}	Log K_{ow}	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index
Endrin Ketone***	3 x $10^{-06(11)}$	2.5 x $10^{-04(11)}$	$3.92^{(6)}$	$4.56^{(11)}$	--	7.52 x $10^{-06(11}$)	-13
alpha-Chlordane*	9.8 x $10^{-06(1)}$	5.6 x $10^{-02(1)}$	$5.15^{(2)}$	$5.5^{(1)}$	--	4.9 x $10^{-05(1)}$	-11.4
gamma-Chlordane*	9.8 x $10^{-06(1)}$	5.6 x $10^{-02(1)}$	$5.15^{(2)}$	$5.5^{(1)}$	--	4.9 x $10^{-05(1)}$	-11.4
Aroclor-1254	7.7 x $10^{-05(13)}$	$0.012^{(13)}$	$5.72^{(2)}$	$6.5^{(13)}$	$1.50^{(17)}$	2 x $10^{-03(13)}$	-11.7
Aroclor-1260	4.1 x $10^{-05(13)}$	2.7 x $10^{-03(13)}$	$5.72^{(2)}$	$6.8^{(13)}$	$1.58^{(17)}$	4.6 x $10^{-03(13)}$	-12.7

Notes: -- = Value not available.
* - Values are for Total Chlordane
** - Values are for Endosulfan
*** - Values are for Endrin
(1) SCDM, 1992
(2) SPHEM, 1986.
(3) USEPA, 1985.
(4) USEPA, 1986.
(5) ATSDR, 1988.
(6) Montgomery, 1980.
(7) ATSDR, 1992.
(8) ATSDR, 1989.
(9) Clement, 1985.
(10) ATSDR, 1990.
(11) Howard, 1991.
(12) ATSDR, 1993.
(13) ATSDR, 1989.
(14) Verscheuren, 1983.
(15) Ford and Gurta, 1984.
(16) Lyman, 1982.
(17) Versar

TABLE 5-2

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Volatiles: Methylene Chloride	--	+	?	--	--	--
Acetone	NA	NA	NA	NA	NA	NA
Toluene	+	+	?	--	--	--
Bromomethane	--	+	--	--	+	--
Benzene	+	+	--	--	--	--
Ethylbenzene	?	+	?	--	--	--
Carbon Disulfide	NA	NA	NA	NA	NA	NA
2-Methyl-2-pentanone	NA	NA	NA	NA	NA	NA
1,1,2,2-Tetrachloroethane	?	+	--	--	--	?
Semivolatiles: Phenol	--	+	+	--	--	--
1,4-Dichlorobenzene	+	+	--	?	--	+
1,2,4-Trichlorobenzene	+	+	--	?	--	+
Naphthalene	+	--	+	+	--	--
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA
Acenaphthene(b)	+	--	+	+	--	--
Dibenzofuran	NA	NA	NA	NA	NA	NA
Fluorene(b)	+	--	+	+	--	--
Pentachlorophenol	NA	NA	NA	NA	NA	NA
Phenanthrene(b)	+	+	+	+	--	--
Fluoranthene(b)	+	+	+	+	--	--
Anthracene	+	+	+	+	--	--
Carbazole	NA	NA	NA	NA	NA	NA
Di-n-butylphthalate	+	--	+	--	--	+

TABLE 5-2 (Continued)

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Pyrene(b)	+	--	+	+	--	--
Butyl benzyl phthalate	+	--	+	--	--	+
Benzo(a)anthracene	+	+	+	+	--	--
Chrysene(b)	+	--	+	+	--	--
Bis(2-ethylhexyl)phthalate	+	--	+	--	--	+
Di-n-octylphthalate	+	--	+	--	--	+
Benzo(b)fluoranthene(b)	+	--	+	+	--	--
Benzo(k)fluoranthene(b)	+	--	+	+	--	--
Benzo(a)pyrene	+	+	+	+	--	--
Indeno(1,2,3-cd)pyrene(b)	+	--	+	+	--	--
Benzo(g,h,i)perylene(b)	+	--	+	+	--	--
Pesticides/PCBs: delta-BHC	NA	NA	NA	NA	NA	NA
Aldrin	NA	NA	NA	NA	NA	NA
Dieldrin	+	+	--	+	--	+
4,4'-DDE	+	+	--	+	--	+
Endrin	?	?	?	+	--	+
Endosulfan II	+	+	+	?	+	--
4,4'-DDD	+	+	--	--	--	+
Endosulfan Sulfate	+	+	+	?	+	--
4,4'-DDT	+	+	--	--	+	+
Methoxychlor	NA	NA	NA	NA	NA	NA
Endrin Aldehyde	?	?	?	+	--	+
Endrin Ketone	?	?	?	+	--	+
alpha-Chlordane	+	+	?	--	--	+

TABLE 5-2 (Continued)

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
gamma-Chlordane	+	+	?	--	--	+
Aroclor-1254	+	+	+(a)	?	--	+
Aroclor-1260	+	+	+(a)	?	--	+

Key to Symbols:
+ Could be an important fate process
- Not likely to be an important process
? Importance of process uncertain or not known
NA - Information not avialable

Notes:
(a) Biodegradation is the only process known to transform polychlorinated biphenyls under environmental conditions, and only the lighter compounds are measurably biodegraded. There is experimental evidence that the heavier polychlorinated biphenyls (five chlorine atoms or more per molecule) can be photolyzed by ultraviolet light, but there are no data to indicate that this process is operative in the environment.
(b) Based on information for PAH's as a group. Little or no information for these compounds exists.

Source: U.S. Environmental Protection Agency. September 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water - Part I. EPA/600-6-85/022a.

TABLE 5-3

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Environmental Conditions			
Relative Mobility	Oxidizing	Acidic	Neutral/Alkaline	Reducing
Very High			Se	
High	Se, Zn	Se, Zn, Cu, Ni, Hg, Ag		
Medium	Cu, Ni, Hg, Ag, As, Cd	As, Cd	As, Cd	
Low	Pb, Ba, Se	Pb, Ba, Be	Pb, Ba, Be	
Very Low	Fe, Cr	Cr	Cr, Zn, Cu, Ni, Hg, Ag	Cr, Se, Zn, Cu, Ni, Hg, Pb, Ba, Be, Ag

Notes:

As = Arsenic
Ag = Silver
Ba = Barium
Be = Beryllium
Cd = Cadmium
Cr = Chromium
Cu = Copper

Fe = Iron
Hg = Mercury
Ni = Nickel
Pb = Lead
Se = Selenium
Zn = Zinc

Source: Swartzbaugh, et al. "Remediating Sites Contaminated with Heavy Metals." Hazardous Materials Control, November/December 1992.

6.0 BASELINE RISK ASSESSMENT

6.1 Introduction

This Baseline Risk Assessment (BRA) evaluates the projected impact of contaminants of potential concern (COPCs) on human health and/or the environment, now and in the future, in a "no further remedial action scenario". The BRA process examines the data generated during the sampling and analytical phase of the RI, identifying areas of concern (AOCs) and COPCs with respect to geographical, demographic, physical and biological characteristics of the study area. These factors are combined with an understanding of physical and chemical properties of site-associated constituents, (relative to environmental fate and transport processes) and are then used to estimate contaminant concentrations at logical exposure pathway endpoints. Finally, contaminant intake levels are calculated for hypothetical receptors. Toxicological properties are applied in order to estimate potential public health threats posed by detected contaminants.

The BRA for Operable Unit (OU) No. 8, Site 16 has been conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989a and USEPA, 1991a) and USEPA Region IV Supplemental Risk Guidance (USEPA, 1991b).

The components of the BRA include:

- Identification of contaminants of potential concern
- The exposure assessment
- The toxicity assessment
- Risk characterization
- Uncertainty analysis
- Conclusions of the BRA and potential site risk

The BRA is divided into eight sections, including the introduction. Section 6.2 presents criteria for selecting COPCs. COPCs are chosen, for each environmental medium at each site, from an overall list of detected contaminants. Section 6.3 lists site characteristics, identifies potential exposure pathways, and describes current and future exposure scenarios. In section 6.4, potential exposure is calculated by estimating daily intakes, incremental cancer risks and hazard indices. In addition, advisory criteria for evaluating human health risk is presented. Section 6.5 addresses risk characterization. Section 6.6 addresses sources of uncertainty in the BRA. Section 6.7 provides conclusions regarding potential human health impacts, in terms of total site risk. Section 6.8 lists references sited in the BRA text. Referenced tables and figures are presented after the text portion of this section.

6.2 Contaminants of Potential Concern

COPCs are site-related contaminants used to quantitatively estimate human exposures and associated health effects. Five environmental media were investigated during this RI: surface soil, subsurface soil, groundwater, surface water and sediment. This section presents COPC selection for these media.

6.2.1 Criteria for Selecting Contaminants of Potential Concern

Criteria used in selecting COPCs from constituents detected during the field sampling and analytical phase of the investigation are:

- Historical information
- Comparison to background or naturally occurring levels
- Comparison to field and laboratory blank data
- Comparison to Risk-Based Concentrations (RBCs)
- Prevalence
- Federal and State criteria and standards
- Toxicity
- Comparison to anthropogenic levels
- Persistence
- Mobility

USEPA's Risk Assessment Guidance for Superfund provides the criteria used to establish COPCs (USEPA, 1989a). COPC selection also involves comparing detection levels to additional contaminant-specific criteria. A brief description of the selection criteria used in choosing final COPCs is presented below. A contaminant must not necessarily fit into all of these categories to be retained as a COPC.

6.2.1.1 Historical Information

Using historical information to associate contaminants with site activities, when combined with the following selection procedures, helps determine contaminant retention or elimination.

6.2.1.2 Background or Naturally Occurring Levels

Naturally occurring levels of chemicals are present under ambient conditions. Generally, a comparison to naturally occurring levels applies only to inorganic analytes, because the majority of organic contaminants are not naturally occurring. Background samples are collected from areas that are known to be uninfluenced by site contamination. An inorganic concentration is considered site-related only if it exceeds two times the mean concentration estimated for the site-specific background samples. The mean for surface soil inorganics is estimated using results from 41 sample locations. The mean for subsurface soil inorganics is estimated using results from 35 sample locations.

Background soil data is presented in Appendix F.

6.2.1.3 Contaminant Concentrations in Blanks

Associating contaminants detected in field related QA/QC samples (i.e., trip blanks, equipment rinsates and/or field blanks) or laboratory method blanks with the same contaminants detected in analytical samples can eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared to sample results with which the blanks are associated; however, due to the comprehensive nature of data sets, it is difficult to associate specific blanks with specific environmental samples. Thus, in order to evaluate contaminant levels, maximum contaminant concentrations reported in a given set of blanks are applied to an entire data set for a given medium.

In accordance with the National Functional Guidelines for Organics, common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be regarded as a direct result of site activities only when sample concentrations exceed 10 times the maximum blank concentration. For other contaminants not considered common in a lab, concentrations exceeding five times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991).

When evaluating contaminant concentrations in soil, Contract Required Quantitation Limits (CRQLs) and percent moisture are employed, in order to correlate solid and aqueous detection limits. The CRQL for semivolatiles (SVOCs) and pesticide/PCBs in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess SVOC and pesticide/PCB contaminant levels in soil using aqueous blanks, blank concentrations must be multiplied by 33 or 66 to account for variance from the CRQL. The final value is divided by the sample percent moisture, in order to account for the aqueous-to-solid blank medium adjustment.

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than five percent, a contaminant that may have been included according to its prevalence is eliminated as a COPC.

Maximum concentrations of common laboratory contaminants detected in blanks are presented in Table 6-1.

Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other TCL compounds) are regarded as positive results only when observed concentrations exceed five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds at concentrations less than five times the maximum level of contamination noted in any blank are considered not detected in that sample.

Maximum concentrations of other contaminants detected in blanks are presented in Table 6-1.

6.2.1.4 Risk-Based Concentrations

Risk-Based Concentrations (RBCs) were developed by USEPA Region III as benchmark concentrations for evaluating site investigation data. RBCs are not established as stand-alone decision-making tools, but as screening tools to be used in conjunction with other information to help select COPCs. Selecting COPCs using RBCs is accomplished by comparing the maximum concentration of each contaminant detected in each medium to its corresponding RBC. RBCs were developed using conservative default exposure scenarios suggested by the USEPA and the latest available toxicity indices for carcinogenic and systemic chemicals. The RBC corresponds to a Hazard Quotient of 1.0 and a lifetime cancer risk of 1E-6. RBCs represent protective environmental concentrations at which the USEPA would not typically take action (USEPA, 1995).

RBC values listed in the 1995 Region III Risk-Based Concentration table have been multiplied by a factor of 0.1, in order to generate more conservative values to be used in selecting noncarcinogenic COPCs for the risk assessment. This approach is explained in Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening (USEPA, 1993).

6.2.1.5 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. The judicious use of data sets limits for including infrequently detected contaminants. Chemical occurrence must be evaluated with respect to the number of samples taken in order to determine frequency criteria warranting the inclusion of a chemical as a COPC. Contaminants that are infrequently detected, (i.e., less than 5 percent when at least 20 samples of a medium are available) do not necessarily indicate contamination. Such detections may result from certain sampling or analytical practices.

A contaminant may not be retained for quantitative evaluation in the BRA if: (1) it is detected infrequently in an environmental medium, (2) it is absent or detected at low concentrations in other media, or (3) site history does not provide evidence to suggest that the contaminant should be present.

6.2.1.6 State and Federal Criteria and Standards

Contaminant concentrations in aqueous media can be compared to contaminant-specific state and federal criteria. This risk assessment utilizes North Carolina Water Quality Standards (NCWQS) for groundwater and surface water. The only enforceable federal regulatory standards for water are Federal Maximum Contaminant Levels (MCLs).

Regulatory guidelines are used, when necessary, to infer potential health risks and environmental impacts. Relevant regulatory guidelines include Ambient Water Quality Criteria (AWQC) and Health Advisories (HA).

Chemical-specific criteria and standards for soil are generally not available; however, base-specific background concentrations have been compiled in order to evaluate background levels of organic and inorganic constituents in surface and subsurface soil at MCB Camp Lejeune.

Tables 6-2 through 6-8 present data compared to applicable standards and criteria.

A brief explanation of the criteria and standards used for qualitative evaluation of COPCs is presented below.

North Carolina Water Quality Standards (Groundwater) - NCWQSs are the maximum allowable concentrations, resulting from any discharge of contaminants to the lands or waters of the state, that may be tolerated without threatening human health or otherwise rendering the groundwater unsuitable for its intended purposes.

Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies, designed to protect human health and promulgated under the Safe Drinking Water Act. MCLs also account for the technical feasibility of removing contamination from a public water supply. MCLs are based on laboratory or epidemiological studies and are applied to analyses of drinking water supplies consumed by a minimum of 25 persons. MCLs establish limits under which 70 kg adults, drinking 2 liters of water a day for 70 years, can avoid detrimental health effects.

Health Advisories - HAs are guidelines developed by the USEPA Office of Drinking Water for nonregulated constituents in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight 10 kg) who consume 1 liter of water per day or in adults (assumed body weight 70 kg) who consume 2 liters of water per day. HAs 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 used to set acceptable levels for potential human carcinogens.

North Carolina Water Quality Standards (Surface Water) - The NCWQSs for surface water are the standard concentrations that, either alone or in conjunction with other wastes in surface waters, will neither render waters injurious to aquatic life, wildlife, or public health, nor impair the waters for any designated use.

Ambient Water Quality Criteria - AWQCs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. 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 human health AWQCs 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 (i.e. the 10E-7 to 10E-5 range).

Region IV Sediment Screening Values - Currently, federal sediment quality criteria for the protection of aquatic life are being developed. In the interim, the USEPA Region IV Waste Management Division recommends using sediment values, compiled by the National Oceanic and Atmospheric Administration (NOAA), as screening values for evaluating the potential for chemical constituents in sediments to cause adverse biological effects. NOAA developed this screening method through evaluating biological effects data for marine and freshwater organisms obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed, and the lower 10 percentile (called an Effects Range-Low, or ER-L) and the median (called an Effects Range-Median, or ER-M) were determined.

If sediment contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable. If contaminant concentrations are between the ER-L and the ER-M, adverse effects are considered possible, and the USEPA recommends conducting sediment toxicity tests as a follow-up. If contaminant concentrations are below the ER-L, adverse effects are considered unlikely.

6.2.1.7 Toxicity

Contaminant toxicity assessment must be incorporated when selecting COPCs with respect to human health risk. Toxic properties to be considered in COPC selection include weight-of-evidence classification, carcinogenicity, mutagenicity, teratogenicity, systemic effects and reproductive toxicity. Bioaccumulation and bioconcentration properties may affect the severity of toxic response in an organism and/or subsequent receptors; these additional properties are evaluated if relevant data exist.

Despite their inherent toxicity, certain inorganic contaminants are essential nutrients (eg., calcium, iron). As such, these contaminants need not be considered in a quantitative risk assessment, if one of the following conditions applies: (1) they are detected at relatively low concentrations, (i.e., below two times average base-specific background levels or slightly elevated above naturally occurring levels) or (2) the contaminant is toxic at doses much higher than those which can be assimilated through exposures at the site.

6.2.1.8 Anthropogenic Levels

Ubiquitous anthropogenic background concentrations result from sources of contamination not related to the site, such as combustion of fossil fuels (i.e., automobiles), plant synthesis, natural fires and factories. Polynuclear aromatic hydrocarbons (PAHs) are examples of ubiquitous, anthropogenic chemicals. Sometimes it is difficult to determine whether contamination is actually site-incurred, or caused by contaminant-producing activities that are not site-related (i.e., anthropogenic). It then follows that systematically omitting anthropogenic background chemicals from the risk assessment may produce false negative results. For this reason, anthropogenic chemicals are typically not eliminated as COPCs without considering other selection criteria.

The remaining sections apply the aforementioned selection criteria, beginning with prevalence of detected analytical results in each medium of interest, in order to establish a preliminary list of COPCs for Site 16. Once this task is completed, a final list of media-specific COPCs is selected using the remaining criteria (persistence, mobility, toxicity, ARARs, RBCs, blank concentrations, background concentrations, and anthropogenic concentrations).

6.2.1.9 Persistence

Contaminant persistence in the environment varies in accordance with factors such as microbial content in soil and water, organic carbon content, contaminant concentration, climate and potential for microbes to degrade a contaminant under site conditions. In addition, chemical degradation, (i.e., hydrolysis) photochemical degradation and certain fate processes such as absorption may contribute to the elimination or retention of a particular compound in a given medium.

6.2.1.10 Mobility

A contaminant's physical and chemical properties are responsible for its transport in the environment. These properties, in conjunction with site conditions, determine whether a contaminant will have a greater tendency to volatilize into the air, out of surface soils or surface waters, or to relocate via advection or diffusion through soils, groundwaters, and surface waters.

Physical and chemical properties also determine tendency for contaminant adsorption onto soil/sediment particles. In summary, environmental mobility factors can increase or decrease contaminant effects on human health and/or the environment.

6.2.2 Selection of Contaminants of Potential Concern

The following sections present an overview of the analytical data obtained for each environmental medium during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria.

6.2.2.1 Surface Soil

Twenty-nine surface soil samples were analyzed for volatile organic contaminants (VOCs). Methylene chloride, acetone and toluene were detected in 3 of 29 samples. In each case, maximum concentrations are less than respective residential soil RBC values. Methylene chloride, acetone and toluene are not retained as surface soil COPCs.

Twenty-nine surface soil samples were analyzed for SVOCs. Phenol, 1,4-dichlorobenzene and naphthalene were detected at concentrations less than respective residential soil RBC values. In addition, these SVOCs were detected at frequencies less than 5 percent; as a result, these SVOCs are not retained as COPCs. 2-Methylnaphthalene was detected once at a concentration of 67 µg/kg; however, it is not retained as a COPC because its detection frequency, 1 in 29 samples, is less than 5 percent. Anthracene, fluoranthene, pyrene, butylbenzylphthalate, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene were detected at concentrations less than respective residential soil RBC values. For this reason, these SVOCs are not retained as COPCs. Benzo(g,h,i)perylene, detected in 1 of 29 samples, is not retained as a COPC, because its frequency of detection is less than 5 percent.

Phenanthrene was detected at a maximum concentration of 99 µg/kg, in 3 of 29 samples, a frequency greater than 5 percent. In addition, phenanthrene has no residential soil RBC. Benzo(a)pyrene was detected in 2 of 29 samples, a frequency greater than 5 percent. At 130 µg/kg, its maximum concentration exceeds its residential soil RBC. Consequently, these SVOCs are retained as COPCs in surface soil.

Twenty-nine surface soil samples were analyzed for pesticide/PCBs. Delta-BHC was detected in 1 of 29 samples, a frequency less than 5 percent. As a result, it is not retained as a COPC. Aldrin, 4,4'-DDE, endrin, endosulfan II, 4,4'-DDD, endosulfan sulfate, 4,4'-DDT, methoxychlor, endrin ketone, endrin aldehyde, alpha-chlordane and gamma-chlordane were detected at maximum concentrations less than respective residential soil RBCs. For this reason, these pesticide/PCBs are not retained as COPCs.

Dieldrin was detected in 10 of 29 samples, at a maximum concentration of 77 µg/kg; this concentration exceeds the residential soil RBC. Frequent detection and this exceedance warrant retaining dieldrin as a COPC. Aroclor-1254 and Aroclor-1260 were detected at frequencies of 13 in 29 and 2 in 29 samples, respectively. At respective maximum concentrations of 2,100 µg/kg and 210 µg/kg, Aroclor-1254 and Aroclor-1260 detections exceed respective residential soil RBCs. Consequently, these PCBs are retained as COPCs in surface soil.

Twenty-nine surface soil samples were analyzed for inorganic contaminants. Barium, cobalt, manganese, nickel, selenium, silver and vanadium were detected at maximum concentrations less than respective residential soil RBCs. For this reason, these inorganics are not retained as COPCs. Calcium, iron, magnesium, potassium and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

Thallium was detected at a frequency greater than 5 percent; however, it was detected infrequently, relative to other inorganic contaminants. Thallium was detected in 2 of 28 samples (7 percent), while other inorganics were detected in at least 8 of 28 samples (28 percent). In addition, thallium was detected at a maximum concentration of 3.6 µg/kg, just above the background level, 0.806 µg/kg. Furthermore, the absence of thallium in subsurface soil and groundwater suggests that the presence of thallium in surface soil is not due to site-related activities. Consequently, thallium is not retained as a COPC.

Aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury and zinc were detected frequently in surface soil samples (i.e., greater than 5 percent). These inorganics were detected at maximum concentrations exceeding respective background levels and residential soil RBCs. Consequently, these inorganic contaminants are retained as surface soil COPCs.

6.2.2.2 Subsurface Soil

Thirty-two subsurface soil samples were analyzed for VOCs. Bromomethane and acetone were detected at maximum concentrations less than respective residential soil RBCs. For this reason, these VOCs are not retained as COPCs.

Thirty-two subsurface soil samples were analyzed for SVOCs. The following SVOCs are not retained as COPCs, because they were detected at maximum concentrations less than respective residential soil RBCs: 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, naphthalene, acenaphthene, dibenzofuran, fluorene, pentachlorophenol, phenanthrene, anthracene, carbazole, di-n-butylphtalate, fluoranthene, pyrene, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, di-n-octylphthalate, benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene. 2-Methylnaphthalene and phenanthrene, detected in 1 of 32 samples, are not retained as COPCs, because frequencies of detection are less than 5 percent.

Thirty-two subsurface soil samples were analyzed for pesticide/PCBs. The following pesticide/PCBs were detected in subsurface soil: 4,4'-DDE, endosulfan II, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, gamma-chlordane and Aroclor-1254. None of these contaminants are retained as COPCs, because respective maximum concentrations are less than respective residential soil RBC values.

Thirty-two subsurface soil samples were analyzed for inorganic contaminants. The following inorganics are not retained as COPCs, because they were detected at concentrations less than respective residential soil RBCs: aluminum, barium, chromium, copper, lead, manganese, mercury, selenium, vanadium and zinc. Arsenic and beryllium, detected in 1 of 32 samples, are not retained as COPCs, because frequencies of detection are less than 5 percent. Calcium, iron, magnesium, potassium and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

There are no contaminants retained as COPCs in subsurface soil.

6.2.2.3 Groundwater

Six groundwater samples were analyzed for VOCs. Ethylbenzene was detected in one of six samples, at 1 µg/L. It is not retained as a COPC, because the maximum sample concentration is less than the tap water RBC.

Benzene was detected in one of six samples, at 37 µg/L. It was not detected in background samples or blanks, so it is retained as a COPC.

Six groundwater samples were analyzed for SVOCs. Phenol and naphthalene were detected at maximum concentrations less than respective tap water RBCs. For this reason, these SVOCs are not retained as COPCs. Bis(2-ethylhexyl)phthalate was detected in blanks at 1 µg/L. Because bis(2-ethylhexyl)phthalate is a common lab contaminant, this concentration is multiplied by 10 to yield a blank concentration of 10 µg/L. Bis(2-ethylhexyl)phthalate was detected in four of six samples, at a maximum concentration of 5 µg/L. Because the sample concentration is less than the concentration in blanks, bis(2-ethylhexyl)phthalate is not retained as a COPC.

Six groundwater samples were analyzed for inorganic contaminants. Barium, manganese and zinc were detected at maximum concentrations less than respective tap water RBCs. For this reason, these inorganics are not retained as COPCs. Lead was detected in blanks at 5.2 µg/L. It was detected in one of six samples at 3.2 µg/L. Because the sample concentration is less than the concentration in blanks, lead is not retained as a COPC. Calcium, iron, magnesium and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

6.2.2.4 Surface Water

Five surface water samples were analyzed for VOCs. 4-Methyl-2-pentanone was detected in one sample at 7 µg/L. It is retained as a COPC. 1,1,2,2-Tetrachloroethane was detected in one of five samples at 2 µg/L; however, it was not detected in background samples or blanks. For this reason, it is retained as a COPC in surface water.

Five surface water samples were analyzed for SVOCs. Bis(2-ethylhexyl)phthalate was detected in one of five samples at 10 µg/L. It was also, however, detected in blanks at 6 µg/L. As bis(2-ethylhexyl)phthalate is a common laboratory contaminant, the blank concentration is multiplied by a factor of 10 to yield a blank concentration of 60 µg/L. The bis(2-ethylhexyl)phthalate concentration in samples is less than the blank concentration, so it is not retained as a COPC.

Five surface water samples were analyzed for inorganic contaminants. Arsenic, chromium, lead and silver were detected at high frequencies, but in each case, maximum concentrations are less than respective background levels. For this reason, these inorganics are not retained as COPCs. Aluminum, calcium, iron, magnesium, potassium and sodium were detected frequently; however, these inorganics are not retained as COPCs, because they are considered essential nutrients.

Barium, manganese and vanadium were detected at fairly high frequencies (i.e., greater than 5 percent). Three of five barium detections exceed background levels. For this reason, barium is retained as a COPC in surface water. Manganese and vanadium were not detected in background samples or blanks. For this reason, they are retained as COPCs in surface water.

6.2.2.5 Sediment

Ten sediment samples were analyzed for VOCs. Carbon disulfide and toluene were detected at frequencies of one in ten and two in ten samples, respectively, at 2 µg/kg. These contaminants are retained as COPCs.

No SVOCs were detected in sediment samples.

Ten sediment samples were analyzed for inorganic contaminants. Cobalt was detected in three of ten samples. Cobalt concentrations are less than background levels. Consequently, cobalt is not retained as a COPC. Aluminum, barium, calcium, chromium, iron and manganese were detected in ten of ten samples, at concentrations below respective background levels. For this reason, these inorganics are not retained as COPCs. Magnesium and sodium were detected frequently, but these inorganics are not retained as COPCs, because they are considered essential nutrients.

Arsenic, beryllium and silver were detected in sediment samples, but were not detected in background samples or blanks. Lead, vanadium and zinc were detected in ten of ten samples, at concentrations exceeding respective background levels. Consequently, arsenic, beryllium, lead, silver, vanadium and zinc are retained as COPCs in sediment.

6.2.2.6 Summary of COPCs

Table 6-9 presents a detailed summary of COPCs identified in each environmental medium sampled at Site 16. Worksheets used for COPC selection are presented in Appendix L.

6.3 Exposure Assessment

This section addresses potential human exposure pathways at Site 16 and presents the rationale for their evaluation. Potential source areas and potential migration routes, in conjunction with contaminant fate and transport information, are combined to produce a site conceptual model. Exposure pathways to be retained for quantitative evaluation are subsequently selected, based on the conceptual site model.

6.3.1 Conceptual Site Model of Potential Exposure

A conceptual site model of potential sources, migration pathways and human receptors is developed to encompass all current and future routes for potential exposure at Site 16. Figure 6-1 presents the Site 16 conceptual model. Inputs to the conceptual model include qualitative descriptions of current and future land use patterns in the vicinity of Site 16. All available analytical data and meteorological data are considered, in conjunction with a general understanding of surrounding habitat demographics. The following list of receptors is developed for a quantitative health risk analysis:

- Future on-site residents (child and adult)
- Current military personnel
- Future construction worker

Contaminants detected in surface and subsurface soils are discussed in Section 4.0 (Nature and Extent of Contamination) and in section 6.2.2, selection of COPCs. Migration of COPCs from these sources can occur in the following ways:

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

The potential for a contaminant to migrate spatially and persist in environmental media is important in estimating exposure.

6.3.2 Exposure Pathways

This section presents exposure pathways, shown in Figure 6-1, associated with each environmental medium and each human receptor group. It then qualitatively evaluates each pathway for further consideration in the quantitative risk analysis. Table 6-10 presents the matrix of human exposure at Site 16.

6.3.2.1 Surface Soil

Potential exposure to surface soil may occur by incidental soil ingestion, contaminant absorption through the skin and inhalation of airborne particulates. Surface soil exposure is evaluated for future residential children and adults.

6.3.2.3 Groundwater

Currently, shallow groundwater at Site 16 is not used as a potable supply for residents or base personnel. However, in the future, (albeit unlikely due to poor transmissivity and insufficient flow) shallow groundwater may be tapped for potable water. In this scenario, potential exposure pathways are ingestion, dermal contact and inhalation of volatile contaminants while showering. Groundwater exposure is evaluated for future residential children and adults.

6.3.2.4 Surface Water/Sediment

Access to surface water at Site 16 is limited to a short stretch of the bank bordering Northeast Creek. It is possible that surface water recreational facilities may be expanded for future residents. Surface water and sediment exposure pathways include ingestion and dermal contact. Exposure is evaluated for future residential children and adults.

6.3.3 Quantification of Exposure

The concentrations used to estimate chronic daily intakes (CDIs) must represent the type of exposure evaluated.

Exposure to groundwater, surface water and sediment can occur distinctly, at one sampling location, or collectively, from various locations. These media are transitory in that their contaminant concentrations change over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points than those existing at Site 16. Consequently, the most complete groundwater, surface water and sediment contaminant concentrations, from an exposure standpoint, are representative exposure concentrations.

Soils are less transitory than the aforementioned media, and in most cases, soil exposure occurs over a wider area (eg., residential exposure). For this reason, upper confidence intervals are used to represent soil contaminant concentrations.

The human health risk assessment for future groundwater use incorporates groundwater data collected from all monitoring wells at a given site.

Because all data sets originate from a skewed underlying distribution, lognormal distribution is used to represent all relevant media. This ensures conservative CDI calculations.

Ninety-five percent upper confidence levels, (95 percent U.C.L.) derived for lognormal data sets, produce concentrations in excess of the 95 percent confidence interval derived assuming normality. The 95 percent U.C.L. for lognormal distribution is used for each contaminant in a given data set, in order to quantify conservative exposure values. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent U.C.L. can be greater than the maximum detected concentration. In such cases, the maximum concentration is used instead. The true mean, however, may still be higher than this maximum value. In other words, the 95 percent U.C.L. indicates that a higher mean is possible, especially if the most contaminated portion of the site, by chance, has not been sampled (USEPA, 1992c).

Statistical summaries are presented in Appendix M.

6.3.4 Calculation of Chronic Daily Intakes (CDI)

In order to numerically calculate risks for current and future human receptors at Site 16, a CDI must be computed for each COPC, in each relevant exposure pathway.

Appendix N contains CDI equations for specific exposure scenarios (USEPA, 1989a).

The following paragraphs present the general equations and input parameters used to calculate CDIs. Input parameters are taken from USEPA's default exposure factors guidelines. All inputs not defined by this source are derived either from other USEPA exposure documents or by using best professional judgment. All exposure assessments incorporate representative contaminant concentrations; only one exposure scenario is developed for each exposure route/receptor combination.

Exposure assessment summaries are presented in Tables 6-11 through 6-20.

Carcinogenic risk is calculated as an incremental lifetime risk, and thereby involves exposure duration (years) over the course of a lifetime (70 years, or 25,550 days).

Noncarcinogenic risk, on the other hand, involves average annual exposure. Exposure time and frequency represent the number of hours of exposure per day, and days of exposure per year, respectively. Generally, noncarcinogenic risk for certain exposure routes (e.g., soil ingestion) is greater for children, as the combination of a lower body weight and an exposure frequency equal to that of an adult increases their ingestion rates.

Future residential exposure scenarios address 1 to 6-year old children weighing 15 kg, and adults weighing 70 kg, on average. An exposure duration of 4 years is used to estimate military residential exposure duration. A one year duration is used for future construction workers.

6.3.4.1 Incidental Ingestion of Soil

The equation for CDI, calculated for all human receptors potentially experiencing incidental soil ingestion, is as follows:

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

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor (1E-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 explain the exposure assumptions used to evaluate the impact of COPCs in incidental soil ingestion.

In each exposure scenario, the Fi value, indicating the portion of exposure from soils actually containing COPCs, is 100 percent.

Future On-Site Residents

Future on-site residents may be exposed to COPCs in surface soil, during outdoor activities around their homes. In addition, children and adults may be exposed to COPCs by incidental ingestion of surface soil through hand-to-mouth contact.

Ingestion rates (IR) for adults and children in this scenario are assumed to be 100 mg/day and 200 mg/day, respectively. The EF for both receptor groups is 350 days per year. Residential exposure duration (ED) is divided into two parts. First, a six-year ED, used for young children, represents the period of highest soil ingestion (200 mg/day). Second, a 24-year ED, used for older children and adults, represents a period of lower soil ingestion (100 mg/day) (USEPA, 1991a).

The BW of future residential children (age 1 to 6 years) is assumed to be 15 kg, and 70 kg is used as the BW for future residential adults.

AT values of 25,550 days (70 years x 365 days/year) and 8,760 days (24 years x 365 days/year) are assigned to potentially carcinogenic and noncarcinogenic constituents, respectively, to estimate adult CDIs. The AT used for children exposed to noncarcinogens is 2,190 days (6 years x 365 days/year).

Military Personnel

During the course of daily activities at Site 16, military personnel may be exposed to COPCs by ingesting surface soil.

The IR for military personnel exposed to surficial soils is assumed to be 100 mg/day (USEPA, 1989a). An EF of 350 days per year is used in conjunction with a 4-year ED.

Carcinogenic compounds have an AT 25,550 days (70 years x 365 days/year), and the AT for noncarcinogenic compounds is 1,460 days (4 years ED x 365 days/year). Adult average body weight BW is 70 kg (USEPA, 1989a).

Future Construction Worker

Construction workers may be exposed to COPCs through incidental ingestion of subsurface soil, during the course of excavation activities.

An IR of 480 mg/day is assigned to future construction workers. A 90-day per year EF is used in conjunction with a 1-year ED, representing the estimated length of a typical construction job (USEPA, 1991a). AT_{nc} is 365 days (USEPA, 1989a).

CF, Fi, BW and AT_c values are the same as those used for adults in the residential exposure scenarios.

A summary of incidental soil ingestion exposure assessment input parameters is presented in Table 6-11.

6.3.4.2 Dermal Contact with Soil

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with soil, is as follows:

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

Where:

C = Contaminant concentration in 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)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with soil.

Future On-Site Residents

Future on-site residents may be exposed to COPCs through dermal contact with surface soil during outdoor activities near their homes.

The SA values represent reasonable worst case scenarios for an individual wearing a short-sleeved shirt, shorts, and shoes. The exposed skin surface area is limited to the head, hands, forearms and lower legs. Twenty-five percent of the upper-bound total body surface area yields a default SA of 5,800 cm^2 for adults. The exposed skin surface for a child (2,300 cm^2) is estimated using an average of the 50th (0.866 m^2) and the 95th (1.06 m^2) percentile body surface for a six year old child, multiplied by 25 percent (USEPA, 1992a).

ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1992b).

Military Personnel

Base personnel may be exposed to COPCs through dermal contact with surface soil, during the course of military activities.

It is assumed that military personnel have approximately 5,800 cm^2 of skin surface (SA) available for contact with COPCs (USEPA, 1992a). Exposed body parts include the hands, head, forearms and lower legs, and represent 25 percent of total body surface area (23,000 cm^2). Taking 25 percent of the upper-bound total body surface area gives the default value 5,800 cm^2 for military personnel.

ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Future Construction Worker

Construction workers may be exposed to COPCs through dermal contact with subsurface soil, experienced during excavation activities.

It is assumed that a construction worker wears a short-sleeved shirt, long pants and boots. Exposed skin surface area is then limited to the head, (1,180 cm^2) arms (2,280 cm^2) and hands (840 cm^2) (USEPA, 1992a). Total SA for the construction worker is 4,300cm^2.

ED and EF values are the same as those used in the incidental soil ingestion scenario.

Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1992b).

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

6.3.4.3 Inhalation of Fugitive Particulates

The equation for CDI, calculated for future residents and base personnel potentially inhaling particulates, is as follows:

$$CDI = \frac{C \times IR \times ET \times EF \times ED \times 1/PEF}{BW \times AT}$$

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
1/PEF = Particulate emission factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (days)

PEF relates contaminant concentrations in soil to concentrations of respirable particles in air, from surface soil fugitive dust emissions. A default PEF is used in this assessment (USEPA 1989b). Particulate emissions at contaminated sites occur vis-a-vis wind erosion, and thereby vary according to irritability of the surface material. PEF is 4.63E09m^3/kg for all receptors in this scenario (Cowherd et al., 1985).

The following paragraphs explain the exposure assumptions used to evaluate COPC impact in particulate inhalation.

Future On-Site Residents

Future on-site residents may be exposed to COPCs by inhaling fugitive dust during outdoor activities near their homes.

The adult IR for residential exposure scenarios is 20 m^3/day, and 10 m^3/day is used for children, in the absence of a derived value (USEPA 1989a).

ED, EF, BW and AT values are the same as those used the incidental soil ingestion scenario.

Military Personnel

During work related activities, military personnel may inhale COPCs emitted as fugitive dust. An inhalation rate of 20 m^3/day is used in this scenario (USEPA 1991a).

ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Future Construction Worker

Construction workers may be exposed to COPCs through inhalation of fugitive particulates in subsurface soil, during excavation activities. IR is 20 m^3/day (USEPA 1991a).

ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

A summary of particulate inhalation exposure assessment input parameters is presented in Table 6-13.

6.3.4.4 Ingestion of Groundwater

Currently at Site 16, deep groundwater provides the potable water supply. Due to the generally low water quality and poor flow rates in the shallow aquifer, it is not likely that the shallow aquifer will be developed as a potable water supply. However, should residential housing be constructed in the future, shallow groundwater may be used to provide potable supplies. Currently, there are five supply wells within a one-half mile radius of this site. These supply wells utilize the Castle Hayne aquifer. If well contamination is reported, the wells are no longer used as potable water supplies.

The equation for CDI, calculated for all human receptors potentially ingesting groundwater, is as follows:

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

Where:

C = Contaminant concentration is groundwater (mg/L)
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)

BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs explain the exposure assumptions used to calculate the impact of COPCs in groundwater ingestion.

Future On-Site Residents

Exposure to COPCs by groundwater ingestion is a possible future exposure pathway for children and adults.

A 6-year-old child weighing 15kg has an IR of 1.0 L/day. This rate provides a conservative exposure estimate, in terms of systemic health effects. This value assumes that children obtain all the tap water they drink from the same source, for 350 days/year (EF). AT is 2,190 days (6 years x 365 days/year) for noncarcinogenic compound exposure.

IR for adults is 2 L/day (USEPA 1989a). ED is 30 years, the national upper-bound (90th percentile) time spent at one residence (USEPA 1989b). AT for noncarcinogens is 10,950 days. An AT of 25,550 days (70 years x 365 days/year) is used to evaluate exposure to potential carcinogenic compounds, for children and adults.

A summary of groundwater ingestion exposure assessment input parameters is presented in Table 6-14.

6.3.4.5 Dermal Contact with Groundwater

As stated previously, deep groundwater currently provides the potable water supply at Site 16. Due to the generally low water quality and poor flow rates in the shallow aquifer, it is not likely that the shallow aquifer will be developed as a potable water supply. However, should residential housing be constructed in the future, shallow groundwater may be used to provide potable supplies. Currently, there are five supply wells within a one-half mile radius of this site. These supply wells tap the Castle Hayne aquifer. If well contamination is reported, the wells are no longer used as potable water supplies.

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with groundwater, is as follows:

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

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 (1 L/1000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with groundwater.

Future On-Site Residents

Children and adults may be exposed to COPCs through dermal contact with groundwater while bathing or showering.

It is assumed that bathing takes place 350 days/year (EF). The SA available for dermal absorption is estimated at 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992c).

PC indicates the movement of a chemical through the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose; however, many compounds do not have published PC values. The permeability constant for water (1.55E-03 cm/hr) is used as a default value for those compounds without established PC values (USEPA 1992a). This value may, in fact, be a reasonable estimate of chemical absorption rates when COPC concentrations are in the part-per-billion range.

ET for bathing or showering is 0.25 hours/day, a conservative estimate.

ED, BW and AT values are the same as those used in the groundwater ingestion scenario.

A summary of dermal contact with groundwater exposure assessment input parameters is presented in Table 6-15.

6.3.4.6 Inhalation of Volatile Organics While Showering

The Foster and Chrostowski (1986) inhalation model is applied in a qualitative assessment of inhaling volatile organics released from shower water. Contaminant (VOC) concentrations in air while showering are estimated by determining the following: the rate of chemical releases into air, (generation rate) the buildup of VOCs in the shower room air when the shower is on, the decay of VOCs in the shower room after the shower is turned off and the quantity of airborne VOCs inhaled while the shower is on and off.

The equation for CDI, calculated for all human receptors potentially inhaling volatile organics while showering, is as follows:

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

Where:

C = Contaminant concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT_c = Averaging time carcinogen (days)
AT_{nc} = Averaging time noncarcinogen (days)

Future On-Site Residents

The potential to inhale vaporized volatile organic COPCs while showering is considered for both children and adults.

It is assumed that showering takes place 350 days/year (EF). IR for children and adults is 0.6 m^3/hr. ET is 0.25 hrs/day for both receptors (USEPA, 1989a).

ED, BW and AT values are the same as those used in the groundwater ingestion scenario.

A summary of groundwater inhalation exposure assessment input parameters is presented in Table 6-16.

6.3.4.7 Incidental Ingestion of Surface Water

The equation for CDI, calculated for all human receptors potentially ingesting surface water, is as follows:

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

Where:

C = Contaminant concentration in surface water (mg/L)
IR = Ingestion rate (L/hr)
ET = Exposure time (hrs/event)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (years)
DY = Days per year (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in surface water ingestion.

Future On-Site Residents

The IR, ET and EF values used for future residents apply to both children and adults. IR is 0.05 L/hr (USEPA, 1989a). ET is 2.6 hr/day (USEPA, 1992a). EF is 48 events/yr. This value represents a site-specific professional judgement, according to which exposure to surface water is estimated at 8 days/month, for 6 months/year.

ED values represent lifetime residential exposure durations. They are the same as those used for future children and adult residents in the groundwater exposure scenarios.

BW and AT values are also the same as those used in groundwater exposure scenarios.

A summary of surface water ingestion exposure assessment input parameters is presented in Table 6-17.

6.3.4.8 Dermal Contact with Surface Water

The equation for CDI, for all residents potentially experiencing dermal contact with surface water, is as follows:

$$Intake\ (mg/kg{\cdot}day) = \frac{C \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

Where: C = Contaminant concentration in surface water (mg/L)
SA = Exposed skin surface available for contact (cm^2)
PC = Permeability constant (cm/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (1 L/1,000 cm^3)
BW = Body weight (kg)
AT_c = Averaging time carcinogen (days)
AT_{nc} = Averaging time noncarcinogen (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with surface water.

Future On-Site Residents

SA values represent dermal surface area of hands, forearms and lower extremities exposed for contact with surface water. SA is 2100 cm^3 for children and 8300 cm^3 for adults (USEPA, 1992a).

ET, EF, ED, BW and AT values are the same as those used for future children and adult residents in the groundwater ingestion exposure scenario.

PC values are chemical-specific (USEPA, 1992a). They are provided on the CDI spreadsheets in Appendix N.

A summary of surface water dermal contact exposure assessment input parameters is presented in Table 6-18.

6.3.4.9 Incidental Ingestion of Sediment

The equation for CDI, for all residents potentially experiencing incidental ingestion of sediment, is as follows:

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

Where:

C = Contaminant concentration in sediment (mg/kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor for kg to mg (mg/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (years)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in sediment ingestion.

Future On-Site Residents

IR is 200 mg/day for both children and adults (USEPA, 1989a).

EF, ED, BW and AT values are the same as those used for future children and adult residents in the groundwater exposure scenarios.

CF is 1E-06 kg/mg (USEPA, 1989a). It is applied to sediment exposure analyses for both children and adults.

A summary of sediment ingestion exposure assessment input parameters is presented in Table 6-19.

6.3.4.10 Dermal Contact with Sediment

The equation for CDI, for all residents potentially experiencing dermal contact with sediment, is as follows:

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

Where:
C = Concentration of contaminant in sediment (mg/kg)
CF = Conversion factor for kg to mg
SA = Exposed skin surface area (cm^2)
AF = Sediment to skin adherence factor (mg/cm$^{2)}$
Abs = Fraction absorbed (unitless)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (years)
DY = Days per year (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in dermal contact with sediment.

Future On-Site Residents

SA values are the same as those used for future residential children and adults in the dermal contact with surface water exposure scenario.

AF is 1.0 mg/cm^2. It is used to evaluate dermal contact with sediment for both children and adults. ABS is 1.0 percent for organics and 0.1 percent for inorganics (USEPA, 1991b).

EF, ED, BW, AT and CF values are the same as those used in the sediment ingestion exposure scenario.

A summary of sediment dermal contact exposure assessment input parameters is presented in Table 6-20.

Appendix N contains CDI calculation spreadsheets for specific exposure scenarios (USEPA 1989a).

6.4 Toxicity Assessment

This section reviews toxicological information available for COPCs identified in Section 6.2.

6.4.1 Toxicological Evaluation

Toxicological evaluation addresses the inherent toxicity of chemical compounds. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with exposure to various contaminants.

Because of uncertainties in exposure estimates and inherent difficulties in determining causal relationships established by epidemiological studies, human data from occupational exposures are often insufficient for determining quantitative indices of toxicity. For this reason, animal bioassays are conducted under controlled conditions, and results are extrapolated to humans. There are several stages in this extrapolation. First, to account for species differences, conversion factors are used to apply test animal data to human studies. Second, high dosage administered to test animals must be translated into lower dosage, more typical of human exposure. When developing acceptable human doses of noncarcinogenic contaminants, safety factors and modifying factors are applied to animal test results. When studying carcinogens, mathematical models are used to convert high dosage effects to effects at lower dosages. Epidemiological data can then be used to determine credibility of these experimentally derived indices.

Reference dose (RfD) is an experimentally derived exposure index for noncarcinogenic contaminants, and carcinogenic slope factor (CSF) is an experimentally derived exposure index for carcinogens. These values are addressed, within the context of dose-response evaluation, in the next section.

Available toxicological information indicates that many COPCs have both carcinogenic and noncarcinogenic health effects in humans and/or experimental animals. Although COPCs may cause adverse health and environmental effects, dose-response relationships and exposure must be evaluated before receptor risk can be determined. Dose-response relationships correlate dose magnitude with the probability of toxic effects, as discussed in the following section.

6.4.2 Dose-Response Evaluation

An important component in risk assessment is the relationship between the dose of a compound 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.

6.4.2.1 Carcinogenic Slope Factor

CSFs are used to estimate upper-bound lifetime probability of developing cancer as a result of exposure to a particular dose of a potential carcinogen (USEPA, 1989a). This factor is generally reported in $(mg/kg/day)^{-1}$ CSF is derived by converting high dose-response values produced by animal studies to low dose-response values, and by using an assumed low-dosage linear multistage model. The value used in reporting the slope factor is the upper 95th percent confidence limit.

USEPA WOE classifications accompany CSFs. They provide the weight of evidence according to which particular contaminants are defined as potential human carcinogens.

The USEPA's Human Health Assessment Group (HHAG) classifies carcinogenic potential by placing chemicals into one of the following groups, according to weight of evidence from epidemiological and animal studies:

Group A	-	Human Carcinogen (sufficient evidence of carcinogenicity in humans)
Group B	-	Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)

Group C	-	Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
Group D	-	Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)
Group E	-	Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies)

6.4.2.2 Reference Dose

RfD is developed for chronic and/or subchronic chemical exposure and is based solely on noncarcinogenic effects of chemical substances. It is defined as an estimate of the daily exposure level for a human population that is not likely to produce 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 the appropriate "uncertainty factor (UF)". Effect levels are determined by laboratory or epidemiological studies. The UF is based on the availability of toxicity data.

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

- 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 UFs, 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 WOE classifications are presented in Table 6-21. The hierarchy for choosing these values is as follows (USEPA, 1989a):

- Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Table (HEAST)
    - USEPA Environmental Criterion Assessment Office (EPA-ECAO) (USEPA, 1995)

The IRIS database is updated monthly and contains both verified CSFs and RfDs. The USEPA has formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup to review and to validate toxicity values used in developing CSFs. Once the slope factors have been verified with extensive peer review, they appear in the IRIS database. Like the CSF Workgroup, an RfD Workgroup has been formed by the USEPA to review existing data used to derive RfDs. Once RfDs have been verified, they also appear in IRIS.

HEAST, on the other hand, provides both interim (unverified) and verified CSFs and RFDs. This document is published quarterly and incorporates any applicable changes to its database.

6.5 Risk Characterization

This section presents estimated incremental lifetime cancer risks (ICRs) and hazard indices (HIs) for identified receptor groups possibly exposed to COPCs by the exposure pathways presented in Section 6.3.

Quantitative risk calculations for carcinogenic compounds estimate ICR levels for individuals in a given population. An ICR of 1E-06, for example, indicates that, within a lifetime of exposure to site-specific contamination, one additional case of cancer may occur per one million exposed individuals.

The following represents an individual's ICR:

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

where CDI_i is the chronic daily intake (mg/kg/day) for compound i, and CSF_i is the compound's carcinogenic slope factor [(mg/kg/day)-1]. The CSF is defined as an upper 95th percentile confidence limit of the probability of a carcinogenic response, based on experimental animal data. The CDI defines 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 is 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.

Quantitative noncarcinogenic risk calculations assume that noncarcinogenic compounds have threshold values for toxicological effects. Noncarcinogenic effect weighs CDI against threshold levels (RfDs). Noncarcinogenic effect is estimated by calculating the hazard index (HI), defined by the following equation:

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

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

$$\gamma \text{ where } HQ_i = CDI_i / RfD_i$$

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

6.5.1 Human Health Risks

ICR and HI values associated with exposure to environmental media at Site 16 (soil, groundwater and surface water/sediment) are presented in Tables 6-22, 6-23 and 6-24, respectively. Total carcinogenic and noncarcinogenic risks, per medium, for all relevant receptor groups, are provided in these tables. ICR and HI are also broken down to show risks from specific exposure pathways: ingestion, dermal contact and inhalation (where applicable).

The text in this section explains the calculated risk results for Site 16, presented in Tables 6-22, 6-23 and 6-24.

A cancer risk range of 1E-04 to 1E-06 is used to evaluate calculated ICR levels. Any ICR value within this range is considered "acceptable"; an ICR greater than 1E-04 denotes an existing cancer risk. A noncarcinogenic risk of 1.0 is used as an upper limit to which calculated HI values are compared. Any HI exceeding 1.0 indicates an existing noncarcinogenic risk (USEPA 1989a).

6.5.1.1 Soil

ICR values calculated for future residential children and adults, Current Military Personnel, and future construction workers fall within the USEPA's acceptable risk range. Cancer risks above the acceptable range are not likely for receptors exposed to Site 16 soil. HI values calculated for these receptors are less than 1.0, below the acceptable risk level. Adverse systemic health effects above the acceptable limit are not likely to be caused by noncarcinogens in Site 16 soil.

6.5.1.2 Groundwater

ICR values calculated for future residential children and adults fall within the USEPA's acceptable risk range. Cancer risks above the acceptable range are not likely for receptors exposed to Site 16 groundwater. HI values calculated for future residential children and adults are less than 1.0, below the acceptable risk level. Adverse systemic health effects above the acceptable limit are then not likely to be caused by noncarcinogens in Site 16 groundwater.

6.5.1.3 Surface Water/Sediment

ICR values calculated for future residential children and adults fall within or below the USEPA's acceptable risk range. Cancer risks above the acceptable range are not likely for receptors exposed to Site 16 surface water/sediment. HI values calculated for future residential children and adults are less than 1.0, below the acceptable risk level. Adverse systemic health effects above the acceptable limit are not likely to be caused by noncarcinogens in Site 16 surface water/sediment.

6.6 Sources of Uncertainty

Uncertainties may arise during the risk assessment process. This section presents site specific sources of uncertainty in the risk assessment:

- Analytical data
- Exposure Assessment
- Toxicity Assessment
- Compounds Not Qualitatively Evaluated

6.6.1 Analytical Data

The credibility of the BRA relies on the quality of the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the analytical method of analysis. In addition, the statistical methods used to compile and analyze data (mean concentration, standard deviation, and detection frequencies) are subject to uncertainty in the ability to acquire data.

Data validation serves to reduce some of the inherent uncertainty associated with 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 risk estimation. Data can be qualified as "J" (estimated) for many reasons, including a slight exceedance of holding times, high or low surrogate recovery, or intra-sample variability. Data qualified with "J" were retained for risk assessment. Organic data qualified with "B" (detected in blank) or "R" (rejected/unreliable) were not applied to risk analysis. Because the sampling and analytical program at Site 16 was so comprehensive, dismissing data points qualified with "B" or "R" did not significantly increase uncertainty in the risk assessment.

6.6.2 Exposure Assessment

When performing exposure assessments, uncertainties can 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 can arise in estimating contaminant intakes resulting from contact with a particular medium.

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

Potential inhalation of fugitive dusts from affected soils is estimated by using USEPA's Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination (Cowherd et al., 1985). The Cowherd model employs the use of a site-specific PEF for wind erosion based on source area and vegetative cover. A conservative PEF estimate was derived for Site 16 by assuming that the entire area was not covered with vegetation and was unlimited in its erosion potential.

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, in order to produce the most conservative risk estimates, total organic results were used to calculate the potential intake associated with groundwater use.

As stated previously, the shallow groundwater at Camp Lejeune is currently not used as a potable source. Receptors are only exposed to groundwater drawn from the deep zone. For this reason, exposure to shallow groundwater is not evaluated for current receptors. Groundwater exposure is evaluated for future residents only, as there is a possibility that shallow groundwater may be tapped someday.

To estimate receptor intake, certain assumptions must be made about exposure events, exposure durations and the corresponding assimilation of contaminants by the receptor. Exposure factors have been created from a range of values generated by studies conducted by the scientific community, and have been reviewed by the USEPA. Conservative assumption for daily intakes are employed throughout the BRA when values are not available; they are designed to produce low error, to protect human health and to yield reasonable clean-up goals. In all instances, the values, conservative scientific judgments and conservative assumptions used in the risk assessment concur with USEPA guidelines.

6.6.3 Sampling Strategy

As an environmental medium, soil is available for direct contact exposure, and it is often the main source of contamination released to other media. Soil sampling intervals should be appropriate for the exposure pathways and contaminant transport routes of concern. Surface soil exposure assessment is based on samples collected from the shallowest depth, 0 to 1 foot below the ground surface. Subsurface soil samples are necessary to generate data for exposure assessment when soil excavation is possible, or if leaching of chemicals to groundwater is likely. Subsurface soil samples are collected at depths greater than 1 foot below the ground surface.

6.6.4 Toxicity Assessment

In making quantitative estimates about the toxicity of varying chemical doses, uncertainties arise from two sources. First, existing data usually provide insufficient information about toxic exposure and subsequent effects. Human exposure data display inherent temporal variability and often lack adequate concentration estimates. Animal studies are often used to subsidize available human data. In the process of extrapolating animal results to humans; however, more uncertainties can arise.

Second, in order to obtain visible toxic effects in experimental animals, high chemical doses are employed over short periods of time. Doses typical of human exposure, however, are much lower, relative to those doses administered to experimental animals. In order to apply animal test results to human exposure assessments, then, data must be adjusted to extrapolate from high dose effects to low dose effects.

In extrapolating effects from animal receptors to human receptors, and from 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 in which the animal closely mimics human pharmacokinetics
- Studies are preferred in which dose intake most closely mimics intake route and duration for humans
- Studies are preferred in which the most sensitive responses to the compound in question is demonstrated

In order to evaluate compounds that cause threshold effects, (i.e., noncarcinogens) safety factors are taken into account when experimental results are extrapolated from animals to humans, and from high to low doses.

Employing conservative assumptions yields quantitative toxicity indices that are not expected to underestimate potential toxic effects, but may overestimate these effects by some magnitude.

6.6.5 Compounds Not Quantitatively Evaluated

The following contaminants detected at Site 16 were not quantitatively evaluated in the BRA, as there is no toxicity information promulgated by the USEPA:

- phenanthrene
- lead
- 4-methyl-2-pentanone

6.7 BRA Conclusions

The BRA evaluates environmental media at Site 16, in terms of human health risk. Potential receptors at the site include future residential children and adults, Current Military Personnel and future construction workers. Total site ICR and HI per receptor group are estimated by combining ICRs and HIs associated with specific exposure pathways. The following algorithms define total site risk:

1. Future Residents (Children and Adults)
    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of COPCs in particulates

b. Ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater + inhalation of volatile COPCs

c. Ingestion of COPCs in surface water + ingestion of COPCs in sediment + dermal contact with COPCs in surface water + dermal contact with COPCs in sediment

2. Current Military Personnel

a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs

3. Future Construction Worker

a. Not evaluated, as there are no COPCs in subsurface soil.

6.7.1 Total Site Risk

The text below addresses total site risks by receptor group.

6.7.1.1 Future Residential Children

Total ICR for future residential children, 2.4E-05, is within the USEPA acceptable cancer risk range. Total HI, 1.19, is greater than 1.0. This value indicates that adverse systemic health effects are likely. Soil exposure, incidental ingestion of soil in particular, drives the total noncarcinogenic risk for future residential children (81 percent contribution to risk). The presence of Aroclor-1254 in surface soil drives the risk associated with soil ingestion (52 percent contribution to risk).

6.7.1.2 Future Residential Adults

Total ICR for future residential adults at, 2.3E-05, is within the USEPA acceptable cancer risk range. Total HI, 0.17, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 16 generate no health risks in excess of acceptable levels.

6.7.1.3 Current Military Personnel

Total ICR for Current Military Personnel, 1.2E-06, is within the USEPA acceptable risk range. Total HI, 0.13, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 16 generate no health risks in excess of acceptable levels.

6.7.1.4 Future Construction Workers

Total ICR and HI were not calculated for future construction workers, because there are no contaminants retained as COPCs in subsurface soil.

Total site ICR and HI values are presented in Table 6-25.

6.8 References

Cowherd, C., et al. 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. Prepared for EPA Office of Health and Environmental Assessment. EPA/600/8-85/002.

Foster, S.A. and P.C. Chrostowski. 1986. Inhalation Exposures to Volatile Organic Contaminants in the Shower. ICF-Clement Associates, Inc. Washington, D.C. 1986.

HEAST, Health Effects Assessment Summary Tables. 1995. Office of Research and Development. Office of Emergency and Remedial Response. U.S. Environmental Protection Agency.

IRIS, Integrated Risk Information System. 1995. Accessed through Chemical Information Systems, Inc., Baltimore, MD.

USEPA. 1989(a). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-002. December 1989.

USEPA. 1989(b). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume II. Environmental Evaluation Manual Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-001. May 1989.

USEPA. 1991. United States Environmental Protection Agency. National Functional Guidelines for Organic Data Review. Draft. USEPA Hazardous Site Evaluation Division. June, 1991.

USEPA. 1991(a). United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.

USEPA. 1991(b). United States Environmental Protection Agency. Supplemental Region IV Risk Assessment Guidance. Health Assessment Office. March 20, 1991.

USEPA. 1992(a). United States Environmental Protection Agency. Dermal Exposure Assessment: Principles and Applications. Interim Report. Office of Health and Environmental Assessment. Washington, D.C. EPA/600/8-91/011B. January, 1992.

USEPA. 1992(b). United States Environmental Protection Agency. New Interim Region IV Guidance for Toxicity Equivalency Factor (TEF) Methodology. Region IV Water Management Division. February 11, 1992.

USEPA. 1992(c). United States Environmental Protection Agency. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response. Washington, D.C., Publication 9285.7-081. May, 1992.

USEPA. 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening. Philadelphia, PA. January, 1993.

USEPA. 1994. United States Environmental Protection Agency. Drinking Water Regulations and Health Advisories. Office of Water. Washington, D.C. November, 1994.

USEPA. 1995. United States Environmental Protection Agency. Region III Risk-Based Concentration Table. Philadelphia, PA. March, 1995.

SECTION 6.0 TABLES

TABLE 6-1

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
FORMER DUMP AT MONTFORD POINT
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blank (µg/L)	Medium Associated with Maximum Concentration Detected in Blank	Concentration for Comparison(1) (Aqueous - µg/L)	Concentration for Comparison(2) (Solid - µg/L)
Methylene Chloride	10	Soil	100	100
Acetone	14	Soil	140	140
bis(2-Ethylhexyl)phthalate	1J	Soil	10	330
Aluminum	77.4	Soil	387	387
Barium	4.2	Soil	21	21
Calcium	19,400	Soil	97,000	97,000
Iron	1,400	Soil	7,000	7,000
Magnesium	1,280	Soil	6,400	6,400
Manganese	23	Soil	115	115
Sodium	7,890	Soil	39,450	39,450
Zinc	63.9	Soil	319.5	319.5
bis(2-ethylhexyl)phthalate	1J	Groundwater	10	NA
Calcium	90.2	Groundwater	451	NA
Iron	61.2	Groundwater	306	NA
Lead	5.2	Groundwater	26	NA
Sodium	106	Groundwater	530	NA
Zinc	20.6J	Groundwater	103	NA
bis(2-Ethylhexyl)phthalate	6	Surface Water/ Sediment	60	60
Sodium	847J	Surface Water/ Sediment	4,235	4,235

(1) Concentration is five or ten times (for common laboratory blank contaminants) the maximum detected concentration in a blank.

(2) Concentration is five or ten times the maximum detected concentration in a blank; converted to µg/kg.

(3) Semivolatile blank concentrations are multiplied by 33 or 66 to account for matrix difference.

(4) Constituents are grouped according to environmental media.

NA = Not applicable

TABLE 6-2

ORGANIC DATA SUMMARY
BURN DUMP SURFACE SOIL
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Volatiles		
Methylene Chloride	6J - 15J	3/29
Acetone	11J - 1,200	3/29
Toluene	1J - 4J	3/29
Semivolatiles		
Phenol	70J	1/29
1,4 Dichlorobenzene	43J	1/29
Naphthalene	36J	1/29
2-Methylnaphthalene	67J	1/29
Phenanthrene	52J - 99J	3/29
Anthracene	100J	1/29
Fluoranthene	46J	1/29
Pyrene	39J - 110J	3/29
Butylbenzylphthalate	64J	1/29
Benzo(a)anthracene	43J	1/29
Chrysene	43J - 70J	4/29
bis(2-Ethylhexyl)phthalate	37J - 490	6/29
Benzo(b)fluoranthene	54J - 88J	2/29
Benzo(k)fluoranthene	84J	1/29
Benzo(a)pyrene	42J - 130J	2/29
Indeno(1,2,3-cd)pyrene	52J	1/29
Benzo(g,h,i)perylene	92J	1/29
Pesticide/PCBs		
delta-BHC	4.7	1/29
Aldrin	3.4J	1/29
Dieldrin	5.6 - 77J	10/29
4,4'-DDE	5 - 440	26/29
Endrin	6.5 - 14J	3/29
Endosulfan II	1.9J - 26J	8/29
4,4'-DDT	3.8-540	24/29
Methoxychlor	4.6J	1/29
Endrin ketone	4.2 - 9.9	2/29
Endrin aldehyde	4.6 - 29	9/29
alpha-Chlordane	3.1 - 120	11/29
gamma-Chlordane	1.6J - 72J	9/29
Aroclor 1254	41 - 2100	13/29
Aroclor 1260	50J - 210J	2/29

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-3

INORGANIC DATA SUMMARY
BURN DUMP SURFACE SOIL
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Soil				
Inorganic	Average Base-Specific Background[(1)] Concentration Range	Twice the Average Base Specific Background[(1)] Concentration.	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	2,575.979	5,151.959	866J - 18,500J	29/29	4
Antimony	2.918	5.835	ND	0/29	NA
Arsenic	0.651	1,302	2.3 - 24.7J	17/29	17
Barium	7.614	15.229	3 - 334	29/29	14
Beryllium	0.111	0.222	0.29 - 0.49	6/29	6
Cadmium	0.353	0.706	1.8 - 9.6	2/29	2
Calcium	478.856	957.712	66.4J - 112,000J	25/29	14
Chromium	2.929	5.857	2.2 - 43.2J	27/29	12
Cobalt	1.117	2.233	6.3	1/29	1
Copper	3.645	7.291	2.2J - 543J	24/29	11
Iron	1,630.100	3,260.200	470 - 59,700	24/29	14
Lead	10.899	21.798	3.8J - 5,210J	28/29	10
Magnesium	88.606	177.212	32.5 - 2,520	23/29	7
Manganese	8.821	17.642	2.8J - 1,030J	25/29	11
Mercury	0.043	0.087	0.11J - 14	9/29	9
Nickel	1.688	3.377	24.4	1/29	1
Potassium	93.362	186.724	205 - 475	10/29	10
Selenium	0.415	0.831	1.1 - 6	8/29	8
Silver	0.473	0.945	1.2 - 3.1	2/29	2
Sodium	33.778	67.556	26.8 - 63.4	11/29	0
Thallium	0.538	1.076	2.1 - 3.6	2/29	2
Vanadium	4.249	8.498	2.3J - 45.4	28/29	11
Zinc	6.062	12.124	14.2J - 4,350J	17/29	17

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

[(1)] Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.

ND - Not Detected

J - Estimated Value

TABLE 6-4

ORGANIC DATA SUMMARY
BURN DUMP SUBSURFACE SOIL
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Volatiles		
Bromomethane	1J	1/32
Acetone	42J - 900J	12/32
Semivolatiles		
1,4-Dichlorobenzene	50J - 67J	2/32
1,2,4-Trichlorobenzene	45J - 66J	2/32
Naphthalene	88J	1/32
2-Methylnaphthalene	77J	1/32
Acenaphthene	51J - 290J	3/32
Dibenzofuran	310J	1/32
Fluorene	680	1/32
Pentachlorophenol	38J - 94J	3/32
Phenanthrene	2,200	1/32
Anthracene	380	1/32
Carbazole	180J	1/32
Di-n-butylphthalate	270J	1/32
Fluoranthene	1,200	1/32
Pyrene	670J	1/32
Benzo(a)anthracene	160J	1/32
Chrysene	160J	1/32
bis(2-Ethylhexyl)phthalate	58J - 71J	2/32
Di-n-octylphthalate	46J	1/32
Benzo(b)fluoranthene	57J	1/32
Benzo(k)fluoranthene	58J	1/32
Benzo(a)pyrene	38J	1/32
Pesticide/PCBs		
4,4'-DDE	7.6 - 36	3/32
Endosulfan II	7.1J	1/32
4,4'-DDD	52J	1/32
4,4'-DDT	37 - 630	2/32
alpha-Chlordane	3.8	1/32
gamma-Chlordane	2.4J - 2.5J	2/32
Aroclor-1254	40 - 45	2/32

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-5

INORGANIC DATA SUMMARY
BURN DUMP SUBSURFACE SOIL
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Subsurface Soil				
Inorganic	Average Base-Specific Background[(1)] Concentration Range	Twice the Average Base Specific Background[(1)] Concentration.	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	3,614.723	7,229.446	315J - 7,650J	31/32	1
Antimony	3.647	7.315	ND	0/32	NA
Arsenic	1.160	2.320	2.5J	1/32	1
Barium	7.063	14.126	1.2 - 36.5	25/32	1
Beryllium	0.104	0.207	0.21	1/32	1
Cadmium	0.373	0.745	ND	0/32	NA
Calcium	224.550	449.100	31.7 - 1,400	24/32	4
Chromium	6.751	13,503	2.4 - 7.9	24/32	0
Cobalt	0.880	1.761	ND	0/32	NA
Copper	1.434	2.868	2.3J - 3.4J	5/32	2
Iron	4,101.249	8,202.497	268 - 7,830	25/32	0
Lead	4.336	8.672	1.1J - 68J	26/32	1
Magnesium	136.866	273.731	13.7 - 237	25/32	0
Manganese	4.336	8.673	0.83J - 38.1J	25/32	2
Mercury	0.067	0.135	0.1J - 0.28	3/32	1
Nickel	1.437	2.875	ND	0/32	NA
Potassium	197.447	394.894	194 - 370	9/32	0
Selenium	0.470	0.939	1.2	1/32	1
Silver	0.475	0.950	ND	0/32	NA
Sodium	28.366	56.731	22.7 - 34.7	9/32	0
Thallium	0.588	1.176	ND	0/32	NA
Vanadium	7.039	14.078	2.4 - 14.1	16/32	1
Zinc	3.881	7.763	4.9J - 399J	11/32	10

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.

NA - Not Applicable

ND - Not Detected

J - Estimated Value

TABLE 6-6

GROUNDWATER DATA SUMMARY
MONTFORD POINT BURN DUMP
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
Contaminant	NCWQS[1]	MCL[2]	Federal Health Advisories[3]		No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above Health Advisories	
			10 kg Child	70 kg Adult					10 kg Child	70 kg Adult
Volatiles										
Benzene	1.0	5.0	NE	NE	1/6	37	1	1	NA	NA
Ethylbenzene	29	700	1,000	3,000	1/6	1J	0	0	0	0
Semivolatiles										
Phenol	300	NE	6,000	20,000	3/6	1J - 4J	0	NA	0	0
Naphthalene	210	NE	400	1,000	1/6	6J	0	NA	0	0
bis(2-Ethylhexyl)phthalate	3.0	6.0	NE	NE	4/6	1J - 5J	1	0	NA	NA
Inorganics										
Barium	2,000	2,000	NE	NE	6/6	24.4J - 77.9	0	0	NA	NA
Calcium	NE	NE	NE	NE	6/6	370 - 13,400	NA	NA	NA	NA
Iron	300	300[4]	NE	NE	1/6	712	1	1	NA	NA
Lead	15	15[5]	NE	NE	1/6	3.2J	0	0	NA	NA
Magnesium	NE	NE	NE	NE	6/6	1,020 - 5,090	NA	NA	NA	NA
Manganese	50	50[4]	NE	NE	4/6	9.8J - 31.6J	0	0	NA	NA
Sodium	NE	NE	NE	NE	6/6	2,480 - 16,400	NA	NA	NA	NA
Zinc	2,100	5,000[4]	3,000	10,000	1/6	80.5	0	0	0	0

Notes: Concentrations expressed in microgram per liter (µg/L).

[1] NCWQS = North Carolina Water Quality Standards for Groundwater
[2] MCL = Safe Drinking Water Act Maximum Contaminant Level
[3] Longer Term Health Advisories for a 10 kg Child and 70 kg Adult
[4] SMCL = Secondary Maximum Contaminant Level
[5] Action Level
NE - No Criteria Established
NA - Not Applicable
J - Estimated value

TABLE 6-7

SURFACE WATER DATA SUMMARY
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
		Federal Health AWQCs(2)				Positive Detects Above NCWQS	Positive Detects Above AWQC	
Contaminant	NCWQS(1)	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only
Volatiles								
4-Methyl-2-pentanone	NE	NE	NE	1/5	7J	NA	NA	NA
1,1,2,2-Tetrachloroethane	10.8	0.17	11	1/5	2J	0	1	0
Semivolatiles								
bis(2-Ethylhexyl)phthalate	NE	NE	NE	1/5	10J	NA	NA	NA
Inorganics								
Aluminum	NE	NE	N3	5/5	4,210J - 12,300J	NA	NA	NA
Arsenic	50	0.18	0.14	4/5	2.2J - 3.1J	NA	4	4
Barium	1,000	NE	NE	5/5	22.9 - 30.4	NA	NA	NA
Calcium	NE	NE	NE	5/5	154,000J - 173,000J	NA	NA	NA
Chromium	50	NE	NE	1/5	15.6	NA	NA	NA
Iron	1,000	NE	NE	5/5	2,780 - 6,650	NA	NA	NA
Lead	25	NE	NE	5/5	5.5J - 13.7	NA	NA	NA
Magnesium	NE	NE	NE	5/5	542,000 - 615,000	NA	NA	NA
Manganese	200	NE	NE	5/5	17.2 - 24.4	NA	NA	NA
Potassium	NE	NE	NE	5/5	169,000 - 188,000	NA	NA	NA
Silver	0.06	NE	NE	5/5	6.4 - 8.9	NA	NA	NA
Sodium	NE	NE	NE	5/5	4,240,000J - 4,740,000J	NA	NA	NA
Vanadium	NE	NE	NE	1/5	19.6	NA	NA	NA

Notes: Concentrations expressed in microgram per liter (µg/L).

(1) NCWQS = North Carolina Water Quality Standards for Surface Water

(2) AWQC = Ambient Water Quality Standard

(3) Insufficient data to develop criteria. Value presented is Lowest Observed Effect Level (LOEL).

NE - Not Established

NA - Not Applicable

J - Estimated value

TABLE 6-8

SEDIMENT DATA SUMMARY
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria: Positive Detects Above NOAA	
	NOAA ER-L[(1)] Concentration	NOAA ER-M[(2)] Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Volatiles						
Carbon disulfide	NE	NE	2J	1/10	NA	NA
Toluene	NE	NE	1J - 2J	2/10	NA	NA
Inorganics						
Aluminum	NE	NE	1,380J - 7,460J	10/10	NA	NA
Arsenic	33	85	0.8J - 4.7J	8/10	0	0
Barium	NE	NE	1.9 - 10.8	4/10	NA	NA
Beryllium	NE	NE	0.27 - 0.33	10/10	NA	NA
Calcium	NE	NE	87.4 - 1,220	10/10	NA	NA
Chromium	80	145	3.9 - 21.2	10/10	0	0
Cobalt	NE	NE	2.4 - 3.1	3/10	NA	NA
Iron	NE	NE	336J - 9,960J	10/10	NA	NA
Lead	35	110	2.3J - 6J	10/10	0	0
Magnesium	NE	NE	504 -618	3/10	NA	NA
Manganese	NE	NE	1.7 - 10.5	10/10	NA	NA
Silver	1	2.2	1.2	1/10	1	0
Sodium	NE	NE	170 - 1,320	10/10	NA	NA
Vanadium	NE	NE	3.6 - 29.9	10/10	NA	NA
Zinc	120	270	1.9J - 46.4J	10/10	0	0

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
(1) ER-L - Effective Range-Low
(2) ER-M - Effective Range-Medium

NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 6-9

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	Subsurface Soil	Groundwater		Surface Water		Sediment	
Volatiles								
Carbon disulfide							X	●
Benzene			X	●				
Toluene							X	●
Ethylbenzene				●				
4-Methyl-2-pentanone					X	●		
1,1,2,2-Tetrachlorothane					X	●		
Semivolatiles								
Phenol				●				
Naphthalene				●				
Phenanthrene	X							
bis(2-Ethylhexyl)phthalate				●		●		
Benzo(a)pyrene	X							
Pesticide/PCBs								
Dieldrin	X							
Aroclor-1254	X							
Aroclor-1260	X							
Inorganics								
Aluminum	X					●		●
Arsenic	X					●	X	●
Barium				●	X	●		●
Beryllium	X						X	●
Cadmium	X							
Calcium				●		●		●
Chromium	X					●		●
Cobalt								●
Copper	X							
Iron				●		●		●
Lead	X			●		●	X	●
Magnesium				●		●		●
Manganese				●	X	●		●
Mercury	X							
Potassium						●		
Silver						●	X	●
Sodium				●		●		●
Vanadium					X	●	X	●
Zinc	X			●			X	●

Note: No COPCs were retained for subsurface soil.

● = Detected in media; compared to relevant criteria and standards.

X = Selected as a COPC for human health risk assessment.

TABLE 6-10

MATRIX OF POTENTIAL HUMAN EXPOSURE
OPERABLE UNIT NO. 8 (SITE 16)
MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium/ Exposure Route	Current Military Personnel	Future Construction Worker	Future Residential Population
Soil Incidental Ingestion	M	NE	A,C
Dermal Contact	M	NE	A,C
Subsurface Soil Incidental Ingestion	NE	W	NE
Dermal Contact	NE	W	NE
Groundwater Ingestion	NE	NE	A,C
Dermal Contact	NE	NE	A,C
Surface Water Ingestion	NA	NA	A,C
Dermal Contact	NA	NA	A,C
Sediment Incidental Ingestion	NA	NA	A,C
Dermal Contact	NA	NA	A,C
Air Inhalation of Vapor Phase Chemicals Indoor	NE	NE	A,C
Inhalation of Particulates Outdoor	M	NA	A,C

Notes:

A = Lifetime exposure - adults
C = Exposure - children
M = Military lifetime exposure
W = Construction duration exposure
NE = Not Exposed
NA = Not applicable to receptor group

TABLE 6-11

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION OF SOIL CONTAMINANTS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
IR	Ingestion Rate	Child	200 mg/day	USEPA, 1989a
		Adult	100 mg/day	USEPA, 1991a
		Military Personnel	100 mg/day	
		Construction Worker	480 mg/day	
CF	Conversion Factor	1E-6 kg/mg		USEPA, 1989a
Fi	Fraction Ingested from Contaminated Source	100%		Conservative Professional Judgement
EF	Exposure Frequency	Child	350 days/yr	USEPA, 1989a
		Adult	350 days/yr	
		Military Personnel	350 days/yr	
		Construction Worker	90 days/yr	USEPA, 1991a
ED	Exposure Duration	Child	6 years	USEPA, 1991a
		Adult	24 years	USEPA, 1989a
		Military Personnel	4 years	
		Construction Worker	1 year	
BW	Body Weight	Child	15 kg	USEPA, 1989a
		Adult	70 kg	
		Military Personnel	70 kg	
		Construction Worker	70 kg	
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child	2,190 days	USEPA, 1989a
		Adult	8,760 days	
		Military Personnel	1,460 days	
		Construction Worker	365 days	

TABLE 6-12

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Future Construction Worker			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, 1992b
CF	Conversion Factor	1E-6 kg/mg	USEPA, 1989a
SA	Exposed Surface Area of Skin Available for Contact	Child 2,300 cm^2 Adult 5,800 cm^2 Military Personnel 5,800 cm^2 Construction Worker 4,300 cm^2	USEPA, 1992a Reasonable worst case: individual skin area limited to head, hands, forearms, lower legs
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2	USEPA, 1991b
ABS	Fraction Absorped (unitless)	Organics 1.0% Inorganics 0.1%	USEPA, 1991b
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Military Personnel 350 days/yr Construction Worker 90 days/yr	USEPA, 1989a USEPA, 1991a
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years Construction Worker 1 year	USEPA, 1989a USEPA, 1991a
BW	Body Weight	Child 15 kg Adult 70 kg Military Personnel 70 kg Construction Worker 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days Construction Worker 365 days	USEPA, 1989a

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Future Construction Worker			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, 1992b
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Military Personnel 350 days/yr	USEPA, 1989a
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years	USEPA, 1991a
IR	Inhalation Rate	Child 10 m^3 Adult 20 m^3 Military Personnel 20 m^3	USEPA, 1991a USEPA, 1989b
BW	Body Weight	Child 15 kg Adult 70 kg Military Personnel 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days	USEPA, 1989a
PEF	Site-Specific Particulate Emission Factor	4.63E09 m^3/kg	Cowherd et al., 1985

TABLE 6-14

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF GROUNDWATER CONTAMINANTS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/L)	USEPA, 1992b
IR	Ingestion Rate	Child Adult	1 L/day 2 L/day	USEPA, 1991a USEPA, 1989a
EF	Exposure Frequency	Child Adult	350 days/yr 350 days/yr	USEPA, 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1991a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, 1989a

TABLE 6-15

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH GROUNDWATER CONTAMINANTS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/L)	USEPA, 1992b
SA	Exposed Surface Area of Skin Available for Contact	Child 10,000 cm^2 Adult 23,000 cm^2	USEPA, 1992a
PC	Permeability Constant	Chemical Specific	USEPA, 1992a
ET	Exposure Time	All 0.25 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, 1991a
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, 1989a
CF	Conversion Factor	1 L/1000 cm^3	USEPA, 1989a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, 1989a

TABLE 6-16

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF GROUNDWATER VOLATILE CONTAMINANTS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/m^3)	USEPA, 1992b
IR	Inhalation Rate	Child Adult	0.6 m^3/hr 0.6 m^3/hr	USEPA, 1989a
ET	Exposure Time	All	0.25 hr/day	USEPA, 1992a
EF	Exposure Frequency	All	350 day/yr	USEPA, 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child Adult	2,190 days 10,950 days	USEPA, 1989a

TABLE 6-17

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SURFACE WATER
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/L)	USEPA, 1992b
IR	Ingestion Rate	Child Adult	0.05 L/hr 0.05 L/hr	USEPA, 1989a
ET	Exposure Time	Child Adult	2.6 hr/day 2.6 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child Adult	48 events/yr 48 events/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Resident Future Adult Resident	6 years 30 years	USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogens	Future Child Resident Future Adult Resident	2,190 days 10,950 days	USEPA, 1989a

TABLE 6-18

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SURFACE WATER
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/L)	USEPA, 1992b
SA	Exposed Surface Area of Skin Available for Contact	Child 2,100 cm^2 Adult 8,300 cm^2	(hands, forearms, lower extremities) USEPA, 1992a
ET	Exposure Time	Child 2.6 hr/day Adult 2.6 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child 48 days/yr Adult 48 days/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Resident 6 years Future Adult Resident 30 years	USEPA, 1989a
CF	Volumetric Conversion Factor for Water	1 L/1000 cm^3	USEPA, 1989a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Future Child Resident 2,190 days Future Adult Resident 10,950 days	USEPA, 1989a
PC	Permeability Constant	Chemical-Specific	USEPA, 1992a

TABLE 6-19

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SEDIMENT
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
IR	Sediment Ingestion Rate	Child Adult	200 mg/day 200 mg/day	USEPA, 1989a
EF	Exposure Frequency	Child Adult	48 days/yr 48 days/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Resident Future Adult Resident	6 years 30 years	USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Future Child Resident Future Adult Resident	2,190 days 10,950 days	USEPA, 1989a
CF	Conversion Factor	1E-06 kg/mg		USEPA, 1989a

TABLE 6-20

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SEDIMENT
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, 1992b
SA	Surface Area of Skin Available for Contact	Child Adult	2,100 cm^2 8,300 cm^2	(hands, forearms, lower extremities) USEPA, 1992a
AF	Sediment Adherence Factor	1.0 mg/cm^2		USEPA, 1991b
ABS	Absorption Factor (dimensionless)	Organics Inorganics	1.0% 0.1%	USEPA, 1991b
EF	Exposure Frequency	Child Adult	48 events/yr 48 events/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Future Child Resident Future Adults Resident	6 years 30 years	USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	70 years	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Future Child Resident Future Adult Resident	290 days 10, 950 days	USEPA, 1989a
CF	Conversion Factor	1E-06 kg/mg		USEPA, 1989a

TABLE 6-21

TOXICITY FACTORS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD	RfC	CSF	CSFI	WOE	Reference
Volatiles						
1,1,2,2-Tetrachloroethane	ND	ND	2.0E-01	2.03E-01	D	IRIS, 1995
Benzene	PDG	PDG	2.9E-02	2.9E-02	A	IRIS, 1995
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	IRIS, 1995
Carbon Disulfide	1.0E-01	2.86E-03	ND	ND	D	HEAST, 1995
Toluene	2.0E-01	1.14E-01	ND	ND	D	IRIS, 1995
Semivolatiles						
Benzo(a)pyrene	ND	ND	7.3E+00	6.10E+00	B2	IRIS, 1995
Phenanthrene	ND	ND	ND	ND	ND	IRIS, 1995
Pesticides/PCBs						
Dieldrin	5.0E-05	ND	1.6E+01	1.6E+01	B2	IRIS, 1995
Aroclor-1254	2.0E-05	ND	ND	ND	B2	IRIS, 1995
Aroclor-1260	ND	ND	7.7E+00	ND	B2	IRIS, 1995
Inorganics						
Aluminum	1.0E+00	ND	ND	ND	ND	EPA-ECAO
Arsenic	3.0E-04	ND	1.5E+00	1.51E+01	A_I	IRIS, 1995
Barium	7.0E-02	1.43E-04	ND	ND	D	IRIS, 1995; HEAST, 1995
Beryllium	5.0E-03	ND	4.3E+00	8.4E+00	B2	IRIS, 1995
Cadmium	5.0E-04	ND	ND	6.3E+00	D	IRIS
Chromium	5.0E-03	ND	ND	4.2E+01	D	IRIS
Lead	ND	ND	ND	ND	ND	IRIS, 1995
Copper	3.71E-02	ND	ND	ND	D	HEAST, 1995
Manganese	1.4E-01	1.43E-05	ND	ND	D	IRIS, 1995
Mercury	3.0E-04	8.57E-05	ND	ND	D	HEAST, 1995
Silver	5.0E-03	ND	ND	ND	D	IRIS, 1995
Vanadium	7.0E-03	ND	ND	ND	D	HEAST, 1995
Zinc	3.0E-01	ND	ND	ND	D	IRIS, 1995

Notes:

RfD	Oral Reference Dose (mg/kg - day)
RfC	Inhalation Reference Concentration (mg/cu m)
CSF	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
CSFI	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
WOE	Weight of Evidence
IRIS	Integrated Risk Information System
HEAST	Health Effects Assessment Summary Tables
EPA	Environmental Protection Agency
ECAO	Environmental Criterion Assessment Office
ND	Not Determined
A	Human Carcinogen
B1	Probable Human Carcinogen - Limited Evidence
B2	Probable Human Carcinogen - Sufficient Evidence
C	Possible Human Carcinogen
D	Not Classifiable as to Human Carcinogenicity
I	Ingestion
	(1) RfD for evaluation in water
	(2) RfD for evaluation in soil/sediment

TABLE 6-22

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH SOIL
OPERABLE UNIT NO. 8 (SITE 16)
FORMER BURN DUMP AT MONTFORD POINT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult		Current Military Personnel		Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Soil	1.4E-05	0.9	5.8E-06	0.1	9.6E-07	0.1	NA	NA
Dermal Contact with Soil	3.1E-07	0.06	6.7E-07	0.03	1.1E-07	0.03	NA	NA
Inhalation of Soil Particulates	1.2E-09	<0.01	2.1E-09	<0.01	3.5E-10	<0.01	NA	NA
Total	1.4E-05	0.96	6.5E-06	0.13	1.2E-06	0.13	<1E-06	<0.01

NA - Not Applicable (no carcinogenic or noncarcinogenic contaminants selected as COPCs in subsurface soil).

TABLE 6-23

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH GROUNDWATER
OPERABLE UNIT NO. 8 (SITE 16)
FORMER BURN DUMP AT MONTFORD POINT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Groundwater	5.9E-06	NA	1.3E-05	NA
Dermal Contact with Groundwater	1.6E-06	NA	1.7E-06	NA
Inhalation - Shower	8.3E-07	0.2	8.9E-07	0.04
Total	8.3E-06	0.2	1.6E-05	0.04

NA - Not Applicable (no noncarcinogenic contaminants selected as COPCs).

TABLE 6-24

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH SURFACE WATER/SEDIMENT
OPERABLE UNIT NO. 8 (SITE 16)
FORMER BURN DUMP AT MONTFORD POINT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Surface Water	3.9E-08	<0.01	4.2E-05	<0.01
Dermal Contact with Surface Water	1.5E-08	<0.01	6.3E-08	<0.01
Incidental Ingestion of Sediment	1.4E-06	0.03	7.7E-07	<0.01
Dermal Contact with Sediment	1.5E-08	<0.01	6.4E-08	<0.01
Total	1.5E-06	0.03	9.4E-07	<0.01

TABLE 6-25

TOTAL SITE RISK
OPERABLE UNIT NO. 8 (SITE 16)
FORMER BURN DUMP AT MONTFORD POINT
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Groundwater		Surface Water/Sediment		Total	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Current Military Personnel	1.2E-06 (100)	0.13 (100)	NE	NE	NE	NE	1.2E-06	0.13
Future Child Resident	1.4E-05 (62)	0.96 (81)	8.3E-06 (32)	0.2 (17)	1.5E-06 (6)	0.03 (2)	2.4E-05	1.19
Future Adult Resident	6.5E-06 (28)	0.13 (75)	1.6E-05 (69)	0.04 (25)	9.4E-07 (3)	<0.01 (<1)	2.3E-05	0.17
Future Construction Worker	NE	NE	NE	NE	NE	NE	<1.0E-06	<0.01

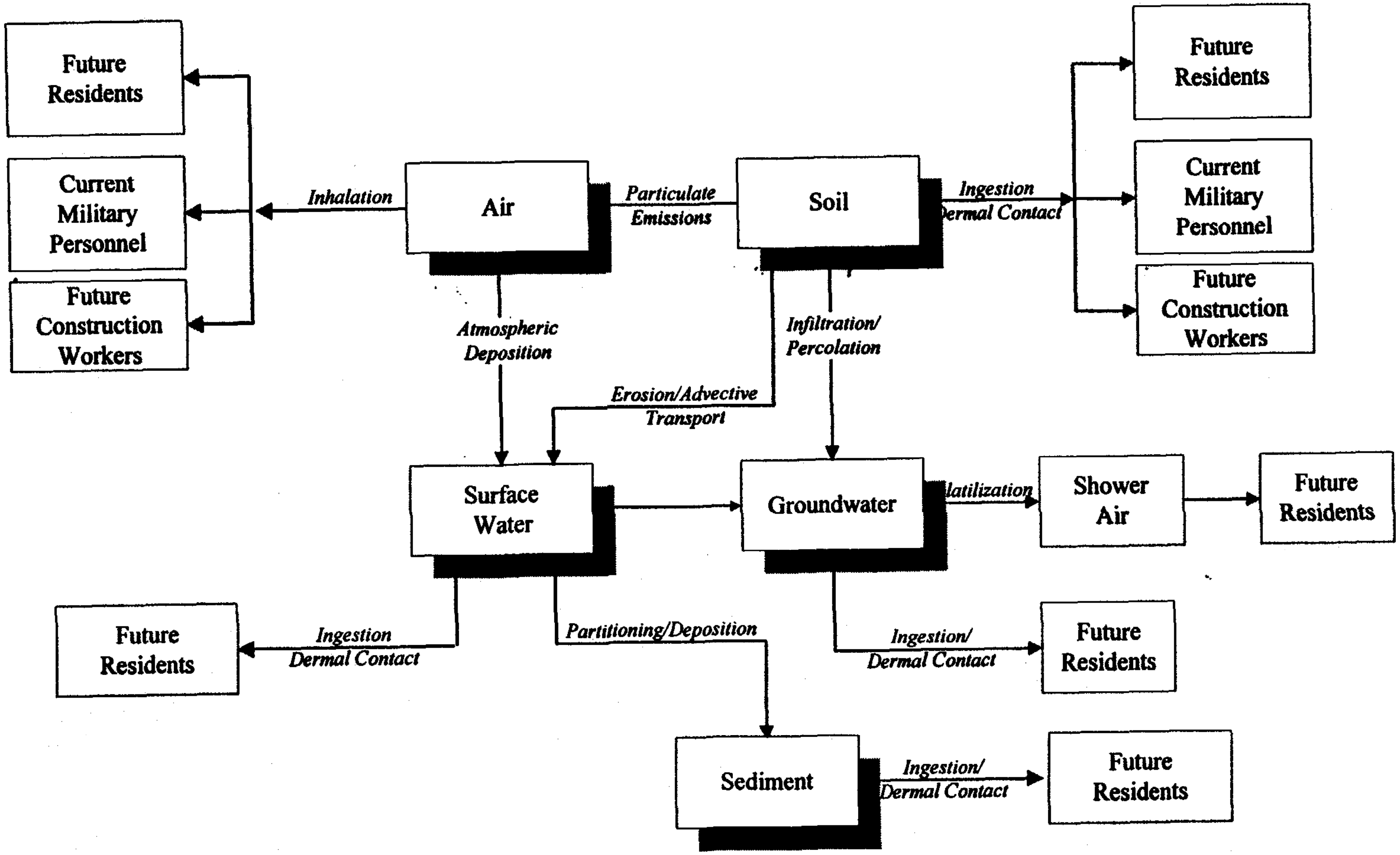
Notes:

CR	=	Incremental Lifetime Cancer Risk
HI	=	Hazard Index
( )	=	Approximate percent contribution to the total ICR or HI values
Total	=	Soil + Groundwater + Surface Water/Sediment
NE	=	Not Evaluated for Potential Receptor.

SECTION 6.0 FIGURE

FIGURE 6-1

CONCEPTUAL SITE MODEL
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA



7.0 ECOLOGICAL RISK ASSESSMENT

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, directs USEPA to protect human health and the environment with respect to releases or potential releases of contaminants from abandoned hazardous waste sites (USEPA, 1989a). This section of the report presents the ecological risk assessment (ERA) conducted at Operable Unit No. 8 (Site 16) that assesses the potential impacts to ecological receptors from contaminants detected at these site.

7.1 Objectives, Scope, and Organization of the Ecological Risk Assessment

The objective of this ERA is to evaluate if past reported disposal practices at Site 16 are potentially adversely impacting the ecological integrity of the terrestrial and aquatic communities on, or adjacent to, the site. This assessment also evaluates the potential effects of contaminants at Site 16 on sensitive environments including wetlands, protected species, and fish nursery areas. The conclusions of the ERA are used in conjunction with the human health risk assessment to evaluate the appropriate remedial action for this site for the overall protection of public health and the environment.

This ERA evaluates and analyzes the results from the Remedial Investigation (RI) including chemical analysis of the surface water, sediments, soil, and groundwater.

Information used to evaluate sensitive environments is obtained from historical data and previous studies obtained in the literature, or through conversations with appropriate state, federal, and local personnel.

The media of concern for this ERA are the surface water, sediment and surface soil. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

The risk assessment methodologies used in this evaluation are consistent with those outlined in the Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information found in the following documents was used to supplement the USEPA guidance document:

- USEPA Supplemental Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989b)
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989c)

Based on the USEPA Framework for Ecological Risk Assessment, an ERA consists of three main components: (1) Problem Formulation, (2) Analysis, and (3) Risk Characterization (USEPA, 1992a). The problem formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the analysis, the data is evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the risk characterization, the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section also evaluates the potential impact on the ecological integrity at the site from the contaminants detected in the media. This ERA is organized to parallel these three components.

7.2 Problem Formulation

Problem formulation is the first step of an ERA and includes a preliminary characterization of exposure and effects (USEPA, 1992a). Chemical analyses were performed on samples collected from the surface water, sediment, soil, and groundwater to evaluate the presence, concentrations, and variabilities of the contaminants. A habitat characterization also was conducted as part of the field activities. Based on these observations, potential ecological receptors were identified. Finally, toxicological information for the contaminants detected in the media was obtained from available references and literature and used to evaluate the potential adverse ecological effects to the ecological receptors.

The components of the problem formulation include identifying the stressors and their potential ecological effects, identification of ecosystems potentially at risk, defining ecological endpoints and presenting a conceptual model. The following sections discuss each of these components, and how they are evaluated in this ERA.

7.3 Contaminants of Potential Concern

One of the initial steps in the problem formulation stage of an ERA is identifying the stressors and their potential ecological effects. For this ERA, the stressors that were evaluated include contaminants detected in the surface water, sediment, and surface soil.

Contaminants in the subsurface soil and groundwater are not evaluated in this ERA. Some terrestrial species burrow in the subsurface soil, and microorganisms most likely exist in the groundwater. However, current guidance does not provide sufficient information to evaluate risk to these receptors.

The nature and extent of contaminants detected in the environmental media at Site 16 is presented in Section 4.0 of this report. Sample locations were based on available historical site information and a site visit to evaluate potential ecosystems and ecological receptors.

7.3.1 Criteria for Selecting of Contaminants of Potential Concern

Quantifying risk for all positively identified contaminants may distract from the dominant risk-driving contaminants at the site. Therefore, that data set was reduced to a list of contaminants of potential concern (COPCs). COPCs are site-related contaminants used to quantitatively estimate ecological exposures and associated potential ecological effects.

The criteria used in selecting the COPCs from the contaminants detected during the field sampling and analytical phase of the investigation are:

- Historical information
- Prevalence
- Toxicity
- Comparison to federal and state criteria and standards
- Comparison to investigation associated field and laboratory blank data
- Comparison to background or naturally occurring levels

- Comparison to anthropogenic levels

7.3.1.1 Historical Information

Using historical information to associate contaminants with site activities, when combined with the following selection procedures, helps determine contaminant retention or elimination. To be conservative, contaminants that may not have been historically used at a site were retained as COPCs to evaluate risk, but are eliminated in the ecological significance section as not being site-related.

7.3.1.2 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. Contaminants that were detected infrequently are not retained a COPCs.

7.3.1.3 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the ERA. Several of the contaminants detected in the media at Site 16 are prevalent, however, their inherent toxicity to aquatic and terrestrial receptors is low (e.g., calcium, magnesium, potassium, and sodium). Therefore, they are not retained as COPCs. In addition, several the contaminants have not been adequately studied to develop published toxicity values, or even accepted toxicological data with which to assess the contaminants. Contaminants that fall into this category are retained as COPCs (if they were not eliminated due to other criteria), however, they are not quantitatively evaluated in the ERA.

7.3.1.4 State and Federal Criteria and Standards

Water Quality Standards (WQSs) for surface water have been developed for North Carolina (NC DEHNR, 1994). These are the only enforceable surface water standards. In addition to WQSs, Water Quality Screening Values (WQSVs) have been developed by USEPA Region IV (USEPA, 1995a), USEPA Region III (USEPA, 1995b), and Oak Ridge National Laboratory (ORNL) (Suter and Mabrey, 1994). The WQS and WQSVs will be herein referred to as Surface Water Screening Values (SWSVs).

Sediment quality standards have not been developed for North Carolina. However, Sediment Screening Values (SSVs) are available for many contaminants including: SSVs (Long et.al., 1995; Long and Morgan, 1991; and, USEPA, 1995b), calculated Sediment Quality Criteria (SQC) (USEPA, 1993a), Apparent Effect Threshold values (AET) (Tetra-Tech Inc., 1986), and Wisconsin Department of Natural Resources interim guidance criteria for in-water disposal of dredged sediments (Sullivan et.al., 1985).

The SWSVs and SSVs are used for comparative purposes to infer potential ecological risks. Contaminants that were detected at concentrations less than these screening values are not retained as COPCs for aquatic receptors since contaminants detected at concentrations less than these values are not expected to pose a significant risk to the aquatic receptor population. However, these contaminants are or maybe retained as COPCs for the terrestrial receptors.

There are no state or federal soil reference values that can be used to evaluate potential ecological risks to terrestrial receptors (other than plants or invertebrates). Therefore, toxicity of contaminants in the surface soil to terrestrial receptors is not used as a criteria for retaining COPCs except for calcium, magnesium, potassium, and sodium, which are not retained as COPCs in any of the media.

A brief explanation of the standards, criteria, and screening values used for the evaluation of the COPCs is presented below.

North Carolina Water Quality Standards (Surface Water) - WQS are the concentrations of toxic substances that will not result in chronic toxicity to aquatic life (NC DEHNR, 1994). WQS are provided for both freshwater and saltwater aquatic systems.

USEPA Water Quality Screening Values - WQSVs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. WQSVs are provided for both freshwater and aquatic systems, and are reported as acute and/or chronic values (USEPA, 1995a,b). Most of the WQSVs are the same as the USEPA Ambient Water Quality Criteria (AWQC), however, some of the WQSVs are based on more current information.

Oak Ridge National Laboratory Aquatic Benchmarks - ORNL Aquatic Benchmarks were developed for many contaminants, including those that do not have WQS of WQSVs (Suter and Mabrey, 1994). The ORNL aquatic Benchmarks include secondary acute values and secondary chronic values that were calculated using the Tier II method described in the EPA's Proposed Water Quality Guidance for the Great Lakes System (USEPA, 1993b). Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for the USEPA AWQC. The benchmarks are limited to contaminants in freshwater.

Sediment Screening Values - Sediment Screening Values (SSV) have been compiled to evaluate the potential for contaminants in sediments to cause adverse biological effects (Long, et.al, 1995; Long and Morgan 1991; and, USEPA, 1995). The lower ten percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-Median [ER-M]) of biological effects have been developed for several contaminants. The concentration below the ER-L represents a minimal-effects range (adverse effects would be rarely observed). The concentration above the ER-L but below the ER-M represents a possible-effects range (adverse effects would occasionally occur). Finally, the concentration above the ER-M represents a probable-effects range (adverse effects would probable occur).

Sediment Quality Criteria - Currently, promulgated Sediment Quality Criteria (SQC) only exist for a few contaminants. However, SQC can be calculated for nonionic organic compounds using the procedures in the Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning (USEPA, 1993a) as follows:

$$SQC = (Foc)(Koc)(FCV)/1{,}000{,}000$$

Where:

SQC = sediment quality criteria (μg/kg)
Foc = sediment organic carbon content (mg/kg)
Koc = chemical organic carbon partition coefficient (mL/g)
FCV = final chronic water quality value (μg/L)

Other Sediment Screening Values - In addition to the SSVs, Apparent Effects Threshold (AET) Sediment Quality Values have been developed by Tetra Tech Inc. (1986), for the Puget Sound. AETs are the concentrations of contaminants above which statistically significant biological effects would always be expected. Finally, the Wisconsin Department of Natural Resources has developed interim criteria for in-water disposal of dredged sediments (Sullivan, et.al., 1985). However, these criteria were established using background data and were not based on aquatic toxicity.

7.3.1.5 Field and Laboratory Blank Data

Associating contaminants detected in field related blanks (i.e., trip blanks, equipment rinsates and/or field blanks) or laboratory method blanks with the same contaminants detected in analytical samples can eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared to sample results with which the blanks are associated. However, for this data set, it is difficult to associate specific blanks with specific environmental samples. Thus, in order to evaluate detection levels, maximum contaminant concentrations reported in a given set of blanks are applied to a corresponding set of samples.

In accordance with the National Functional Guidelines for Organics, common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be regarded as a direct result of site activities only when sample concentrations exceed 10 times the maximum blank concentration. For other contaminants not considered common in a lab, concentrations exceeding 5 times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991a).

Contract Required Quantitation Limits (CRQLs) and percent moisture are employed when evaluating contaminant concentrations in soil, in order to correlate solid and aqueous detection limits. For example, the CRQL for semivolatiles in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess semivolatile contaminant levels in soil using aqueous blanks, the blank concentration must then also be multiplied by 33 or 66 to account for variance from the CRQL (common lab contaminants must first be multiplied by 5 or 10, as explained in the paragraph above). The final value is divided by the sample percent moisture.

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than 5 percent, a contaminant that may have been included according to its prevalence is eliminated as a COPC.

Maximum concentrations of common laboratory contaminants detected in blanks are presented in Section 6.0, Table 6-1.

Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other Target Compound List (TCL) compounds) are regarded as positive results only when observed concentrations exceed 5 times the maximum concentration detected in any blank (USEPA, 1989d). All TCL compounds at less than 5 times the maximum level of contamination noted in any blank are considered not detected in that sample.

7.3.1.6 Background or Naturally Occurring Levels

Contaminants that were detected in the surface soil at concentrations less than two-times the average Base background concentration are not retained as COPCs. As is presented in Section 4.0, off-site surface water and sediment samples were collected from several waterbodies in the White Oak River water basin. The off-site samples are used for comparison to the site stations to determine if contaminants are below naturally occurring regional levels. The three off-site downstream (saltwater) samples (HM03, HC03, and WC03) are compared to the five stations in the Northeast Creek. Contaminants that were detected in the surface water or sediment at concentrations less than the average background concentration, are not retained as COPCs.

7.3.1.7 Anthropogenic Levels

Ubiquitous anthropogenic background concentrations result from non-site related sources such as combustion of fossil fuels (i.e., automobiles), plant synthesis, natural fires and factories. Examples of ubiquitous, anthropogenic chemicals are polycyclic aromatic hydrocarbons (PAHs). Anthropogenic chemicals are typically not eliminated as COPCs without considering other selection criteria. It is difficult to determine that such chemicals are present at the site due to operations not related to the site or the surrounding area. Omitting anthropogenic background chemicals from the risk assessment may result in the loss of important information for those potentially exposed.

The following sections apply the aforementioned selection criteria beginning with the prevalence of detected analytical results in each medium of interest to establish a preliminary list of COPCs for Site 16. Once this task has been completed, a final list of media-specific COPCs will be selected based on the remaining criteria.

7.3.2 Selection of Contaminants of Potential Concern

The following sections present an overview of the analytical data obtained for each medium during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria. Calcium, magnesium, potassium, and sodium were not retained as COPCs in any of the media because they are common naturally occurring chemicals, are not related to the site, and no published toxicity data was identified to assess potential impacts to aquatic or terrestrial life.

Tables 7-1 through 7-2 present the comparison of the surface water and sediment contaminant concentrations to the SWSVs or SSVs and off-site background concentrations. A comparison of the surface soil contaminant concentrations to Base background concentrations is presented in Section 6.0, Table 6-3. A summary of the COPCs in each media are presented in Table 7-3. All the samples were analyzed for TCL organics including, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and pesticides/PCBs, and Target Analyte List (TAL) inorganics.

7.3.2.1 Surface Water

Five surface water samples were collected at Site 16 in Northeast Creek. Two VOCs were detected in the surface water samples (4-methyl-2-pentanone and 1,1,2,2-tetrachloroethane). To be conservative, they are retained as COPCs even though they were not detected in any of the groundwater, sediment, or surface soil samples. However, 1,1,2,2-tetrachloroethane is not retained as a COPC for the aquatic receptors because it did not exceed its SWSV; it is retained as a COPC for the terrestrial receptors.

Bis(2-ethylhexyl)phthalate) was the only SVOC detected in the surface water samples. It is not retained as a COPC because it was detected at a concentration less than ten times the concentration in the blank sample.

Thirteen inorganics were detected in the surface water samples. Arsenic, chromium, lead and silver are not retained as COPCs for aquatic or terrestrial receptors because they were detected at concentrations less than the background concentrations. Vanadium is not retained as a COPC for the aquatic receptors because it was detected at a concentration below the SWSV. As presented above, calcium, magnesium, potassium, and sodium are not retained as COPCs. The remaining four inorganics (aluminum, barium, iron, and lead) are retained as COPCs.

7.3.2.2 Sediments

Ten sediment samples were collected at Site 16 in Northeast Creek. Two VOCs were detected in the sediment samples. Toluene is not retained as a COPC because it does not exceed the SSV. Carbon disulfide is retained as a COPC. No SVOCs, pesticides or PCBs were detected in any of the sediment samples.

Fifteen inorganics were detected in the sediment samples. Aluminum, barium, chromium, cobalt, iron, and manganese are not retained as COPCs because they were detected at concentrations less than the background concentrations. In addition, arsenic, beryllium, lead, and zinc are not retained as COPCs because they do not exceed their respective SSVs. As presented above, calcium, magnesium, potassium, and sodium are not retained as COPCs. Therefore, silver and vanadium are the only two inorganics that are retained as COPCs.

7.3.2.3 Surface Soil

Twenty-nine surface soil samples were collected at Site 16. Three VOCs were detected in the surface soil samples. Methylene chloride is not retained as a COPC because it was detected at a concentration less than ten times the concentration in the blank samples. Acetone and toluene are retained as COPCs.

Seventeen SVOCs were detected in the surface soil samples. The following contaminants are not retained as COPCs because they were detected infrequently (1/29): anthracene, benzo(a)anthracene, benzo(g,h,i)perylene, butylbenzylphthalate, benzo(k)fluoranthene, 1,4-dichlorobenzene, fluoranthene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, and phenol. The remaining six SVOCs (benzo(a)pyrene, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, phenanthrene, and pyrene) are retained as COPCs.

Fourteen pesticides and two PCBs were detected in the surface soil samples. Aldrin, delta-BHC, endosulfan sulfate, and methoxychlor are not retained as COPCs because they were detected infrequently (1/29). The remaining ten pesticides and two PCBs (alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, endrin, endrin aldehyde, endrin ketone, endosulfan II, Aroclor-1254, and Aroclor-1260) are retained as COPCs.

Twenty-two inorganics were detected in the surface soil samples. Cobalt and nickel are not retained as COPCs because they were detected infrequently (1/29). As presented above, calcium, magnesium, potassium, and sodium are not retained as COPCs. The remaining inorganics (aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, thallium, vanadium, and zinc) are retained as COPCs.

7.3.3 Physical/Chemical Characteristics of COPCs

Physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioconcentration factors (BCFs), organic carbon partition coefficient (Koc), octanol water partition coefficient (Kow), and biotransfer factors (Bv, Bb, Br). Table 7-4 summarizes these values for the COPCs detected in the sediment, surface water, and surface soil samples. Information from these tables is used in the terrestrial intake models and the risk characterization to assess the fate and transport of the constituents and the potential risks to the environmental receptors at each site. The following paragraphs discuss the significance of each parameter included in the table.

Bioconcentration factors measure the tendency for a chemical to partition from the water column or sediment and concentrate in aquatic organisms. Bioconcentration factors are important for ecological receptors because chemicals with high BCFs could accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain. The BCF is the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in the water. Therefore, the BCF is unitless. The bioconcentration factor is used in the terrestrial intake model to estimate the COPC concentration in fish that would potentially be ingested by the raccoon.

The organic carbon partition coefficient (Koc) measures the tendency for a chemical to partition between sediment particles containing organic carbon and water. This coefficient is important in the ecological environment because it determines how strongly an organic chemical will be bound to the organics in the sediments. The Koc is used to calculate sediment quality criteria.

The octanol/water partition coefficient (Kow) is the ratio of a chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and with adsorption to soil or sediment. The Kow is used to calculate the plant biotransfer factors that are used to estimate the COPC concentration in plants that would potentially be ingested by the terrestrial receptors in the intake model.

The plant biotransfer factors (Bv or Br) measures the potential for a chemical to accumulate in a plant. These factors are used to calculate the concentration of the COPCs in either the leafy part of the plant (Bv) or the fruit of the plant (Br). The factors for inorganics were obtained from Baes et.al., (1984), while the factors for organics were calculated according to Travis and Arms, (1988). The Bv and Br values for the organics are assumed to be same value.

Finally, the beef biotransfer factors (Bb) measures the potential for a chemical to accumulate in an animal. This factor is used to calculate the concentration of the COPCs in the small mammal that was being ingested by the red fox. The factors for inorganics were obtained from Baes et.al., (1984), while the factors for organics were calculated according to Travis and Arms, (1988).

7.4 Ecosystems Potentially at Risk

Ecological receptors that might be potentially at risk from contaminants at Site 16 were identified during the field investigations and the habitat evaluation. Potential receptors of contaminants in surface water and sediment include fish, benthic macroinvertebrates, other aquatic flora and fauna and some terrestrial faunal species. Potential receptors of contaminants in soil include: deer, rabbits, foxes, raccoons, birds and other terrestrial flora and fauna.

7.4.1 Regional Ecology

Camp Lejeune covers approximately 108,800 acres, 84 percent of which is forested (USMC, 1987). Approximately 45.1 percent of this is pine forest, 22 percent is mixed pine/hardwood forest, and 16.8 percent is hardwood forest. Nine percent of the base, a total of 3,587 acres, is wetland and includes pure pond pine stands, mixed pond pine/hardwood stands, marshes, pocosins, and wooded swamps. The base also contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds.

The base drains primarily to the New River or its tributaries. These tributaries include Northeast Creek, Southwest Creek, Wallace Creek, Frenchs Creek, Bear Head Creek, and Duck Creek.

Because of the natural resources on the base, forested areas are actively managed for timber. Game species are also managed for hunting and ponds are maintained for fishing. Game species managed include wild turkey, white-tailed deer, black bear, grey and fox squirrels, bobwhite quail, eastern cottontail and marsh rabbits, raccoons, and wood ducks.

MCB Camp Lejeune is located in the Coastal Plain. The ecology of the region is influenced by climate, which is characterized by hot, humid summers and cool winters. Some subfreezing cold spells occur during the winters, and there are occasional accumulations of snow that rarely persist. The average precipitation is 55.96 inches and the mean temperature is 60.9°F. The area exhibits a long growing season, typically more than 230 days. Soils in the region range from very poorly drained muck to well-drained sandy loam.

A number of natural communities are present in the Coastal Plain. Subcommunities and variations of these major community types are also present and alterations of natural communities have occurred in response to disturbance and intervention (i.e., forest cleared to become pasture). The natural communities found in the area are summarized as follows:

- Mixed Hardwood Forest - Found generally on slopes of ravines. Beech is an indicator species with white oak, tulip, sweetgum, and holly.

- Southeastern Evergreen Forest - Dominated by pines, especially longleaf pine.

- Loblolly Pine/Hardwoods Community - Second growth forest that includes loblolly pine with a mix of hardwoods -- oak, hickory, sweetgum, sour gum, red maple, and holly.

- Southern Floodplain Forest - Occurs on the floodplains of rivers. Hardwoods dominate with a variety of species present. Composition of species varies with the amount of moisture present.

- Maritime Forest - Develop on the lee side of stable sand dunes protected from the ocean. Live oak is an indicator species with pine, cedar, yaupon, holly, and laurel oak. Deciduous hardwoods may be present where forest is mature.

- Pocosins - Lowland forest community that develop on highly organic soils that are seasonally flooded. Characterized by plants adapted to drought and acidic soils low in nutrients. Pond pine is dominant tree with dense layer of evergreen shrubs. Strongly influenced by fire.

- Cypress Tupelo Swamp Forest - Occurs in the lowest and wettest areas of floodplains. Dominated by bald cypress and tupelo.

- Freshwater Marsh - Occurs upstream from tidal marshes and downstream from non-tidal freshwater wetlands. Cattails, sedges, and rushes are present. On the coast of North Carolina swamps are more common than marshes.

- Salt Marsh - Regularly flooded, tidally influenced areas dominated by salt-tolerant grasses. Saltwater cordgrass is a characteristic species. Tidal mud flats may be present during low tide.

- Salt Shrub Thicket - High areas of salt marshes and beach areas behind dunes. Subjected to salt spray and periodic saltwater flooding. Dominated by salt resistant shrubs.

- Dunes/Beaches - Zones from the ocean shore to the maritime forest. Subjected to sand, salt, wind, and water.

- Ponds and Lakes - Low depressional areas where water table reaches the surface or where ground is impermeable. In ponds rooted plants can grow across the bottom. Fish populations managed in these ponds include redear, bluegill, largemouth bass, and channel catfish (USMC, 1987).

- Open Water - Marine and estuarine waters as well as all underlying bottoms below the intertidal zone.

7.4.2 Water Body Description

Northeast Creek is designated by the NC DEHNR as SC NSW (NC DEHNR, 1993). The SC classifies the water body as a tidal saltwater, which allows for aquatic life propagation and survival, fishing, wildlife, and secondary recreation (NC DEHNR, 1993). The NSW indicates that the water body is a Nutrient Sensitive Water that requires limitations on nutrient inputs (NC DEHNR, 1993).

7.4.3 Site-Specific Ecology

During December 1994, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 16. Appendix O includes data sheets that provide more detailed information.

Site 16 - Montford Point Burn Dump

Four habitat types are present at Site 16. These four include an open area, deciduous forest, pine forest, and an ecotone between the open area and the forests.

The open area, a clearing in the middle of the forest, is very sparsely vegetated. Much of the area is bare sand with no vegetation at all. Some grasses are present at the edges of this open area.

Deciduous forest is found to the north, east, and south of the open area. This forest is dominated by deciduous trees with some scattered pines. Species present in the deciduous forest include the following:

- Loblolly Pine- Pinus taeda
- Water Oak- Quercus nigra
- Sweetgum- Liquidambar styraciflua
- Sycamore- Platanus occidentalis
- Southern Red Oak- Quercus falcata
- Magnolia- Magnolia grandifolia
- Tulip Poplar- Liriodendron tulipifera
- Red Maple- Acer rubrum

Shrubs were noted in the understory of this forest during the habitat evaluation. Four species were identified: sweet myrtle (Myrica cerifera), beautyberry (Callicarpa americana), juniper (Juniperus virginiana), and blueberry (Vaccinum sp.). None of these shrubs are dominant in the understory. Two vines, greenbriar (Smilax rotundifolia) and bullbriar (Smilax bona-nox) are also present. Little vegetation was noted on the forest floor except at the areas where the forest graded to a forest edge ecotone.

In the pine forest loblolly pine (Pinus taeda) is the only species present in the canopy and in the understory. Herbaceous plants are limited to two species: broom sedge (Andropogon virginicus) and bushy beardgrass (Andropogon glomeratus). These two grasses were found primarily at the edge of the pine forest and at openings within the forest.

The area between the forests and the open area is a transition zone or ecotone. Mature trees are not present in the ecotone, although tree species are present as saplings, particularly loblolly (Pinus taeda), sassafras (Sassafras albidum), and sweetgum (Liquidambar styraciflua). These saplings are mixed with shrubs and vines including the following:

- Privit- Ligustrum vulgare
- Redbay- Persea borbonia
- Blackberry- Rubus sp.
- Sweet Myrtle- Myrica cerifera
- Greenbriar- Smilax rotundifolia
- Bullbriar- Smilax bona-nox
- Greenbriar- Smilax smalli

Herbaceous perennials and annuals are present in the ecotone, although no individual species is dominant. Herbs identified during the habitat evaluation included the following:

- Ladies Thumb- Polygonum persicaria
- Shepherd's Purse- Capsella bursa-pastoris
- Mock Bishopsweed- Ptilimnium capillaceum
- Goosegrass- Eleusine indica
- Bushy Beardgrass- Andropogon glomeratus
- Ebony Spleenwort- Asplenium platyneuron
- Lyre-leaved Sage- Salvia lyrata
- Broomsedge- Andropogon virginicus
- Dogfennel- Eupatorium capillifolium
- Indian Strawberry- Duchesnea indica
- Slender Bush Clover- Lezpedeza virginica
- Yucca- Yucca filamentosa
- Great Mullein- Verbascum thapsus
- Clover- Trifolium repens
- Pussytoes- Antennaria sp.
- Eryngium prostratum

A number of birds were identified at Site 16 during the habitat evaluation. They included the following species:

- Junco- Junco hyemalis
- Kingfisher- Megaceryle alcyon
- Mourning Dove- Zenaida macroura
- Great Blue Heron- Ardea herodias
- Red-bellied Woodpecker- Melanerpes carolinus
- Downy Woodpecker- Picoides pubescens
- Carolina Chickadee- Parus carolinensis
- Osprey- Pandion haliaetus
- Great Horned Owl- Bubo virginianus
- Flicker- Colaptes auratus

Signs of whitetail deer (Odocoileus virginianus) were also observed. One reptile and one amphibian, an anole (Anole carolinensis) and a southern toad (Bufo terrestris), also were noted during the habitat evaluation.

Sensitive Environments

This section describes the sensitive environments that were evaluated at Site 16. These sensitive environments include wetlands, threatened and endangered species, and other potentially sensitive environments.

Wetlands

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992a). In addition, certain activities affecting wetlands also are regulated by the U.S. Corps of Engineers.

The U.S. Fish and Wildlife Service (FWS) has prepared National Wetlands Inventory (NWI) maps for the Camp Lejeune, North Carolina area by stereoscopic analysis of high altitude aerial photographs (USDI, 1982). Sites 41 and 74 are included on these maps. 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 (Cowardin, et. al; 1979). NWI maps are intended for an initial identification of wetland areas. They cannot be substituted for an actual wetland delineation that may be required by Federal, State and/or local regulatory agencies. Information from the wetlands maps was transferred to the site-specific biohabitat maps (Figure 7-1).

Site-specific wetland delineations were not conducted at Site 16, although potential wetland areas, were noted during the habitat evaluation. In addition, NWI maps were reviewed to locate and classify wetlands. According to the NWI map, no wetlands are present along Northeast Creek in the vicinity of Site 16.

Threatened and Endangered Species

Certain species have been granted protection by the FWS under the Federal Endangered Species Act (16 U. S. C. 1531-1543), and/or by the North Carolina Wildlife Resources Commission, under the North Carolina 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 rare; or State watch list. While only the Federal or State threatened or endangered and State special concern species are protected from certain actions, the other classified species have the potential for protection in the future.

Surveys have been conducted to identify threatened and endangered species at Camp Lejeune and several programs are underway to manage and protect them. Table 7-5 lists protected species present at the base and their protected classification. Of these species, the red-cockaded woodpecker, American alligator, and sea turtles are covered by specific protection programs.

The red-cockaded woodpecker requires a specific habitat in mature, living longleaf or loblolly pine trees. The birds live in family groups and young are raised cooperatively. At Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Research on the bird at Camp Lejeune began in 1985 and information has been collected to determine home ranges, population size and composition, reproductive success, and habitat use. An annual roost survey is conducted and 36 colonies of birds have been located.

The American alligator is considered endangered in the northern-most part of its range, which includes North Carolina. It is found in freshwater, estuarine, and saltwater wetlands in Camp Lejeune and base wetlands are maintained and protected to protect alligators. Signs have been erected where alligators are known to live. Annual surveys of Wallace, Southwest, French, Duck, Mill, and Stone Creeks have been conducted since 1977 to identify alligators and their habitats on base.

Two protected sea turtles, the Atlantic loggerhead and Atlantic green turtle, nest on Onslow Beach at Camp Lejeune. The green turtle was found nesting in 1980; the sighting was the first time the species was observed nesting north of Georgia. The turtle returned to nest in 1985. Turtle nests on the beach are surveyed and protected, turtles are tagged, and annual turtle status reports are issued.

Four bird species, black skimmer, piping plover, Bachmans sparrow, and peregrine falcon have also been identified during surveys at Camp Lejeune. The black skimmer and piping plover are sea and shore birds, respectively. Skimmers nest on low sandy islands and sand bars along the coast and piping plovers prefer beaches with broad open sandy flats above the high tide line. Skimmers feed above open water and piping plovers feed along the edge of incoming waves. Like the black skimmer and piping plover, Bachmans sparrows are very specific in their habitat requirements. They live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout southern Camp Lejeune.

In addition to the protected species that breed or forage at Camp Lejeune, several protected whales migrate through the coastal waters off the base during spring and fall. These include the Atlantic right whale, finback whale, sei whale, and sperm whale. Before artillery or bombing practice is conducted in the area, aerial surveys are made to assure that whales are not present in the impact areas.

No protected species were observed at Site 16 during the habitat evaluation nor would they be expected to occur. Protected species at Camp Lejeune require specific habitats that do not correspond to the habitats identified at the sites. Previous survey results and maps of locations were protected species have been identified were consulted to produce biohabitat maps. No protected species have been identified within half-mile radius of Site 16.

A natural heritage resources was conducted at Camp Lejeune (LeBlond, 1991) to identify threatened or endangered plants and areas of significant natural interest. From this list, the rough-leaf loosestrife was the only Federally threatened or endangered plant species found on the Marine Corps Base. In addition, several State endangered or threatened and Federal and State candidate species were found on the MCB. The results of this survey are included in Appendix P. No critical species or areas of significant natural interest were identified in the vicinity of Site 16.

Other Sensitive Environments

In addition to wetlands and protected species, other sensitive environments, including those listed in 40 CFR Part 300, were evaluated during Hazard Ranking System evaluations. These sensitive environments and their presence or absence at Site 16 are discussed below.

- Marine Sanctuary - Site 16 is not located within a Marine Sanctuary (NCMFC, 1994).
- National Park - Site 16 is not located within a National Park (NPS, 1993a).
- Designated Federal Wilderness Area - Site 16 is not located within a Designated Federal Wilderness Area (WS, 1989, 1993).
- Areas Identified under the Coastal Zone Management Act - The North Carolina Coastal Area Management Act (CAMA) regulates various types of Areas of Environmental Concern including estuarine waters, coastal wetlands, public trust areas, and estuarine shoreline through the establishment of unified policies, criteria, standards, methods, and processes (CAMA, 1974).
- Sensitive Areas Identified under the National Estuary Program (NEP) or Near Coastal Waters Program (NCWP) - Site 16 is not located within a Sensitive Area identified under the NEP or NCWP (NCMFC, 1994).

- Critical Areas Identified under the Clean Lakes Program - Site 16 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1993).

- National Monument - Site 16 is are not located near a National Monument (NPS, 1993).

- National Seashore Recreational Area - Site 16 is not located within a National Seashore Recreational Area (NPS, 1993).

- National Lakeshore Recreational Area - Site 16 is not located within a National Lakeshore Recreational Area (NPS, 1993).

- National Preserve - Site 16 is not located within a National Preserve (NPS, 1991).

- National or State Wildlife Refuge - Site 16 is not located within a National or State Wildlife Refuge (NCWRC, 1992).

- Unit of the Coastal Barrier Resource Program - Site 16 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 16 is not located within an Administratively Proposed Federal Wilderness Area (WS, 1989, 1993).

- Spawning Areas Critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters - Due to size restrictions, no critical spawning areas have been identified within Northeast Creek (USMC, 1993).

- Migratory pathways and feeding areas critical for maintenance of anadromous fish species within river reaches or areas in lakes or coastal tidal waters in which fish spend extended periods of time - Northeast Creek adjacent to Site 16 is not a migratory pathway or feeding area critical for the maintenance of an anadromous fish species (USMC, 1993).

- National river reach designated as Recreational - Northeast Creek is not designated as a National Recreational River (NPS, 1990, 1993b).

- Federal designated Scenic or Wild River - Northeast Creek is not a Federally designated Scenic or Wild River (NPS, 1990, 1993b).

- State land designated for wildlife or game management - Site 16 is are not located within a State game land (NCWRC, 1992).

- State designated Scenic or Wild River - Northeast Creek is not a State designated Scenic or Wild River (NCMFC, 1992).

- State designated Natural Area - Site 16 is not located within a State designated Natural Area or Area of Significant Value (LeBlond, 1991).

- State designated areas for protection or maintenance of aquatic life - No areas within the boundaries of Site 16 are designated as primary nursery areas or are unique or special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses (NC DEHNR, 1994).

- Areas of Significant Value - Site 16 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 16 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

7.5 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics and ecosystems potentially at risk) is used to select the ecological endpoints for this ERA. The following section contains a description of the ecological endpoints selected for this ERA, and the reasons they are selected.

There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are environmental characteristics, which, if they are found to be significantly affected, would indicate a need for remediation (e.g., decrease in sports/fisheries). Measurement endpoints are quantitative expressions of an observed or measured effect of the contamination of concern. Measurement endpoints may be identical to assessment endpoints (e.g., measurement of abundance of fish), or they may be used as surrogates for assessment endpoints (e.g., toxicity test endpoints). Both types of endpoints are used in the ecological risk evaluation and are discussed in the following sections.

A measurement endpoint, or "ecological effects indicator" as it is sometimes referred, is used to evaluate the assessment endpoint. Therefore, measurement endpoints must correspond to, or be predictive of, assessment endpoints. In addition, they must be readily measurable, preferably quickly and inexpensively, using existing techniques. Measurement endpoints must take into consideration the magnitude of the contamination and the exposure pathway. The measurement endpoint should be an indicator of effects that are temporally distributed. Low natural variability in the endpoint is preferred to aid in attributing the variability in the endpoint to the contaminant. Measurement endpoints should be diagnostic of the pollutants of interest, as well as broadly applicable to allow comparison among sites and regions. Also, measurement endpoints should be standardized (e.g., standard procedures for toxicity tests). Finally, it is desirable to use endpoints that already are being measured (if they exist) to determine baseline conditions.

7.5.1 Aquatic Endpoint

The assessment endpoint for the aquatic portion of this ERA is the potential reduction of an aquatic receptor population or subpopulation that is attributable to site-related contaminants. The measurement endpoint for the aquatic assessment endpoint is exceedances of contaminant-specific surface water and sediment effect concentrations (i.e., SWSVs, and SSVs).

7.5.2 Terrestrial Endpoint

The assessment endpoint for the terrestrial portion of the ERA is the reduction of a receptor population or subpopulation that is attributable to contaminants from the site. The measurement endpoints for the terrestrial assessment endpoint include exceedances of contaminant-specific soil effect concentrations and contaminant-specific effect doses (i.e., Surface Soil Screening Values (SSSVs) and Terrestrial Reference Values (TRVs)).

7.6 Conceptional Model

This section of the ERA presents each potential exposure pathway via air, soil, and groundwater, and the likelihood that an exposure will occur through these pathways. Figure 7-2 presents the flowchart of potential exposure pathways and ecological receptors.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis is conducted including the identification and characterization of the exposure pathways. The following four elements are examined to determine if a complete exposure pathway was present:

- A source and mechanism of chemical release
- An environmental transport medium
- A feasible receptor exposure route
- A receptor exposure point

The following sections discuss the potential exposure scenarios at Site 16 including surface water, sediments, soil, groundwater and air.

7.6.1 Surface Water and Sediment Exposure Pathway

Potential release sources to be considered in evaluating the surface water and sediment pathway are contaminated surface soil and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated surface water/sediment are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the surface water/sediment on-site or downgradient of the site.

COPCs were detected in the surface water and sediment demonstrating a release from a source to the surface water or sediment transport medium. Potential receptors that may be exposed to contaminants in surface water and sediment include: fish, benthic macroinvertebrates, deer, birds, and other aquatic and terrestrial life.

Aquatic receptors are exposed to contaminants in the surface water and sediment by ingesting water while feeding and by direct contact while feeding or swimming. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioaccumulated chemicals from the surface water and sediment. No fish or crab tissue samples were collected at Site 16 during the field investigations because it was not expected that contaminants related to Site 16 would impact the surface water or sediment quality in Northeast Creek. The results of the RI verified this expectation. Therefore, no tissue samples are proposed to be collected from this site in the future. However, this exposure pathway is likely to occur at Site 16 and is retained for further qualitative analysis.

Terrestrial faunal receptors potentially are exposed to contaminants in the surface water and sediment through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated waters. In addition, terrestrial species may ingest organisms (e.g., fish, small mammals, invertebrates, and plants) that have bioconcentrated contaminates from the surface water and sediment. These exposure pathways are likely to occur at Site 16. However, only the surface water pathway is retained for further analysis, since current guidance does not exist to evaluate the sediment pathway for terrestrial receptors.

7.6.2 Soil Exposure Pathway

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. The release mechanisms to be considered are fugitive dust, leaching, tracking, and surface runoff. The transport medium is the soil. The potential routes to be considered for ecological exposure to the contaminated soil are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the soil.

COPCs were detected in the surface soil demonstrating a release from a source to the surface soil transport medium. Potential receptors that may be exposed to contaminants in surface soil at/or around surface soil in the areas of detected COPCs including: deer, fox, raccoon, rabbits, birds, plants, and other terrestrial life.

Terrestrial receptors potentially are exposed to contaminants in the soil through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated soil. In addition, terrestrial species may ingest organisms that have bioconcentrated contaminates from the soil. This exposure pathway is likely to occur at Site 16 and is retained for further analysis.

7.6.3 Groundwater Exposure Pathway

The potential release source to be considered in evaluating the groundwater pathway is contaminated soil. The release mechanism to be considered is leaching. The routes to be considered for ecological exposure to the contaminated groundwater are ingestion and dermal contact. Groundwater discharge to area surface waters may represent a pathway for contaminant migration.

Sub-surface biota (i.e., microorganisms) are the only ecological receptors expected to be directly exposed to groundwater. These biota are not assessed in this ERA because current guidance does not provide sufficient information to evaluate risk. In addition, since the receptors of concern are not directly exposed to groundwater at Site 16, the groundwater to surface water exposure is accounted for in the surface water section of the ERA.

7.6.4 Air Exposure Pathway

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil, groundwater and surface water. The potential exposure points for receptors are areas on or adjacent to the site. The air exposure pathway is not be evaluated in this ERA because current guidance does not provide sufficient information to evaluate risk

7.7 Exposure Assessment

The next phase after the problem formulation is the exposure assessment that consists of quantifying the potential exposure of the stressors (COPCs) to the ecological receptors.

The RI included collecting samples for analytical analysis from four media; surface water, sediment, soil, and groundwater. As presented earlier in the ERA, contaminants in the subsurface soil and groundwater are not evaluated. The analytical results for the data used in ERA were presented in Section 4.0 of this report.

The regional ecology, site ecology, and habitat characterization in the areas surrounding Site 16 are presented in Section 7.4 of this report. Information on sensitive environments and endangered species also is included in this section.

Exposure of contaminants in the surface water and sediment to aquatic receptors were assumed to be equal to the contaminant concentration in the surface water and sediment. Exposure of contaminants in the surface soil to terrestrial flora and fauna (invertebrates and microorganisms) were assumed to be equal to the contaminant concentration in the surface soil. It is noted in the uncertainty section of this ERA that all the contaminants in the surface soil may not be bioavailable to the terrestrial flora or fauna. Exposure of contaminants in the surface water and surface soil to other terrestrial fauna (mammals, birds) were estimated using the chronic daily intake models.

7.7.1 Surface Water and Sediment Sampling

Surface water and sediment samples were collected at Site 16 as presented in the FSAP (Baker, 1994). The analytical results for the data used in ERA are presented in Section 4.0 of this report. The following sections presents the abiotic habitat of the sampling stations which consists of the description of the stations with regard to size of the creek, depth of the water, substrate type, water chemistry and other such non-biological descriptors. Site specific descriptions and field measurements were recorded on field data sheets (see Appendix O).

Table 7-6 presents the sampling station characterization summary which includes the stream width and depth, canopy cover, sediment type, and sediment odor. The stream widths and depths were not measured at these stations due to the large size of the Northeast Creek (greater than 0.5 miles wide). However, all the samples were collected within five feet from the bank and the water depth at these stations was less than one foot. The canopy cover was open. In addition, the sediment was primarily fine sand or silt, with odors ranging from normal to anaerobic.

Table 7-7 presents the results of the field chemistry data including the temperature, pH, dissolved oxygen concentration, conductivity, and salinity. The temperature ranged from 24.9 to 30.9 °C, the pH ranged from 7.88 to 8 S.U., the dissolved oxygen ranged from 4.7 to 7.3 mg/L, the conductivity ranged from 31,800 to 33,000 umhos/cm, and the salinity ranged from 23 to 30 ppt. The field chemistry at these stations appear to be typical of surface waters at MCB Camp Lejeune.

7.8 Ecological Effects Characterization

The ecological effects data that are used to assess potential risks to aquatic and/or terrestrial receptors in this ERA include aquatic and terrestrial screening values as are presented in

Section 7.3.4.1 to aid in the selection of the COPCs. The following sections presents a summary of the ecological effects comparison.

7.8.1 Surface Water

Contaminant concentrations detected in the surface water at Site 16 are compared to the saltwater SWSVs to determine if there are any exceedances of the published values (see Table 7-1).

In summary, manganese was the only COPC that exceeded a SWSV. No SWSVs were available for aluminum, barium or iron; however, published toxicological data was available for barium and iron. This data is presented in the following paragraphs.

It was reported that soluble barium concentrations in marine waters generally would have to exceed 50,000 µg/L before toxicity to aquatic life would be expected (USEPA, 1987). The maximum barium concentration was 30.4 µg/L is well below the reported toxicity level.

The concentrations of total iron (2,780J-6,650J µg/L) in the surface water were above the concentrations that caused adverse impacts to aquatic life of some of the studies obtained from the Aquatic Information Retrieval Database (AQUIRE) (100 to 330,000 µg/L). However, the majority of the effect concentrations from AQUIRE are several orders of magnitude greater then the maximum iron concentration detected in the surface water. Most of the studies on iron in AQUIRE are conducted with various marine phytoplankton cultures.

7.8.2 Sediment

Contaminant concentrations detected in the sediments at Site 16 were compared to SSVs to determine if there were any exceedances of the published values (see Table 7-2). Silver was the only COPC that exceeded its respective SSV. No SSV or other toxicological data were available for vanadium.

7.8.3 Surface Soil

Although promulgated standards do not exist, Surface Soil Screening Values (SSSVs) that can be used to evaluate potential ecological risks to terrestrial flora and fauna have been developed by USEPA Region III (USEPA, 1995b) and Oak Ridge National laboratory (Will and Suster, 1994a, 1994b). The contaminant concentrations in the surface soils are compared to the SSVs to determine if potential impacts to terrestrial flora and fauna (invertebrates) may be expected.

4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and alpha-chlordane were the only pesticides COPCs that exceeded the SSSVs in any of the samples. Aroclor-1254 and Aroclor-1260 exceeded the SSSVs in all the samples they were detected. Pyrene was the only SVOC COPC that exceeded a SSSV.

7.8.4 Terrestrial Chronic Daily Intake Model

In addition to comparing the soil concentrations to toxicity values for terrestrial invertebrates and plants, a terrestrial Chronic Daily Intake (CDI) model is used to estimate the exposure of the COPCs to terrestrial receptors. The following describes the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 16 by both direct and indirect exposure to COPCs via surface water, soil, and foodchain transfer.

Based on the regional ecology and potential habitat at the site, the indicator species used in this analysis are the white-tailed deer, cottontail rabbit, red fox, raccoon, and the bobwhite quail. The exposure points for these receptors are the surface soil, surface water, and biota. The routes for terrestrial exposure to the COPCs in the soil and water are incidental soil ingestion, drinking water, vegetation (leafy plants, seeds and berries) ingestion, fish ingestion, and ingestion of small mammals.

7.8.4.1 Derivation of Terrestrial Reference Value

Total exposure of the terrestrial receptors to the COPCs in the soil and surface waters was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. The TRVs were developed from No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from the Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry Toxicological Profiles, mineral tolerance levels of domestic animals (NAS, 1992), or other toxicological data in the literature. Appendix Q presents the methodology used in deriving the TRVs and which animals were used to derive each TRV.

7.8.4.2 Calculation of Chronic Daily Intake

Total exposure of the terrestrial receptors to the COPCs in the soil and surface water is determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. The estimated CDI dose of the bobwhite quail, cottontail rabbit, white-tailed deer and small mammal to soil, surface water, and vegetation is determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv)(Iv)+(Cs)(Is)][H]}{BW}$$

Where:

CDI = Total Exposure, mg/kg/d
Cw = Contaminant concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Contaminant concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

To calculate the contaminant concentration in the small mammal, the resulting CDI from the above equation is multiplied by the biotransfer factor for beef (Bb) for organics (Travis and Arms, 1988) and metals (Baes et.al., 1984).

The estimated CDI dose of the raccoon is determined using the following equation:

$$CDI = \frac{(Cw)(Iw) + [(Cs)(Br)(Iv) + (Cs)(Is) + (Cf)(If)][H]}{BW}$$

Where:

CDI = Total Exposure, mg/kg/d
Cw = Contaminant concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Contaminant concentration in soil, mg/kg
Br = Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
Cf = Contaminant concentration in the fish, mg/kg
If = Rate of fish ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

The contaminant concentration in the fish is calculated by multiplying the contaminant concentration in the fish by the bioconcentration factor (BCF).

The estimated CDI dose of the red fox is determined using the following equation:

$$CDI = \frac{(Cw)(Iw) + [(Cs)(Bv)(Iv) + (Cs)(Is) + (Cm)(Im)][H]}{BW}$$

Where:

CDI = Total Exposure, mg/kg/d
Cw = Contaminant concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Contaminant concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
Cm = Contaminant concentrations in small mammals, mg/kg
Im = Rate of small mammal ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

Bioconcentration of the COPCs to plants is calculated using the soil to plant transfer coefficient (Bv or Br) for organics (Travis and Arms, 1988) and metals (Baes et.al., 1984). The concentrations of the COPCs used in the models are the upper 95 percent confidence limit or the maximum concentration detected of each COPC. The exposure parameters used in the CDI calculations are presented in Table 7-9.

7.9 Risk Characterization

The risk characterization is the final phase of a risk assessment. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section evaluates the potential decrease in aquatic and terrestrial populations at Site 16 from contaminants identified at the site.

A Quotient Index (QI) approach is used to characterize the risk to aquatic receptors from exposure to surface water and sediments and terrestrial receptors from exposure to surface soil, surface water, and biota. This approach characterizes the potential effects by comparing exposure levels of COPCs in the surface water and sediments to the aquatic reference values presented in Section 3.4, Ecological Effects Characterization. The QI is calculated as follows:

$$QI = \frac{(EC \ or \ CDI)}{(SWSV, \ SSV, \ or \ TRV)}$$

Where: QI = Quotient Index
EC = Exposure Concentration, µg/L, µg/kg, or mg/kg
CDI = Chronic Daily Intake, mg/kg/day
SWSV = Surface Water Screening Value, µg/L or mg/L
SSV = Sediment Screening Value, µg/kg, or mg/kg
TRV = Terrestrial Reference Value, mg/kg-day

A QI of greater than "unity" is considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded. The evaluation of the significance of the QI has been judged as follows: (Menzie et.al., 1993)

- QI exceeds "1" but less than "10": some small potential for environmental effects;
- QI exceeds "10": significant potential that greater exposures could result in effects based on experimental evidence;
- QI exceeds "100": effects may be expected since this represents an exposure level at which effects have been observed in other species.

The risks characterized above provide insight into general effects upon animals and plants in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

7.9.1 Surface Water

Table 7-10 presents the QIs for the surface water COPCs, while Figure 7-3 graphically displays the QIs that exceeded "1". Manganese is the only COPC in the surface water that exceeded a SWSV. The QIs ranged from 1.72 to 2.44 indicating that there is a slight exceedence of the SWSV.

The source for the SWSV for manganese of 10 µg/L is not known. However, AQUIRE reported that 10 µg/L caused decreased growth in the pacific oyster (Crassostrea gigas). This study, which did not meet the criteria for reliability, may be the data source for the Region III value. Other toxicity values for manganese from AQUIRE listed adverse effects at 20,000 µg/L which is higher than any of the samples collected at Site 16. These studies also were conducted with mollusks.

Manganese typically has been detected in the surface waters at MCB Camp Lejeune. In addition, there is no correlation between the sample concentration of manganese in the surface water and the proximity of the sample to the site. Therefore, the manganese detected in the surface water does not appear to be site-related.

7.9.2 Sediment

Table 7-11 presents the QIs for the sediment COPCs, while Figure 7-3 graphically displays the QIs that exceeded "1". Silver is the only COPC in the sediment that exceeded a SSV. The ER-L QI was 1.2, while the ER-M QI was 0.32. Therefore, there is a possible risk to aquatic receptors from silver in the sediment. However, this risk does not appear to be related to the site since silver was detected in the sample collected approximately 1/4 mile upstream of the site and was not detected in any of the other sediment samples.

7.9.3 Terrestrial Chronic Daily Intake Model

Table 7-12 presents the terrestrial CDI model QIs. Appendix Q contains the CDI spreadsheets. The cottontail rabbit (with a QI of 7.85) and the raccoon (with a QI of 205) are the only terrestrial species that had QI greater than "1". Aluminum (with a QI of 1.07) and zinc (with a QI of 1.42) are the only individual COPC QIs that exceeded "1" for the rabbit. Aluminum (with a QI of 204) is the only individual COPC QI that exceeded "1" for the raccoon.

The source of the high aluminum QI in the raccoon is aluminum in the surface water. This aluminum does not appear to be site-related because the highest concentration (12,300J µg/L) was detected in the sample collected 1/4 mile downstream of Site 16. The concentration of aluminum in the remaining four surface water samples ranged from 4,210J to 5,550J µg/L.

7.10 Ecological Significance

This section essentially summarizes the overall risks to the ecology at the site. It addresses impacts to the ecological integrity at Site 16 from the COPCs detected in the media and determines which COPCs are impacting the site to the greatest degree. This information, to be used in conjunction with the human health risk assessment, supports the selection of remedial action(s) for Site 16 that are protective of public health and the environment.

7.10.1 Aquatic Endpoints

A slight potential adverse impact to aquatic receptors is expected from manganese in the surface water and silver in the sediment. However, as is presented in the risk characterization section of this report, these contaminants do not appear to be site-related since there is no correlation between the sample concentration and the proximity of the sample to the site.

7.10.2 Terrestrial Endpoints

Several COPCs in the surface soil exceeded their respective SSSVs. Most of the surface soil samples collected at Site 16 were located in areas that are bare and/or gravel covered. This area is used as vehicle storage and maneuvers. There are, however, also some exceedences of the SSSVs in the wooded areas surrounding the open area so there is the potential for adverse impacts to terrestrial flora and fauna in these areas. No areas of dead or stressed vegetation were visually observed during either the field investigations or the habitat characterization. In summary, although COPCs in these areas do exceed SSSVs, the exceedences are not expected to be ecologically significant to the terrestrial floral or faunal population due to the current use of the land, most of which is not conducive to habitats of the modeled ecological receptors.

There is a slight potential risk to the cottontail rabbit from contaminants at Site 16. The rabbit's diet is 100 percent vegetation. Since most of Site 16 is unvegetated, the rabbit will not ingest vegetation at most of the Site 16 stations, the model overestimates the risk to the rabbit. Therefore, there does not appear to be a significant risk to the rabbit from site-related COPCs.

The majority of the risk to the raccoon was due to aluminum in the surface water. Since the aluminum is not site-related, there does not appear to be a significant risk to the raccoon from site-related COPCs

7.10.3 Threatened and Endangered Species

No threatened or endangered species are known to occur at Site 16, therefore no adverse impacts to these species from contaminants at Site 16 are expected.

7.10.4 Wetlands

No wetlands have been identified at Site 16, therefore no adverse impacts to wetlands from contaminants at Site 16 are expected.

7.11 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following discusses some of the uncertainty in this ERA.

The chemical sampling program at Site 16 consisted of surface water, sediment, soil, and groundwater. The surface water samples consisted of five samples, while the sediment samples consisted of ten samples. Because there were less than twenty samples, contaminants could not be eliminated because of infrequency. Therefore, contaminants not related to the site may have been retained as COPCs and thus carried through the ERA.

There is uncertainty in the ecological endpoint comparison. The SWSVs (WQS and AWQC) are established to be protective of a majority of the potential receptors. However, there will be some species will not be protected by the values because of their increased sensitivity to the chemicals. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, hardness, total organic carbon) that influence toxicity are most likely at different concentrations in the site water.

Potential adverse impacts to aquatic receptors from contaminants in the sediments were evaluated by comparing the COPC concentration in the sediments to SSVs. These SSVs have more uncertainty associated with them than do the SWSLs, since the procedures for developing them are not as established as those used in developing SWSLs. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) also has a significant impact on the bioavailability and toxicity of contaminants.

Potential adverse impacts to terrestrial invertebrates and plants were evaluated by comparing the COPC concentration in the soil to SSSVs. Most of these studies do not take into account the soil type, which may have a large influence on the toxicity of the contaminants. For example, soil with high organic carbon content will tend to sorb many of the organic COPCs, thus making them less bioavailable to terrestrial receptors. In addition, most of the SSSVs are based on one or two studies, which greatly adds to their uncertainty.

There are some differences of opinion found in the literature as to the effectiveness of using models to predict concentrations of contaminants found in terrestrial species. According to one source, the food chain models currently used incorporate simplistic assumptions that may not represent actual site conditions, bioavailability of contaminants, or site-specific behavior of the receptors. Simple food chain models can provide an effective means of initial characterization of risk, however, residue analyses, toxicity tests, and the use of biomarkers provide a better approach for assessing exposure (Menzie et.al., 1993).

There are several sources of uncertainty when using these models. First, most of the terrestrial reference values are based on toxicity data from another species, which is then extrapolated to the species of concern using a body-size scaling equation. Since the toxicity of all contaminants may not be proportional to body size, the calculated TRVs may not accurately predict risk to the species of concern. Another source of uncertainty with the models is that many of the input parameters are based on default values (i.e., ingestion rate) that may or may not adequately represent the actual values of the parameters. Also, there is uncertainty in the amount that the indicator species will represent other species potentially exposed to COPCs at the site. There is uncertainty in use of the bioconcentration and biotransfer factors. Bioconcentration and biotransfer factors can vary widely from species to species. The species used in the calculation of the bioconcentration and biotransfer factors probably are different that the species that actually occur at the site. Therefore, use of the factors will tend to either overestimate or underestimate actual bioaccumulation of contaminants. Finally, terrestrial receptors also may be exposed to contaminants in the sediments. However, currently, there is no guidance in the literature that can be used to evaluate this potential exposure pathway.

The toxicity of chemical mixtures is not well understood. All the toxicity information used in the ERA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals due to synergistic or antagonistic effects. In addition, the species that were used to develop the toxicity data may not be present at the site, or have the potential to exist at the site. Depending on the sensitivity of the tested species to the species at the site use of the toxicity values may overestimate of underestimate risk. Many chemicals are not acutely toxic, however, they have the potential to bioaccumulate in ecological receptors through food chain transfer. This bioaccumulation potential typically is not taken into account when comparing contaminant concentrations to screening values.

Finally, toxicological data for several of the COPCs were limited or do not exist. Therefore, there is uncertainty in any conclusions involving the potential impacts to aquatic receptors from these contaminants

7.12 Conclusions

7.12.1 Aquatic Ecosystem

No site-related contaminants were detected in the surface water or sediment at concentrations that exceeded any of the surface water or sediment screening values. Therefore, a potential decrease in the aquatic receptor population from site-related COPCs is not expected.

7.12.2 Terrestrial Ecosystem

Several COPCs were detected in the surface soils at concentrations that exceeded the surface soil screening values. Although most of these exceedences were located in areas not expected to have an ecologically significant population of terrestrial flora or fauna due to the activities occurring on the land (vehicle storage and maneuvers), some of these exceedences were located in wooded areas. Therefore, there is the potential for a limited decrease in the terrestrial floral and/or faunal population in these areas. However, it should be noted that no areas of dead or stressed vegetation were observed during the field investigations or habitat characterization. A potential decrease in the terrestrial vertebrate receptor population from site-related COPCs is not expected.

7.13 References

Arthur and Alldredge. 1979. Public Health Evaluation and Ecological Assessment. Martin Marrietta Astronautics Group, Waterton Facility, Vol. II of III, Appendix A and B. Cited in Scarano, 1993.

ASTDR. 1993. Toxicological Profile for Endosulfan. Prepared by Clement Associates for the US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry

ASTDR. 1989. Toxicological Profile for Endrin/Endrin Aldehyde - Draft. Prepared by Life Systems, Inc, for the US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry.

Baes, C.F., Sharp, A.L., and R.W. Shor. 1984. "Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture." Oak Ridge National Laboratory. September 1984.

Baker. 1994. Remedial Investigation, Feasibility Study Project Plans For Operable Units No. 8, 11, and 12 (Sites 16, 7, 80, and 3). Final. Prepared by Baker Environmental Inc Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, VA.

Beyer, N., E. Connor, and S. Gerould. 1993. "Estimates of Soil Ingestion by Wildlife". Patuxent Wildlife Research Center, Laurel, MD.

CAMA, North Carolina Coastal Management Act of 1974. (1973, c.1284, s; 1975, c.452, s.: c. 932, s. 2.1.). 1974.

Collins, Henry Hill, Jr. 1959. Complete Field Guide to American Wildlife. Harper and Row. New York, New York.

Conant, Roger. 1975. A Field Guide to Reptiles and Amphibians. Houghton Mifflin Company. Boston, Massachusetts.

Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Performed for U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services - FWS/OBS-79/31. December 1979.

Dee, J.C. 1991. "Methodology For Assessing Potential Risks To Deer Populations: A Case Study at a Superfund Site". Paper presented at the 1991 Annual Meeting of the Society of Environmental Toxicology and Chemistry. Abstract No. 426. November 1991.

Fitchko, J. 1989. Criteria for Contaminated Soil/Sediment Cleanup. Pudvan Publishing Company, Northbrook, Illinois.

Francis, Mary Evans. 1912. The Book of Grasses. Doubleday, Page and Company. Garden City, New York.

Fussell, John. 1991. Progress Reports for Bachmans Sparrow Survey. Mailed to Environmental Management Department, Marine Corps Base, Camp Lejeune, North Carolina.

Hulzebos, E.M., Adema, D.M.M., Dirven-van Breemen, E.M., Henzen, L., Van Dis, W.A., Herbold, H.A., Hoekstra, J.A., Baerselman, R., and Van Gestel, C.A.M. 1993. "Phytotoxicity Studies with *Lactuca sativa* in Soil and Nutrient Solution". Environmental Toxicology and Chemistry. Vol. 12, No. 6:1079-1094.

LeBlond, Richard. 1991. Critical Species List - Camp Lejeune Endangered Species and Special-Interest Communities Survey. Principal Investigator.

Long, E.W., D.D. Macdonald, S.L. Smith, and F.D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." Environmental Management Vol. 19, No.1, pp. 81-97.

Long, E.R and Morgan, L.G. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic and Atmospheric Administration Technical Memorandum NOS OMA 52.

Menzie, C.A., Cura J. and J. Freshman. 1993. Evaluating Ecological Risks and Developing Remedial Objectives at Forested Wetland Systems in New England. Paper contained in: Application of Ecological Risk Assessment To Hazardous Waste Site Remediation. Water Environmental Federation. January 1993.

Montgomery, J.H. and L.M. Welkon. 1990. Groundwater Chemicals Desk Reference. Lewis Publishers, Inc. Chelsea, Michigan.

Nagy, Kennith. 1987. "Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds. Ecological Monographs." 57(2). pp. 111-128.

NAS. 1992. Subcommittee on Mineral Toxicity in Animals. Mineral Tolerance of Domestic Animals. National Academy of Sciences. Washington, D.C. pp 5-7.

NC DEHNR. 1994. 15A NCAC 2b.0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina. State of North Carolina Department of Health and Natural Resources. June 1, 1994.

NC DEHNR. 1993. Classifications and Water Quality Standards Assigned to the Waters of the White Oak River Basin. State of North Carolina Department of Health and Natural Resources. February 1, 1993.

NC DEHNR, North Carolina Department of Environment, Health, and Natural Resources. May, 1992. Interim Guidance for Wetlands Protection. Division of Environment, Water Quality Section.

NC MFC. 1994. North Carolina Fisheries Rules for Coastal Waters, 1994-1995. North Carolina marine Fisheries Commission, Division of Marine Fisheries.

NCWRC, North Carolina Wildlife Resources Commission. June, 1992. 1992-1993 Hunting and Fishing Maps for North Carolina Game Lands.

NPS, National Park Service. 1993a. National Park System Map and Guide. U.S. Department of the Interior, National Park Service, Washington D.C.

NPS, Telephone conservation with the National Park Service. 1993b. The Wild and Scenic Rivers Division. U.S. Department of the Interior, National Park Service, Park Planning and Protection Division, Washington D.C.

NPS, National Park Service. 1990. The Wild and Scenic Rivers Act. U.S. Department of the Interior, National Park Service, Park Planning and Protection Division, Washington D.C.

Opresko, D.M., B.E. Sample, and G.W. Suter II. 1994. Toxicological Benchmarks for Wildlife, 1994 Revisions. Prepared for the US Department of Energy, Office of Environmental Restoration and Waste Management. September, 1994. ES/ER/TM-86/R1.

Peterson, Roger Tory. 1980. A Field Guide to the Birds of Eastern and Central North America. Houghton Mifflin Company. Boston, Massachusetts.

Peterson, Roger Tory and Margaret McKenny. 1968. A Field Guide to Wildflowers. Houghton Mifflin Company. Boston, Massachusetts.

Petrides, George A. 1986. A Field Guide to Trees and Shrubs. Houghton Mifflin Company. Boston, Massachusetts.

Scarano, Louis, J. Ph.D. and Daniel M. Woltering, Ph.D. 1993. "Terrestrial and Aquatic Eco-Assessment for A RCRA Hazardous Waste Site". Paper contained in: Application of Ecological Risk Assessment To Hazardous Waste Site Remediation. Cited in WEF, January 1993.

SCDM. 1991. Superfund Chemical Data Matrix. United States Environmental Protection Agency Hazardous Site Evaluation Division. December 1991.

Sullivan, J., J. Ball, E. Brick, S. Hausmann, G., G. Pilarski, and D. Sopcich. 1985 Report of the Technical Subcommittee on Determination of Dredge Material Suitability for In-Water Disposal. Wisconsin Department of Natural Resources, Madison, WI. November, 1985.

Suter, Glenn W. II. 1993 Ecological Risk Assessment. Lewis Publishers. Chelsea, Michigan.

Suter, G.W. II. and J.B. Mabrey. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota:1994 Revision. Environmental Sciences Division, Oak Ridge National Laboratory.

Tetra Tech, Inc. 1986. Development of Sediment Quality Values for Puget Sound, Volume I. Puget Sound Dredged Disposal Analysis Report. Cited in Fitchko, 1989.

Travis, Curtis C. and Angela Arms. 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environmental Science Technology. Vol. 22, No. 3.

USDI, U.S. Department of the Interior. 1993. Correspondence and Maps showing units within the Coastal Barriers Resource System. Fish and Wildlife Service.

USDI, U.S. Department of the Interior. March 1982. National Wetland Inventory Map, Jacksonville South, N.C. Fish and Wildlife Service.

USEPA, 1995a. "Toxic Substance Spreadsheet". US Environmental Protection Agency, Region IV, Atlanta, Georgia. January 26, 1995

USEPA, 1995b. "Region III BTAG Screening Levels". US Environmental Protection Agency, Region III, Philadelphia, PA. January 19, 1995

USEPA, 1993a. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning. United States Environmental Protection Agency, Office of Water. September 1993. EPA-822-R-93-011.

USEPA, 1993b. "Water Quality Guidance for the Great lakes System and Correction: Proposed Rules". Federal Register. 58(72) 20802-21047. Cited in Suter and Mabrey, 1994.

USEPA, 1993c. Wildlife Exposure Factors Handbook. United States Environmental Protection Agency. Office of Research and Development. Washington, D.C. EPA/600/R-93/187a. December 1993.

USEPA, 1993d. Sediment Quality Criteria for the Protection of Benthic Organisms- Phenanthrene. United States Environmental Protection Agency. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. EPA-822-R-93-014. September, 1993.

USEPA, 1993e. Sediment Quality Criteria for the Protection of Benthic Organisms- Dieldrin. United States Environmental Protection Agency. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. EPA-822-R-93-015. September, 1993.

USEPA. 1992a. Framework for Ecological Risk Assessment. United States Environmental Protection Agency. Risk Assessment Forum. EPA/630/R-92/001. February 1992.

USEPA, 1991a. National Functional Guidelines for Organic Data Review. Draft. USEPA Contract Laboratory Program. June 1991.

USEPA, 1991b. "Water Quality Criteria Summary" (Wall Chart). United States Environmental Protection Agency. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. May 1, 1991.

USEPA. 1989a. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Interim Final EPA/540/1-89/002. December, 1989.

USEPA. 1989b. United States Environmental Protection Agency. Risk Assessment Guidance for Superfund Volume II. Environmental Evaluation Manual Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. EPA/540/1-89-001. March 1989.

USEPA. 1989c. United States Environmental Protection Agency. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. Environmental Research Laboratory, Corvallis, OR. EPA/600/3-89/013. March 1989.

USEPA. 1987. Quality Criteria for Water-1986. U.S. Environmental Protection Agency, Office of Water Regulations, May 1987.

USEPA. 1986. United States Environmental Protection Agency. Chemical, Physical, and Biological Properties of Compounds Present at Hazardous Waste Sites. Office of Solid Waste and Remedial Response. Washington D.C. EPA/540/1-86/060. October 1986.

USMC, MCB Camp Lejeune. 1993. Fish and Wildlife Division, Environmental Management Department, Marine Corps Base Camp Lejeune, North Carolina. Personal Communication with Charles Peterson. October 1993.

USMC, MCB Camp Lejeune. 1991. Sea Turtle Inventory for Summer and Fall 1991. Assistant Chief of Staff, Environmental Management Department, Fish and Wildlife Division, Marine Corps Base, Camp Lejeune, North Carolina.

USMC, MCB Camp Lejeune. 1987. Multiple-Use Natural Resources Management Plan. Fish and Wildlife Division, Environmental Management Department, Marine Corps Base, Camp Lejeune, North Carolina.

Walters, J.R. and J.M. Goodson. 1991. Status of the Red-Cockaded Woodpecker at Camp Lejeune, 1991. North Carolina State University. Submitted to the Department of Defense, USMC, Camp Lejeune, Environmental Management Department.

Water Environment Federation (WEF). 1989. Application of Ecological Risk Assessment to Hazardous Waste Site Remediation. Based on a January 10, 1993 Workshop., 601 Wythe Street, Alexandria, VA 22314-1994.

Will, M.E. and Suter, G.W. II. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Environmental Sciences Division, Oak Ridge National Laboratory.

Will, M.E. and Suter, G.W. II. 1994. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants. Environmental Sciences Division, Oak Ridge National Laboratory.

WS, Telephone conservation with the Wilderness Society, Washington D.C. 1993.

WS, The Wilderness Society. 1989 . The National Wilderness Preservation System, 1964-1989. The Wilderness Society, Washington D.C.

SECTION 7.0 TABLES

TABLE 7-1

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SURFACE WATER SCREENING VALUES
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Screening Values (SWSV)				Contaminant Frequency/Range			
	North Carolina Water Quality Standards (WQS)(1)	USEPA Region IV Water Quality Screening Values (WQSV)(2)						
Contaminant		Acute	Chronic	Average Reference Station Concentration	No. of Positive Detects/No. of Samples	Range of Positive Detection	No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
Inorganics (µg/L)								
Aluminum	NE	NE	NE	ND	5/5	4,210J-12,300J	NA	5
Arsenic	50	69	36	8.13	4/5	2.2J-3.1J	0	0
Barium	NE	NE	NE	24.25	5/5	22.9-30.4	NA	3
Calcium	NE	NE	NE	134,025	5/5	154,000J-173,000J	NA	5
Chromium (IV)	20	1,100	50	128	1/5	15.6	0	0
Iron	NE	NE	NE	318	5/5	2,780J-6,650J	NA	5
Lead	25	220	8.5	16.41	5/5	5.5J-13.7	1	0
Magnesium	NE	NE	NE	511,200	5/5	542,000-615,000	NA	5
Manganese	NE	NE	10(3)	ND	5/5	17.2-24.4	5	5
Potassium	NE	NE	NE	207,250	5/5	169,000-188,000	NA	0

TABLE 7-1 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SALTWATER SURFACE WATER SCREENING VALUES
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
	North Carolina Water Quality Standards (WQS)(1)	USEPA Region IV Water Quality Screening Values (WQSV)(2)			No. of Positive Detects/No. of Samples	Range of Positive Detection		
		Acute	Chronic					
Silver	0.1	2.3	NE	19.13	5/5	6.4-8.9	5	0
Sodium	NE	NE	NE	3,073,350	5/5	4,240,000J-4,740,000J	NA	5
Vanadium	NE	NE	<10,000(3)	ND	1/5	19.6	0	1
Volatiles (µg/L) 4-Methyl-2-pentanone	NE	NE	NE	ND	1/5	7J	NA	1
1,1,2,2-Tetrachloroethane	NE	9,020(4)	NE	ND	1/5	2J	0	1
Semivolatiles (µg/L) Bis(2-ethylhexyl)phthalate	NE	NE	NE	ND	1/5	10J	NA	1

NE = Not Established

NA = Not Applicable

(1) NC DEHNR, 1994 (Water Quality Standards)
(2) USEPA, 1995a (Region IV Toxic Substance Spreadsheet)
(3) USEPA, 1995b (Region III BTAG Screening Levels)
(4) USEPA, 1991 (AWQC Wall Chart-Lowest Observed Effects Level)

TABLE 7-2

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SEDIMENT SCREENING VALUES
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Sediment Screening Values (SSV)				Contaminant Frequency/Range			
Contaminant	ER-L	ER-M	SQC(2)	Average Reference Station Concentration	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration
Inorganics (mg/kg)								
Aluminum	NE	NE	NE	9,864	10/10	1,380J-7,460J	NA	0
Arsenic	8.2(1)	70(1)	NE	ND	8/10	0.8J-4.7J	0	8
Barium	500(3)	NE	NE	12.44	10/10	1.9-10.8	0	0
Beryllium	0.5(4)	NE	NE	ND	4/10	0.27-0.33	0	4
Calcium	NE	NE	NE	2,933	10/10	87.4-1,220	NA	0
Chromium	81(1)	370(1)	NE	30.87	10/10	3.9-21.2	0	0
Cobalt	NE	NE	NE	3.2	3/10	2.4-3.1	NA	0
Iron	27,000(4)	NE	NE	12,869	10/10	336J-9,960J	0	0
Lead	46.7(1)	218(1)	NE	5.75	10/10	2.3J-6J	0	1
Magnesium	NE	NE	NE	5,081	3/10	504-618	NA	0
Manganese	230(4)	NE	NE	45.66	10/10	1.7-10.5	0	0
Silver	1.0(1)	3.7(1)	NE	ND	1/10	1.2	1	1
Sodium	NE	NE	NE	ND	10/10	170-1,320	NA	10
Vanadium	NE	NE	NE	26.59	10/10	3.6-29.9	NA	1
Zinc	150(1)	410(1)	NE	30.66	10/10	1.9J-46.4J	0	1

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SEDIMENT SCREENING VALUES
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration
	ER-L	ER-M	SQC(2)		No. of Positive Detects/No. of Samples	Range of Positive Detections		
Volatiles (µg/kg) Carbon disulfide	NE	NE	NE	ND	1/10	2J	NA	1
Toluene	NE	NE	381	ND	2/10	1J-2J	0	2

NE = Not Established

ER-L - Effects Range Low

SQC = Sediment Quality Criteria

NA = Not Applicable

ER-M - Effects Range Median

(1) Long et.al., 1995

(2) Values were calculated using the following equation: SQC = Foc*Koc*FCV/1000000

Where:

Foc = Fraction of organic carbon in the sediments (used 2,700 mg/kg)

Koc = Organic carbon partition coefficient (chemical specific)

FCV = Final water chronic value (chemical specific)

(3) Sulliven et.al., 1985

(4) Tetra Tech Inc., 1986 (Apparent Effects Threshold Sediment Quality Values)

TABLE 7-3

CONTAMINANTS OF CONCERN IN EACH MEDIA
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water		Sediment	Surface Soil
	Aquatic receptors	Terrestrial receptors		
Inorganics				
Aluminum	X	X		X
Arsenic				X
Barium	X	X		X
Beryllium				X
Cadmium				X
Chromium				X
Copper				X
Iron	X	X		X
Lead				X
Manganese	X	X		X
Mercury				X
Selenium				X
Silver			X	X
Thallium				X
Vanadium		X	X	X
Zinc				X
Volatiles				
Acetone				X
Carbon disulfide			X	
4-Methyl-2-pentanone	X	X		
1,1,2,2-Tetrachloroethane		X		
Toluene				X
Semivolatiles				
Benzo(a)pyrene				X
Benzo(b)fluoranthene				X
Bis(2-ethylhexyl)phthalate				X
Chrysene				X
Phenanthrene				X
Pyrene				X

TABLE 7-3 (Continued)

CONTAMINANTS OF CONCERN IN EACH MEDIA
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water		Sediment	Surface Soil
	Aquatic receptors	Terrestrial receptors		
Pesticides/PCBs Alpha-chlordane				X
Gamma-chlordane				X
4,4'-DDE				X
4,4'-DDD				X
4,4'-DDT				X
Dieldrin				X
Endrin				X
Endrin aldehyde				X
Endrin ketone				X
Endosulfan II				X
Aroclor-1254				X
Aroclor-1260				X

X = Retained as COPC

TABLE 7-4

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors		
				Bv(1)(2)	Br(1)(2)	Bb(1)(2)
Inorganics						
Aluminum	231(4)	ND	ND	4.00e-03	6.50e-04	1.50e-03
Arsenic	44(3)	ND	ND	4.00e-02	6.00e-03	2.00e-03
Barium	8(4)	ND	ND	1.50e-01	1.50e-02	1.50e-04
Beryllium	19(3)	ND	ND	1.00e-02	1.50e-03	1.00e-03
Cadmium	64(3)	ND	ND	5.50e-01	1.50e-01	5.50e-04
Chromium	16(3)	ND	ND	7.50e-03	4.50e-03	5.50e-03
Copper	36(3)	ND	ND	4.00e-01	2.50e-01	1.00e-02
Iron	ND	ND	ND	4.00e-03	1.00e-03	2.00e-02
Lead	49(3)	ND	ND	4.50e-02	9.00e-03	3.00e-04
Manganese	35(4)	ND	ND	2.50e-01	5.00e-02	4.00e-04
Mercury	5,500(3)	ND	ND	9.00e-01	2.00e-01	2.50e-01
Selenium	6(3)	ND	ND	2.50e-02	2.50e-02	1.50e-02
Silver	0.5(3)	ND	ND	4.00e-01	1.00e-01	3.00e-03
Thallium	119(3)	ND	ND	4.00e-03	4.00e-04	4.00e-02
Vanadium	ND	ND	ND	5.50e-03	3.00e-03	2.50e-03
Zinc	47(3)	ND	ND	1.50e+00	9.00e-01	1.00e-01
Semivolatiles						
Benzo(a)pyrene	30(3)	5,500,000(5)	6.0(6)	1.30e-02	1.30e-02	2.51e-02
Benzo(b)fluoranthene	30(3)	550,000(5)	6.6(6)	6.00e-03	6.00e-03	1.00e-01
Bis(2-ethylhexyl)phthalate	130(3)	100,000(7)	5.1(6)	4.40e-02	4.40e-02	3.16e-03
Chrysene	30(3)	200,000(5)	5.7(6)	2.00e-02	2.00e-02	1.26e-02
Phenanthrene	30(3)	28,840(8)	4.5(6)	9.70e-02	9.70e-02	7.94e-04
Pyrene	30(3)	38,000(5)	5.3(6)	3.30e-02	3.30e-02	5.01e-03
Pesticides						
Alpha-chlordane	14,100(3)	140,000(5)	5.5(6)	2.60e-02	2.60e-02	7.94e-03
Gamma-chlordane	14,100(3)	140,000(5)	5.5(6)	2.60e-02	2.60e-02	7.94e-03
4,4'-DDD	53,600(3)	770,000(5)	6(6)	1.32e-02	1.32e-02	2.51e-02
4,4'-DDE	53,600(3)	4,400,000(5)	5.7(6)	2.00e-02	2.00e-02	1.26e-02
4,4'-DDT	53,600(3)	243,000(5)	6.4(6)	8.00e-03	8.00e-03	6.31e-02
Dieldrin	4,670(3)	177,828(9)	4.6(6)	8.50e-02	8.50e-02	1.00e-03

TABLE 7-4 (Continued)

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCS
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors		
				Bv(1)(2)	Br(1)(2)	Bb(1)(2)
Endosulfan II	270(3)	3,162(10)	3.6(6)	3.22e-01	3.22e-01	1.00e-04
Endrin	3,970(3)	1,698(11)	5.6(6)	2.20e-01	2.20e-01	1.00e-02
Endrin aldehyde	3,970(12)	1,698(12)	5.6(12)	2.20e-01	2.20e-01	1.00e-02
Endrin ketone	3,970(12)	1,698(12)	5.6(12)	2.20e-01	2.20e-01	1.00e-02
PCBs, total	31,200(3)	530,000(5)	5.6(6)	2.20e-02	2.20e-02	1.00e-02
Volatiles Acetone	0.69(4)	2.2(5)	-0.24(6)	5.30e+01	5.30e+01	1.45e-08
Carbon disulfide	ND	54(5)	0(6)	3.90e+01	3.90e+01	2.51e-08
4-Methyl-2-Pentanone	5(4)	ND	1.2(6)	7.84e+00	7.84e+00	3.98e-07
1,1,2,2-Tetrachloroethane	5(3)	54(5)	2.6(6)	1.22e+00	1.22e+00	1.00e-05
Toluene	10.7(3)	300(5)	2.7(6)	1.07e+00	1.07e+00	1.26e-05

BCF = Bioconcentration Factor
ND = No Data
Bv = Biotransfer factor for vegetation (stems, leaves)
Br = Biotransfer factor for vegetation (berries, fruits)
Bb = Biotransfer factor for beef
(1) Baes et.al., 1984 for the inorganics
(2) The organics were calculated using Travis and Arms, 1988
(3) USEPA, 1995b (Region IV)
(4) USEPA, 1995a (Region III)
(5) USEPA, 1986.
(6) SCDM, 1991.
(7) Montgomery, 1990.
(8) USEPA, 1993d (Sediment Quality Criteria for Phenanthrene)
(9) USEPA, 1993e (Sediment Quality Criteria for Dieldrin)
(10) ASTDR, 1993 (Toxicological Profile for Endosulfan)
(11) ASTDR, 1989b (Toxicological Profile for Endrin)
(12) Used Endrin Value

TABLE 7-5

PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
American alligator (Alligator mississippienis) (2)	T(f), T(s)
Bachmans sparrow (Aimophilia aestivalis)(1)	SC
Black skimmer (Rhynochops niger)(1)	SC
Green (Atlantic) turtle (Chelonia m. mydas) (2)	T(f), T(s)
Loggerhead turtle (Caretta caretta) (2)	T(f), T(s)
Peregrine falcon (*)(1)	(*)
Piping plover (Charadrius melodus)(1)	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)(3)	E(f), E(s)
Rough-leaf loosestrife (Lysimachia asperulifolia)(4)	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

* The observer did not differentiate between the American eastern peregrine falcon [E(f), E(s)] or the Arctic peregrine falcon [T(f), T(s)].

Source:
(1) Fussell, 1991
(2) USMC, 1991
(3) Walters, 1991
(4) LeBlond, 1991

TABLE 7-6

SAMPLING STATION CHARACTERIZATION SUMMARY
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Media Sampled	Stream Width (ft)	Stream Depth (ft)	Canopy Cover	Sediment Description	Sediment Odor
16-NC-01	SW,SD	NM	NM	Open	Sand, fine to medium grained with trace silt and medium grained gravel, sandy clay in bottom 6"	Normal
16-NC-02	SW,SD	NM	NM	Open	Sand, fine to medium grained with trace silt and fine grained gravel, some rooted material	Anaerobic
16-NC-03	SW,SD	NM	NM	Open	Sand, fine grained with trace silt and trace fine grained gravel	Normal
16-NC-04	SW,SD	NM	NM	Open	Sand, fine grained with trace silt and some fine grained gravel	Normal
16-NC-05	SW,SD	NM	NM	Open	Silty clay with oxidation present	Normal

NM - Not measured due to large size of the Northeast Creek
SW - Surface Water Samples
SD - Sediment Samples
NC - Northeast Creek Stations

TABLE 7-7

FIELD CHEMISTRY
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Temperature (deg. C)	pH (S.U.)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Salinity (ppt)
16-NC-01	24.9	7.8	5.6	31,800	27
16-NC-02	28.1	7.8	4.7	32,800	23
16-NC-03	29.2	8	6.8	32,500	29
16-NC-04	30.1	8	7.2	33,000	30
16-NC-05	30.9	7.99	7.3	32,200	30

S.U. - Standard Units
ppt - Parts Per Thousand
mg/L = milligrams per liter
umhos/cm - micromhos per centimeter

TABLE 7-8

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil Flora and Fauna Screening Values(1) (SSSV)				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Inorganics (mg/kg)							
Aluminum	50	NE	NE	600	29/29	866J-18,500	29
Arsenic	10	60	NE	100	17/29	2.3-24.7J	2
Barium	500	440(2)	440(2)	3,000	29/29	3-334	0
Beryllium	10	NE	NE	NE	6/29	0.24-0.49	0
Cadmium	3	20	3	20	2/29	1.8-9.6	1
Chromium	1	0.4	0.0075(2)	10	27/29	2.2-43.2J	27
Copper	100	50	20	100	24/29	2.2J-543J	5
Iron	100(2)	NE	3,515	200	24/29	470-69,700	24
Lead	50	500	300	900	28/29	3.8J-5,210J	7
Manganese	500	330(2)	330(2)	100	25/29	2.8J-1,030J	1
Mercury	0.3	0.1	300	30	9/29	0.11J-14	9
Selenium	1	70	0.26(2)	100	8/29	1.1-6	8
Silver	2	NE	NE	50	2/29	1.2-1.3J	0
Thallium	1	NE	NE	NE	2/29	2.1-3.6	2
Vanadium	2	58(2)	58(2)	20	28/29	2.3J-45.4	28
Zinc	50	200	500	100	17/29	14.2J-4,350J	9

TABLE 7-8 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil Flora and Fauna Screening Values(1) (SSSV)				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Pesticides/PCBs (µg/kg)							
4,4'-DDD	NE	100(2)	100(2)	NE	20/29	2.6J-120	1
4,4'-DDE	NE	100(2)	100(2)	NE	26/29	5-440	4
4,4'-DDT	NE	4(2)	4(2)	NE	24/29	3.8-540	19
Alpha-chlordane	NE	<100(2)	<100(2)	NE	11/29	3.1J-120	1
Gamma-chlordane	NE	<100(2)	<100(2)	NE	9/29	1.6J-72J	0
Dieldrin	NE	<100(2)	<100(2)	NE	10/29	5.6-77J	0
Endrin	NE	<100(2)	<100(2)	NE	3/29	6.5-14J	0
Endrin aldehyde	NE	<100(2)	<100(2)	NE	9/29	4.6-29	0
Endrin ketone	NE	<100(2)	<100(2)	NE	2/29	4.2-9.9	0
Endosulfan	1,000(3)	NE	NE	NE	8/29	1.9-26J	0
Aroclor-1254	40,000(4)	40(2)(4)	40(2)	NE	13/29	41-2,100	13
Aroclor-1260	40,000(4)	40(2)(4)	40(2)	NE	2/29	50J-210J	2

TABLE 7-8 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil Flora and Fauna Screening Values(1) (SSSV)				Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSSV
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Semivolatiles (μg/kg)							
Bis(2-ethylhexyl)phthalate	NE	NE	NE	NE	6/29	37J-490	NA
Chrysene	NE	100(2)	100(2)	NE	4/29	43J-70J	0
Phenanthrene	NE	100(2)	100(2)	NE	3/29	52J-99J	0
Pyrene	NE	100(2)	100(2)	NE	3/29	39J-110J	1
Volatiles (μg/kg)							
Acetone	NE	NE	NE	NE	3/29	11J-1,200	NA
Toluene	200,000	100(2)	100(2)	NE	3/29	1J-4J	0

(1) Will and Suter, 1994a and 1994b unless indicated otherwise (Values presented for plants, earthworms, and microorganisms and microbial processes are benchmarks below which adverse inpacts to these species are not expected. Values for invertebrates are No Observed Effects Concentrations, however, they are based on less data than the benchmarks)

(2) USEPA, 1995 (Region III BTAG Soil Screening Values for Soil Fauna)

(3) Hulzebos et.al., 1993 (EC50)

(4) Based on total PCBs

TABLE 7-9

EXPOSURE FACTORS FOR THE TERRESTRIAL CHRONIC DAILY INTAKE MODEL
OPERABLE UNIT NO. 8 (SITE 16)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION, CTO-0274

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Raccoon	Small Mammal
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 40% Fish 60%	Vegetation 100%
Feeding Rate	kg/day	1.6$^{(2)}$	0.237$^{(4)}$	0.0135$^{(3)}$	0.601$^{(3)}$	0.214$^{(6)}$	0.112$^{(3)}$
Incident Soil Ingestion	kg/day	0.0185$^{(1)}$	0.0057$^{(5)}$	0.0011$^{(5)}$	0.0168$^{(5)}$	0.0201$^{(5)}$	0.00269$^{(5)}$
Rate of Drinking Water Ingestion	L/day	1.1$^{(2)}$	0.119$^{(3)}$	0.0191$^{(3)}$	0.385$^{(3)}$	0.422$^{(3)}$	0.0652$^{(3)}$
Rate of Vegetation Ingestion	kg/day	1.6	0.237	0.0135	0.12	0.086	0.112
Body Weight	kg	45.4$^{(2)}$	1.229$^{(3)}$	0.174$^{(3)}$	4.54$^{(3)}$	5.12$^{(3)}$	0.3725$^{(3)}$
Rate of Small Mammal Ingestion	kg/day	NA	NA	NA	0.48	NA	NA
Rate of Fish Ingestion	kg/day	NA	NA	NA	NA	0.128	NA
Home Range Size	acres	454$^{(2)}$	9.30$^{(3)}$	26.24$^{(3)}$	1,245$^{(3)}$	257$^{(3)}$	0.032$^{(3)}$

NA - Not Applicable

(1) Arthur and Alldridge, 1979

(2) Dee, 1991

(3) USEPA, 1993b

(4) Opresko, et.al., 1994

(5) Beyer, 1993

6) Nagy, 1987

TABLE 7-10

SURFACE WATER QUOTIENT INDEX
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Station	Concentration	Quotient Index		
			North Carolina WQS	USEPA WQSV	
				Acute	Chronic
Inorganics (µg/L)					
Manganese	16-NC-SW01	19.30	NE	NE	1.93
Manganese	16-NC-SW02	21.20	NE	NE	2.12
Manganese	16-NC-SW03	19.30	NE	NE	1.93
Manganese	16-NC-SW04	17.20	NE	NE	1.72
Manganese	16-NC-SW05	24.40	NE	NE	2.44

NE - Not Established
WQS - Water Quality Standard
WQSV - Water Quality Screening Value
Shaded areas are samples with Quotient Indices exceeding "1"

TABLE 7-11

SEDIMENT QUOTIENT INDEX
NORTHEAST CREEK
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Station	Concentration (µg/kg)	Quotient Index		
			ER-L	ER-M	SQC
Silver	16-NC-SD01-06	1.20	1.20	0.32	NE

NE - Not Established
ER-L - Effects Range Low
ER-M - Effects range Median
SQC - Sediment Quality Criteria
Shaded area is sample with Quotient Index exceeding "1"

TABLE 7-12

TERRESTRIAL INTAKE MODEL QUOTIENT INDICES
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
Aluminum	5.55e-02	2.05e-01	1.07e+00	2.04e+02	4.85e-02
Arsenic	1.55e-02	5.07e-04	1.24e-02	1.80e-01	5.61e-04
Barium	3.19e-02	3.41e-02	4.61e-01	1.05e-01	1.96e-02
Beryllium	1.11e-05	1.48e-04	1.59e-03	5.58e-05	1.26e-05
Cadmium	5.42e-04	1.21e-03	1.48e+00	5.52e-02	4.82e-02
Chromium	1.41e-03	7.85e-05	4.63e-04	8.27e-03	6.69e-05
Copper	3.07e-04	6.42e-03	1.56e-01	8.71e-04	1.01e-02
Iron	3.37e-02	6.22e-02	7.15e-01	5.78e-02	2.95e-02
Lead	1.24e-03	4.03e-02	6.61e-01	8.95e-03	1.96e-02
Manganese	9.91e-04	6.77e-04	5.10e-02	7.32e-03	3.68e-03
Mercury	5.76e-04	2.66e-02	4.47e-01	6.06e-04	1.52e-02
Selenium	9.11e-04	7.24e-04	3.73e-02	4.55e-03	9.60e-04
Silver	2.32e-02	3.25e-04	4.86e-01	2.78e-02	1.94e-02
Thallium	1.64e-03	2.12e-02	2.00e-01	8.48e-03	1.38e-03
Vanadium	6.55e-03	3.31e-04	5.35e-01	8.86e-03	1.65e-03
Zinc	3.87e-02	3.98e-02	1.42e+00	1.47e-03	4.69e-02
Alpha-chlordane	2.30e-06	6.14e-06	1.81e-03	4.80e-05	1.41e-07
Gamma-chlordane	7.68e-07	2.05e-06	6.03e-04	1.60e-05	4.71e-08
4,4'-DDD	1.48e-06	4.91e-04	2.25e-04	7.57e-06	1.86e-06
4,4'-DDE	8.30e-06	2.84e-03	1.43e-03	4.20e-05	1.27e-05
4,4'-DDT	1.14e-05	3.68e-03	1.52e-03	5.88e-05	1.15e-05
Dieldrin	3.89e-05	2.26e-04	3.63e-02	5.38e-04	6.08e-07
Endrin	1.24e-06	3.10e-06	6.80e-05	1.90e-06	6.20e-07
Endrin aldehyde	3.24e-06	8.14e-06	1.78e-04	4.99e-06	1.63e-06
Endrin ketone	1.02e-06	2.57e-06	5.62e-05	1.57e-06	5.13e-07
Endosulfan II	3.02e-07	9.59e-07	4.14e-04	3.37e-06	4.97e-06

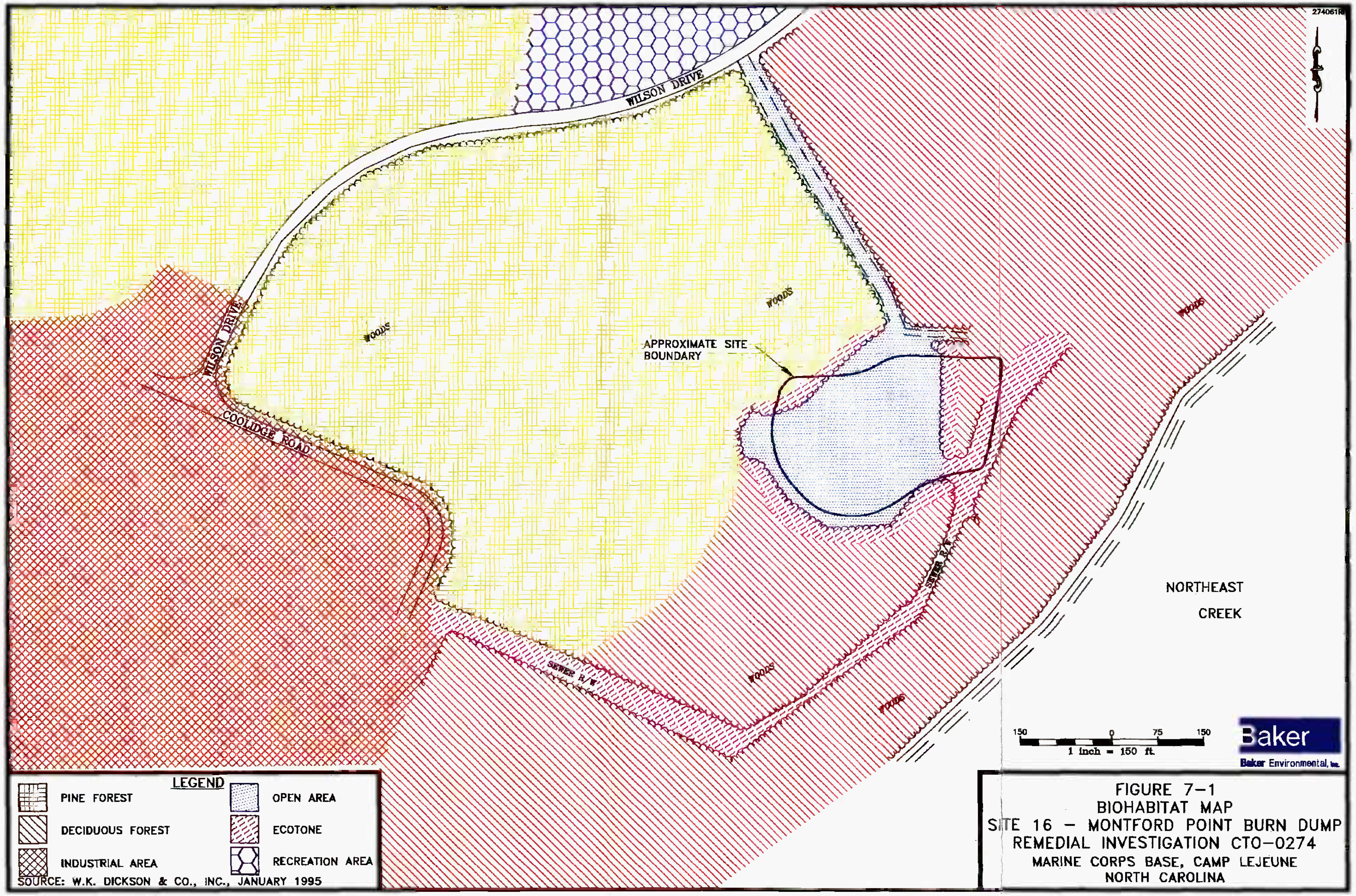
TABLE 7-12 (Continued)

TERRESTRIAL INTAKE MODEL QUOTIENT INDICES
OPERABLE UNIT NO. 8 (SITE 16)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
Aroclor-1254	1.54e-05	1.28e-03	2.76e-03	7.74e-05	2.70e-04
Aroclor-1260	1.81e-04	2.52e-03	3.25e-02	9.09e-04	2.96e-04
Benzo(a)pyrene	9.10e-06	1.22e-04	1.38e-03	4.66e-05	1.15e-05
Benzo(b)fluoranthene	5.97e-06	7.65e-05	7.54e-04	3.06e-05	5.49e-06
Bis(2-ethylhexyl)phthalate	7.42e-03	7.52e-04	2.23e-02	3.01e-01	4.68e-03
Chrysene	5.09e-06	7.03e-05	8.74e-04	2.58e-05	7.79e-06
Phenanthrene	1.14e-07	1.88e-06	3.69e-05	5.11e-07	4.12e-07
Pyrene	1.16e-06	1.67e-05	2.41e-04	5.69e-06	2.35e-06
Acetone	3.37e-05	7.33e-04	2.12e-02	1.07e-04	2.64e-04
Toluene	4.32e-08	8.97e-07	2.46e-05	1.49e-07	3.04e-07
TOTAL QI	2.20e-01	4.52e-01	7.85e+00	2.05e+02	2.71e-01

Shaded areas are samples with Quotient Indices exceeding "1".

SECTION 7.0 FIGURES



LEGEND

▦	PINE FOREST	░	OPEN AREA
▧	DECIDUOUS FOREST	▨	ECOTONE
▩	INDUSTRIAL AREA	⬡	RECREATION AREA

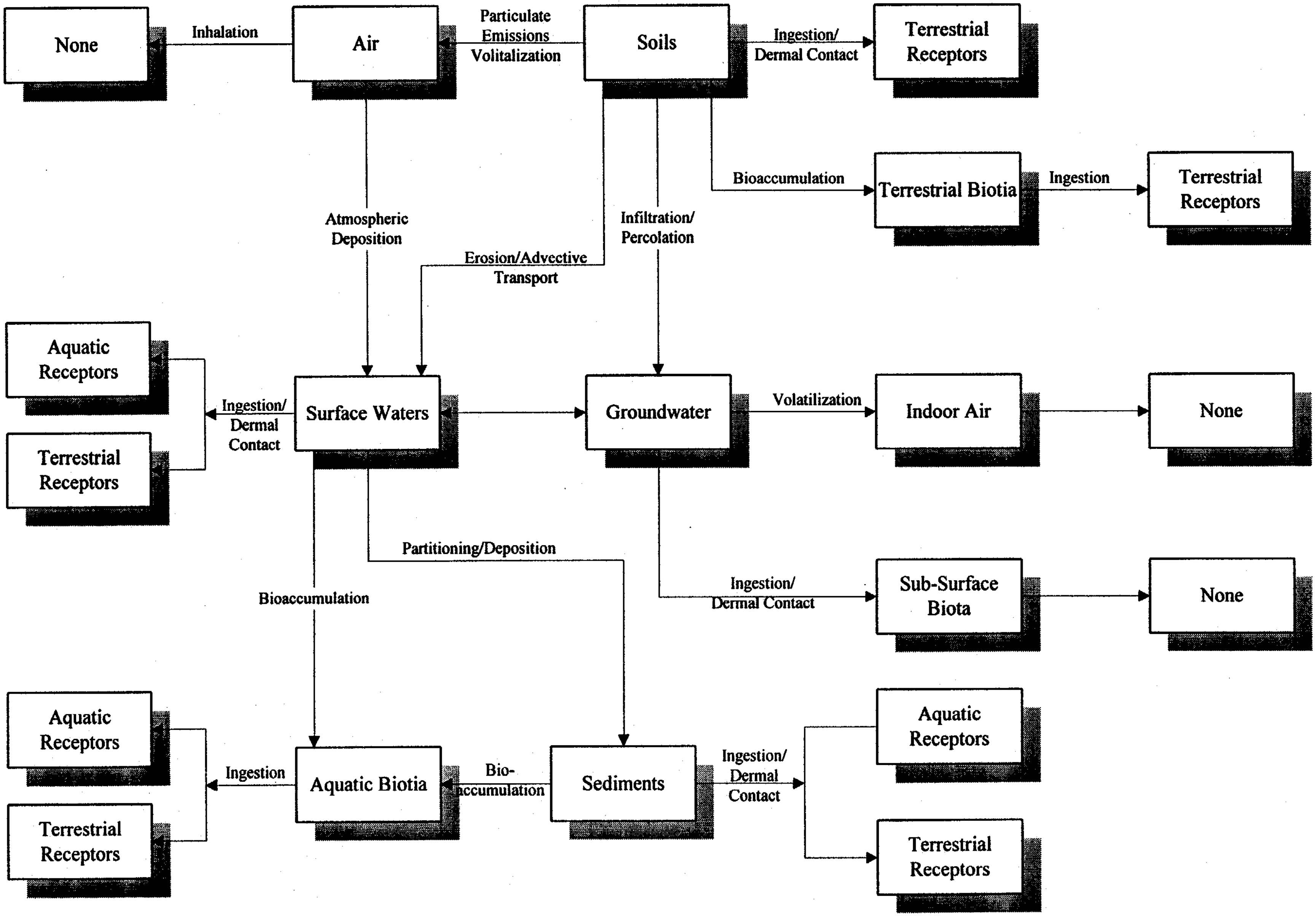
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

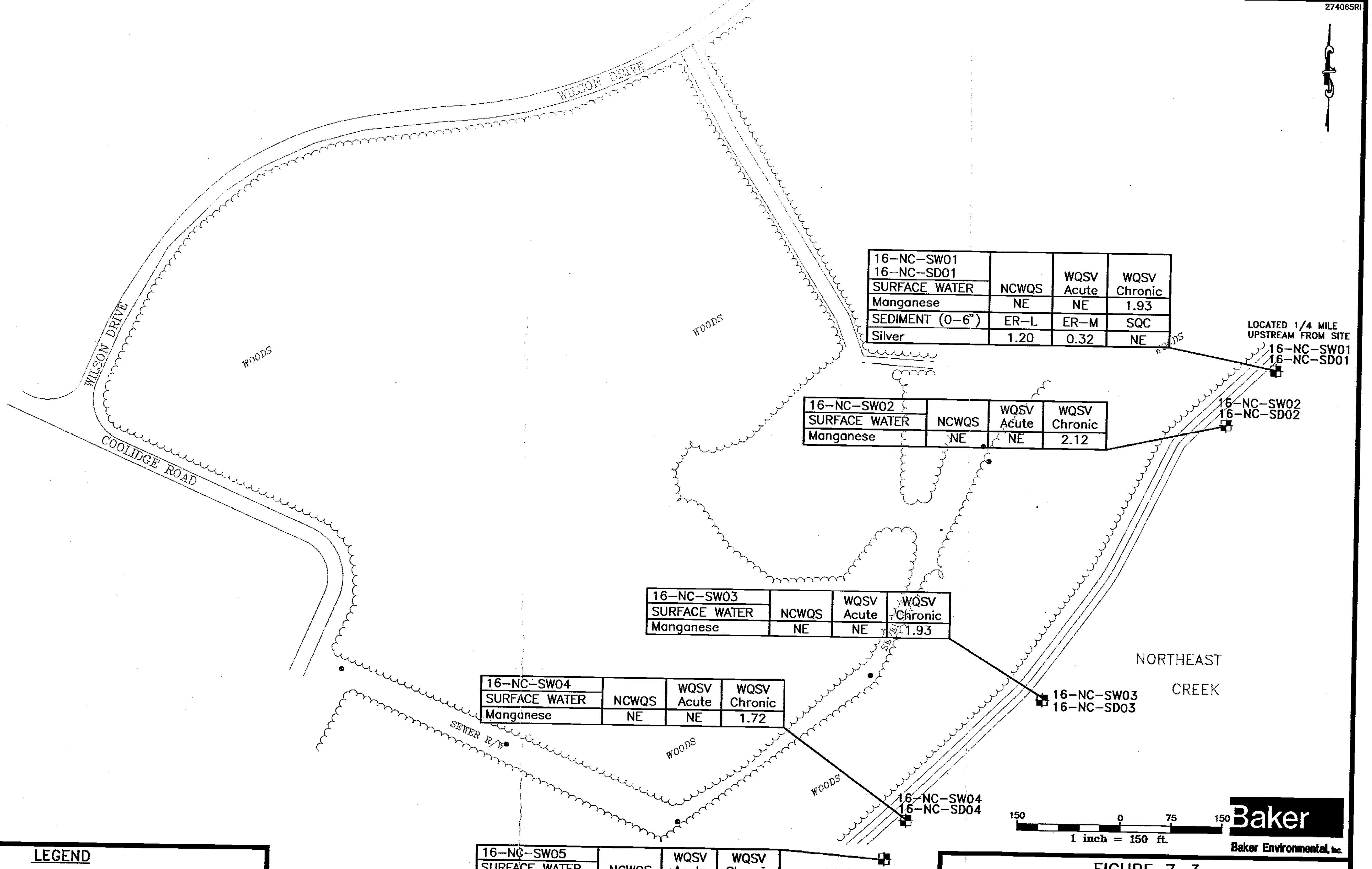
FIGURE 7-1
BIOHABITAT MAP
SITE 16 – MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q26Y

FIGURE 7-2

CONCEPTIONAL EXPOSURE MODEL FOR ECOLOGICAL RECEPTORS





16-NC-SW01 16-NC-SD01			
SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NE	NE	1.93
SEDIMENT (0-6")	ER-L	ER-M	SQC
Silver	1.20	0.32	NE

16-NC-SW02			
SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NE	NE	2.12

16-NC-SW03			
SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NE	NE	1.93

16-NC-SW04			
SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NE	NE	1.72

16-NC-SW05			
SURFACE WATER	NCWQS	WQSV Acute	WQSV Chronic
Manganese	NE	NE	2.44

LEGEND

16-NC-SW01
16-NC-SD01
⊞ SURFACE WATER/SEDIMENT SAMPLE LOCATION

SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 7-3
QUOTIENT INDEX RATIOS THAT EXCEEDED "1" IN THE SURFACE WATER AND SEDIMENT
SITE 16 - MONTFORD POINT BURN DUMP
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01695Q272

8.0 CONCLUSIONS

The following conclusions for Operable Unit (OU) No. 8 (Site 16) are based on the results of the Remedial Investigation, and the human health and ecological risk assessment.

1. The site is primarily underlain by sands and silty sands. These sands are generally overlain by thin layers of silt and silty clay. Occasional lenses and/or discontinuous layers of sand and clay, and clay are present at depth. Fill material (i.e., treated timbers, rubber, and gravel) was identified at bore hole locations in the northern portion of the study area, ranging in thickness from one to nine feet.

2. The presence of PAHs in soil may be the result of past burning operations conducted at the site. The extent of PAH contamination in the surface and subsurface is primarily in the central portion of the study area. PAHs were not detected in the groundwater.

3. Pesticide concentrations in soil are similar to levels detected across the base. These levels are indicative of historical pest control spraying. Pesticides were not detected in the groundwater.

4. Although a limited number of inorganic contaminants in soil exceed base background levels, previous operations do not appear to have resulted in widespread or significant levels of inorganic contamination.

5. The wide distribution of PCBs (Aroclor 1254 and 1260) may be due to use of oils used in burning activities. These contaminants were not detected in the groundwater.

7. Site-related contaminants such as PAHs and PCBs were not detected in the surface water or sediment.

8. The presence of iron in groundwater is potentially due to naturally occurring conditions based or background levels.

9. Under current scenarios, there are no carcinogenic or noncarcinogenic risks to human receptors. However, under a future residential scenario a potential noncarcinogenic risk is possible. The potential total noncarcinogenic risk to a future child (1.2) slightly exceeds the acceptable noncarcinogenic risk level 1.0. This exceedence is primarily due to the ingestion of PCBs in the soil.

10. Due to the absence of contaminants in the surface water and sediment, a potential decrease in the aquatic receptor population is not expected.

11. Several contaminants detected in the surface soil exceed surface soil screening values. Therefore, there is a potential for a limited decrease in the terrestrial floral and faunal population in this area. However, it should be noted that no areas of dead or stressed vegetation were observed during the habitat evaluation. A potential decrease in the terrestrial vertebrate receptor population is not expected. A large portion of the

investigation area is cleared and used for vehicle traffic, thereby masking any possible stressed vegetation.