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FINAL

REMEDIAL INVESTIGATION REPORT
OPERABLE UNIT NO. 11 (SITE 80)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

TEXT AND FIGURES

CONTRACT TASK ORDER 0274

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	microgram per kilogram
µg/L	micrograms per liter
ABS	absorption factor
AET	Apparent Effect Threshold Values
AF	adherence factor
AOC	Area of concern
AQUIRE	Aquatic Information Retrieval Database
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AT_c	averaging time, carcinogen
At_{nc}	averaging time, noncarcinogen
b	saturated thickness
Baker	Baker Environmental, Inc.
Bb	biotransfer factor for beef
BB	background boring
BCF	bioconcentration factor
bgs	below ground surface
BI	biotoxic index
Br	biotransfer factor fruit part of plant
BRA	baseline risk assessment
BW	body weight
C	contaminant concentration
CADD	Computer Aided Drafting Design
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
CFR	Code of Federal Regulations
CL	low plasticity clay
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
cm/sec	centimeter/second
CoC	Chain-of-Custody
CO	Commercial Development
COPC	contaminant of potential concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	Carcinogenic Slope Factor
DA	Drum Area
DDE	dichlorodiphenyldichloroethylene
DDT	diphenyltrichloroethane
DoN	Department of the Navy

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

DPA	Detected Pesticide Area
DQOs	data quality objectives
ED	exposure duration
EF	exposure frequency
Eh	oxidation reduction potential
EMD	Environmental Management Department
ERA	ecological risk assessment
ESE	Environmental Science and Engineering, Inc.
ET	Eastern Tributary
ET	Exposure Time
FB	Field Blank
FFA	Federal Facilities Agreement
F_i	fraction ingested
FMF	Fleet Marine Force
FSAP	Field Sampling and Analysis Plan
ft	feet
FWS	Fish and Wildlife Service
GA	Existing or Potential Source of Drinking Water for Humans (<250 mg/L Chloride)
gpm	gallons per minute
H	Species Diversity
H'	Diversity Index
HA	health advisories
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HI	hazard index
HQ	hazard quotient
i	hydraulic gradient
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

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

LA	Lawn Area
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LEL	low explosive limit
LOAEL	lowest observed adverse effect level
MA	Maintenance Area
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
MF	modifying factor
mg/L	milligram per liter
mg/kg	milligram per kilogram
mgd	million gallons per day
MI	mobility index
ml	milliliter
msl	mean sea level
MW	monitoring well
NC DEHNR	North Carolina Department of Environment, Health and Natural Resources
NC	Northeast Creek
NC	North Carolina
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
NFESC	Naval Facilities Engineering Service Center
NOAEL or NOEL	No observed adverse effect level
NPL	National Priorities List
NPS	National Park Service
NREA	National Resources and Environmental Affairs
NSW	nutrient sensitive waters
NTU	nephelometric turbidity units
NWI	national wetlands inventory
OA	Open Area
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PC	permeability constant
PCBs	polychlorinated biphenyls

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
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	record of decision
S.U.	Standard Unit
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SM	silty sand
SMA	soil mound area
SOPs	standard operating procedures
SP	poorly graded sands with little to no fines
SQC	sediment quality criteria
SSSVs	surface soil screening values
SVOCs	semivolatile organic compounds
T	transmissivity
TAL	target analyte list
TCL	target compound list
TCRA	Time-Critical Removal Action
TEF	toxicity equivalency factor
TICs	tentatively identified compounds
TOC	total organic carbon or top of casing
TRVs	terrestrial reference values
UCL	upper confidence limit
UF	uncertainty factor
USCS	Unified Soil Classification System
USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

VOCs	volatile organic compounds
VP	vapor pressure
V_x	average seepage velocity
WOE	weight of evidence
°C	Degrees Centigrade
°F	Degrees Fahrenheit

EXECUTIVE SUMMARY

INTRODUCTION

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

The Site Management Plan for MCB, Camp Lejeune, a primary document identified in the FFA, identifies 16 Operable Units (OUs). As of September 1995, Remedial Investigation/Feasibility Study (RI/FS) activities have been conducted or are planned at 41 sites. This report documents the Remedial Investigation (RI) completed for OU No. 11 (Site 80), the Paradise Point Golf Course Maintenance Area. This site along with Site 7 comprise OU No. 11 at MCB, Camp Lejeune.

The purpose of this remedial investigation is to characterize the nature and extent of contamination, and potential human health and environmental impacts for OU No. 11. This RI has been conducted in accordance with the requirements delineated in the National Oil Hazardous Substance Pollution Contingency Plan (NCP) for remedial actions [40 Code of Federal Regulations (CFR) 00.430]. The USEPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a) has been used as guidance for preparing this document.

OPERABLE UNIT DESCRIPTION AND HISTORY

MCB, Camp Lejeune is located within the Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The facility covers approximately 236 square miles. The military reservation is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The eastern border of MCB Camp Lejeune is the Atlantic shoreline. The western and northwestern boundaries are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina, borders MCB Camp Lejeune to the north.

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 33 Installation Restoration Program (IRP) sites at MCB, Camp Lejeune which have been grouped into 16 OUs. Sites 7 and 80 were grouped together as OU No. 11 due to there proximity. Site 7 is located on the northern bank of Northeast Creek and Site 80 is located on the southern bank of Northeast Creek. In addition to proximity, previous investigations at both sites detected the presence of pesticides and Polychlorinated Biphenyls (PCBs) in soils.

OU No. 11 (Site 80) referred to as the Paradise Point Golf Course Maintenance Area is located in an area to the northwest of Brewster Boulevard within the Paradise Point Golf Course. Site 80 is located in the rear of a machine shop (Building 1916) and a maintenance wash area consisting of a concrete wash pad and sump. Golf course maintenance equipment is cleaned on the wash pad. The sump is used to collect the water and oil runoff generated from the cleaning of the equipment, the water and oil from the sump then travels into an oil/water separator located a few feet to the southeast of the wash pad (Baker, 1994).

Information on when the golf maintenance facility was started is unavailable, however, the facility is currently in operation.

REMEDIAL INVESTIGATION ACTIVITIES

The initial phase of the RI field investigation commenced on October 10, 1994 and continued through December 12, 1994. During the week of January 30, 1995, investigation derived waste (IDW) generated during the RI was disposed of accordingly. In addition, a subsequent soil and groundwater investigation at Site 80 commenced on June 12, 1995 and continued through July 15, 1995. The RI field program at Site 80 consisted of a site survey; a soil investigation which included drilling and soil sampling; a groundwater investigation which included groundwater monitoring well installation and sampling. The following details the various investigation activities which were implemented during the RI.

Investigative procedures and methodologies for the RI conducted at Site 80 have been previously discussed in detail within Section 6.0 of the Final Field Sampling and Analysis Plan (FSAP), for OU Nos. 8, 11, and 12 (Baker, 1994).

Site Survey

The site survey task was performed in three phases: Phase I consisted of a initial survey of site features and proposed sample locations; and Phase II consisted of a 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 80 during the week of October 10, 1994. The proposed soil borings and monitoring well locations, provided in the Final RI/FS Work Plan for OU No. 11 (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 80 during the week of November 28, 1994. During Phase II, all soil borings and monitoring wells were surveyed. 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.

Phase III of the site survey task was completed at Site 80 during the week of July 10, 1995. The surveying firm of Brent A. Lanier was retained to perform the additional phase of the site survey. The latitude, longitude, and the elevation in feet above msl were recorded for each of the additional soil borings and one groundwater monitoring well.

Soil Investigation

A two part soil investigation consisting of an initial and subsequent investigation, was conducted at Site 80 to determine the presence or absence of contamination within the study area. The initial soil investigation involved the installation of soil borings and groundwater monitoring wells for the collection of surface and subsurface soils with a drill rig. The subsequent soil investigation involved the installation of additional soil borings and one groundwater monitoring well. A total of 37 locations, comprising soil borings and monitoring well borings were sampled during the initial soil investigation. The subsequent soil investigation had 21 locations, comprising soil borings and one monitoring well boring that were sampled. For discussion purposes, the sections detailing the initial and subsequent surface soil investigations have been combined. This also is the case for the subsurface investigation.

Surface Soil Investigation

A total of 37 surface soil samples (i.e., samples collected from ground surface to one foot bgs)were collected at Site 80 during the initial investigation to evaluate the presence or absence of contamination within the study area. All of the surface soil samples were collected with a stainless steel spoon. Seven out of the 37 surface soil samples were collected from soil borings within the Lawn Area. Four out of the 37 surface soil samples were collected from soil borings within the Maintenance Area. Six out of the 37 surface soil samples were collected from soil borings within the Open Area. Ten out of the 37 surface soil samples were collected from soil borings within the Soil Mound Area. Three out of the 37 surface soil samples were collected from soil borings located in background locations (i.e., not known or suspected to be contaminated). Two surface soil samples were collected from the Drum Area, located north of the corner of Building 600. The drums were encountered during an earlier site visit, and removed prior to commencement of RI activities. The remaining five surface soils were collected from soil borings that were converted into groundwater monitoring wells (i.e., 80-MW03IW [intermediate monitoring well], 80-MW04, 80-MW05, 80-MW06, and 80-MW07). This investigation was conducted between November 1, 1994 through November 7, 1994.

A total of 21 surface soil samples were collected at Site 80 during the subsequent soil investigation. This investigation was conducted to delineate positive pesticide detections obtained in the initial investigation. Twenty out of the 21 surface soil samples were collected from soil borings within the Detected Pesticide Area (DPA). The remaining surface soil sample was collected from a soil boring that was converted into a groundwater monitoring well (i.e., 80-MW08). This investigation was conducted between June 12, 1995 through June 14, 1995. The following provides a summary of the number of surface soil samples collected during both the initial and subsequent soil investigations and the areas in which they were collected:

- Seven surface soils, Lawn Area (LA)
- Four surface soils, Maintenance Area (MA)
- Six surface soils, Open Area (OA)
- Ten surface soils, Soil Mound Area (SM)
- Three surface soils, Background Boring Locations (BB)
- Two surface soils, Drum Area (DA)
- Six surface soils, Groundwater Monitoring Well Locations (MW)
- Twenty surface soils, Detected Pesticide Area (DPA)

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 the American Society for Testing and Materials (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.

During the initial soil investigation, 37 surface soil samples were collected and were analyzed for full Target Compound List (TCL) organics and Target Analyte List (TAL) inorganics. During the subsequent soil investigation, 21 surface soil samples were collected and were analyzed for TCL pesticides.

A total of 38 subsurface soil samples (i.e., samples collected from 1 foot bgs to just above the groundwater table) were collected from Site 80 during the initial soil investigation to evaluate the presence or absence of contamination within the study area. All of the subsurface soil samples were collected with a 2-inch split-spoon sampler from a drill rig. Twenty-nine out of the 38 subsurface soil samples were collected from soil borings. Eight out of the 29 subsurface soil samples were collected from the Lawn Area. Four out of the 29 subsurface soil samples were collected from the Maintenance Area. Eight out of the 29 subsurface soil surface samples were collected from the Open Area. Three out of the 29 subsurface soil samples were collected from the Soil Mound Area. The remaining six out of the 29 subsurface soil samples were collected from three (i.e., two samples per boring) background locations, not known or suspected to be contaminated. Additionally, nine subsurface soil samples were collected from five soil borings that were converted into groundwater monitoring wells (i.e., 80-MW03IW, 80-MW04, 80-MW05, 80-MW06, and 80-MW07). This investigation was conducted between November 1, 1994 through November 7, 1994.

Thirteen subsurface soil samples were collected during the subsequent soil investigation. This investigation was conducted to delineate positive pesticide detections obtained in the initial investigation. Twelve out of the 13 subsurface soil samples were collected from soil borings at the Detected Pesticide Area. It should be noted that subsurface soil samples were not collected from the following soil borings: SB05, SB06, SB07, SB10, SB11, SB14, SB15, and SB16 due to the remnants of a septic system absorption field. The remaining subsurface soil sample was collected from a soil boring that was converted into a groundwater monitoring well (i.e., 80-MW08). This investigation was conducted between June 12, 1995 through June 14, 1995. The following provides a summary of the number of subsurface soil samples collected during both the initial and subsequent soil investigation and the area in which they were collected:

- Eight subsurface soils, Lawn Area (LA)
- Four subsurface soils, Maintenance Area (MA)
- Eight subsurface soils, Open Area (OA)
- Three subsurface soils, Soil Mound Area (SM)
- Six subsurface soils, Background Boring Locations (BB)
- Ten subsurface soils, Groundwater Monitoring Well Locations (MW)
- Twelve subsurface soils, Detected Pesticide Area (DPA)

During the initial soil investigation, 38 subsurface samples were collected and were analyzed for full TCL organics and TAL inorganics. During the subsequent soil investigation, 13 subsurface soil samples were collected and were analyzed for TCL pesticides.

Groundwater Investigation

A groundwater investigation was conducted at Site 80 to determine the presence or absence of contamination in both the surficial aquifer and the deeper Castle Hayne aquifer, which may have resulted from past operational activities. During the initial soil investigation conducted from November 1, 1994 through November 7, 1994, four shallow groundwater monitoring wells (i.e., 80-MW04, 80-MW05, 80-MW06, and 80-MW07) were installed, then sampled during November 19, 1994 through December 3, 1994. In addition, one intermediate monitoring well 80-MW03IW (i.e., installed to the top of the Castle Hayne aquifer), was installed and sampled as part of this investigation. Three on-site existing shallow monitoring wells (80-MW01, 80-MW02, and 80-MW03) were also sampled during the ground water investigation. Existing monitoring wells 80-MW01, and 80-MW02 are located north of the Soil Mound Area. Newly installed monitoring wells 80-MW05, and 80-MW06 are located within the Open Area. Newly installed monitoring well 80-MW04 is located on the northwestern edge of the Maintenance Area. Existing monitoring well 80-MW03 and the newly installed intermediate monitoring well 80-MW03IW are located within the Lawn Area. The remaining well (80-MW07) is located southwest of the Lawn Area in a background location. Depths of the newly installed wells ranged from 27 to 72 feet bgs. All newly installed groundwater monitoring wells were constructed with 2-inch inside diameter (I.D.) Poly Vinyl Chloride (PVC) pipe, with 15 feet of 0.01-inch slotted well screen.

An additional shallow groundwater monitoring well (80-MW08) was installed on June 13, 1995. This groundwater monitoring well was installed to delineate positive pesticide detections obtained during the initial soil investigation. The groundwater monitoring well is located northwest (i.e., downgradient) of the Detected Pesticide Area. The depth of monitoring well 80-MW08 was 25 feet bgs. Monitoring well 80-MW08 was constructed with 2-inch I.D. PVC pipe, with 15 feet of 0.01-inch slotted well screen.

All groundwater monitoring wells including the existing monitoring wells were developed and purged prior to sampling. During development operations water quality readings and turbidity comments were recorded on monitoring well development records.

Groundwater from monitoring wells at Site 80 was sampled using USEPA Region IV's low flow purging and sampling technique. Although this technique has not yet been finalized, the Technical Compliance Branch of the USEPA Region IV, located in Athens Georgia, has set up preliminary procedures and guidelines. Procedurally this technique requires 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. It should be noted that existing wells 80-MW01 and 80-MW02 were purged and sampled with Teflon ® bailers, due to excessive amounts of silt within the monitoring well. The water quality readings collected during purging operations were: pH, conductivity, temperature, and turbidity. Water quality data is provided within Section 4.0 of this report. Once water quality readings had stabilized over three well volumes, a groundwater sample was collected. The first round of groundwater samples collected at Site 80 included sampling of the newly installed and existing monitoring wells during November 19, 1994 through December 3, 1994.

Groundwater from the additional monitoring well at Site 80 (80-MW08) was sampled using USEPA Region IV's low flow purging and sampling technique. Procedures followed the same as those identified above, with one exception. A peristaltic pump instead of the 2-inch submersible was used to purge and sample the monitoring well. In addition, water quality readings were collected during

purging activities. A groundwater sample was collected once the water quality readings stabilized over three well volumes.

The groundwater sample was collected on July 14, 1995.

A second round of groundwater samples were collected from the eight shallow wells and one intermediate well in December 1995. This sampling was conducted in response to NC DEHNR concerns with elevated inorganic levels detected in the groundwater.

All of the groundwater from the monitoring wells, installed during the initial investigation, were sampled and analyzed for full TCL organics and TAL inorganics (total and dissolved fractions). The groundwater from the monitoring well installed during the subsequent investigation was sampled and analyzed for TCL pesticides. The groundwater samples collected during the second round of sampling were analyzed for TAL total inorganics only.

Water Level Measurements

Static water level measurements were collected on three separate occasions. Measurements were recorded from top-of-casing reference points, marked on the PVC at each monitoring well. A complete round of static water level measurements were collected on December 11, 1994, March 27, 1995, July 31, 1995, and December 14, 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.

Quality Assurance and Quality Control

Field QA/QC samples were also submitted during the groundwater investigations. These samples included trip blanks, equipment rinsates, and field duplicates. Equipment rinsates were collected from the submersible pump and peristaltic pump line prior to and during daily usage.

Habitat Evaluation

A habitat evaluation was performed at Site 80 during December 4, 1994 through December 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.

from 13 feet (in the detected pesticide area) to approximately 17 feet (within the open area) above msl. Several large soil mounds are located in the northeast portion of the site, behind the machine shop. The soil mound area in the northeast portion of the site has ground surface elevations of between 21 and 26 feet msl. The golf course maintenance area is surrounded by woods, with an access road leading to Brewster Boulevard and into the golf course proper. During the March 1994 site reconnaissance, surface water runoff was observed flowing toward the southeast in the direction of a drainage ditch, located southeast of the wash area. Surface water flow within the ditch is intermittent, but is in a north/northeast direction away from the site.

Surface Water Hydrology and Drainage Features

The only standing water body located within the site is a drainage ditch southeast of the wash pad area. Observed following a heavy rain during the RI were isolated areas of ponded water, which did not remain for very long. Water flow in the drainage ditch is intermittent. The drainage ditch is shallow in the lawn area (approximately 2 to 4 feet deep) and groundwater would not appear to discharge to the ditch as groundwater level measurements in the surficial aquifer made during the RI indicate depths of between 12 and 16 feet below ground surface (bgs).

Geology and Soil

Site 80 is primarily underlain by silty sand, sand, and silty clay. Isolated zones of silt were also observed primarily in the upper portions of the borings. Percentage of sand increases with depth. 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) indicate 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 borehole locations in the lawn area, ranging in thickness from one to five feet. This fill material consisted of apparent replaced soil. One intermediate well (72.5 foot depth) was installed in the upper portion of the Castle Hayne aquifer. The Castle Hayne was encountered at a depth of approximately 53 feet. The lithology of the upper portion of the Castle Hayne is predominantly a fine grained sand with a trace of silt and shell fragments.

Geologic cross-sections were developed for the surficial and upper Castle Hayne sediments based on samples collected during the RI.

The surficial soils are comprised of fine grained sand with varying amounts of silt between two and four feet thick. Beneath the silty sand is a silty clay layer of fairly uniform thickness. This silty clay layer is not evident in the logs for wells 80-MW01 and 80-MW02, installed during a previous investigation, in the northern portion of the site. A silty sand unit was encountered in well 80-MW03IW beneath the silty clay with a thickness of 44 feet. This silty sand unit is comprised of fine to medium grained sand with decreasing silt content with depth. Traces of clay are found in the upper portion of this unit. Well 80-MW03IW also exhibited fill material to a depth of five feet. The silty sand above the silty clay unit was damp, indicating that the clay unit may inhibit but not preclude the downward groundwater flow due to its apparent lower permeability.

The upper silty sand thickens and dips to the west. The silty clay layer is uniform in thickness across the site and also dips to the west. Beneath the silty clay layer is the lower silty sand. Well 80-MW06 on the eastern side of the site showed a clayey silt from the surface to a depth of 5.5 feet.

Beneath the clayey silt is the silty clay and silty sand encountered over the site area. A 4.5 foot silty clay layer was identified within the lower silty sand unit. Groundwater elevations are similar throughout the shallow wells. The silty clay unit does not appear to inhibit the vertical movement of groundwater, based on moisture contents of samples above the unit and the similar groundwater elevations in the shallow monitoring wells.

Hydrogeology

Groundwater was encountered during drilling during the RI at elevations ranging from 2.16 to 3.34 feet above msl. Groundwater elevation measurements were completed December 11, 1994, March 27, 1995 and July 30, 1995 for Site 80. The contour maps indicate a groundwater mound centered in the lawn area with linear flow in all directions. The mounding may be the result of fill placed in this area. From the installed monitoring wells at the site, the primary groundwater flow direction is northwest/north, towards Northeast Creek (located approximately one-half mile north of Site 80). Local recharge for this area would be from the south/southeast. The shallow groundwater gradient measured from well 80-MW03 to well 80-MW04 to the north for December 11, 1994 was 0.002 ft/ft and March 27, 1995 was 0.005 ft/ft. The hydraulic gradient for July 30, 1995 was 0.003 ft/ft, measured between wells 80-MW03 and 80-MW02. Shallow groundwater eventually discharges to Northeast Creek. The surficial aquifer exhibited seasonal variations in groundwater levels over the seven month period that groundwater level measurements were obtained. The December and July groundwater elevations are similar indicating recharge periods. There was greater rainfall than normal this past summer which would account for the higher groundwater elevations seen in the summer months than would be expected from the normal regional trends. Groundwater elevations were lower in March following the spring season trend from regional data.

One intermediate depth well (80-MW03IW) was installed in the upper portion of the Castle Hayne aquifer at a depth of 72.5 feet. Elevations for the intermediate well varied from 1.87 feet above msl (July 30, 1995) to 4.02 feet above msl (March 27, 1995). There is a groundwater elevation difference between monitoring wells installed in the surficial aquifer and the upper portion of the Castle Hayne aquifer. This elevation difference produces a potential vertical gradient of 0.05 ft/ft downward from the shallow water-bearing zone to the upper Castle Hayne. The recharge area for the upper Castle Hayne aquifer may be to the northeast with the Castle Hayne potentially discharging to the New River where the Castle Hayne formation is near surface.

The lithology does not indicate a confining or semiconfining layer between the surficial water table aquifer and the Castle Hayne aquifer. This is substantiated by the similar groundwater elevations exhibited in the shallow and intermediate wells across the site. The differentiation between the two water bearing zones is based on lithology, groundwater parameters as seen from the evaluation of slug test data, and usage (the surficial aquifer is not used as a water supply on the base). Evaluation of groundwater elevations indicated a potential vertical gradient between the two aquifers of 0.05 ft/ft.

Ecological Features

Four general habitat types are present at Site 80. These four include a deciduous forest, mixed forest, open area, and a transition area between the open area and the forests. In the deciduous forest, pines are found along with the predominating oaks. Other leaf trees as well as shrubs are found in this forest. In the mixed forest, loblolly pines are prevalent. The open area covers most of the site and consists of grasses with herbaceous plants. The transition zone between the forested

areas and the open area include saplings, herbaceous plants and vines. Several species of birds were identified in the area as was evidence of whitetail deer. No amphibians or reptiles were observed as the habitat evaluation was conducted during the winter. Site 80 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.

Potable Water Supply Wells

There are two base supply wells within a one-mile radius of Site 80: HP-701 and ON-T2-87 (Harnad, et al., 1989). These wells are in an apparent upgradient direction from Site 80. It would not appear that Site 80 would impact these base supply wells.

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

Thirty-four surface and thirty-two subsurface soil samples submitted for analysis were analyzed for full TCL organics and TAL inorganics, using CLP protocols and Level III data quality. Twenty-one surface and thirteen subsurface soil samples were submitted only for pesticide analysis from the detected pesticide area in the west/northwest section of the site.

Surface Soil

A total of 55 surface soil samples were collected and submitted from the lawn area, maintenance area, drum area, open area, soil mounds, detected pesticide area, and monitoring well locations at Site 80. The only volatile detected was acetone in one surface soil sample. The highest concentration of acetone detected in a rinsate blank was 780 µg/L. The detected concentration of acetone in the surface soil sample at location 80-MW05 was 28 µg/kg, which is less than 10 times the highest QA/QC blank concentration. This low concentration detected in the surface soil sample indicates that acetone is not considered a site related contaminant, but a laboratory or field procedure contaminant.

The predominant semivolatiles detected in the surface soil at Site 80 were polynuclear aromatic hydrocarbons (PAH) constituents. Sample 80-SM-SB04 exhibited the greatest number and maximum concentrations of PAHs. Phthalate esters were also detected in surface soil. Di-n-butylphthalate was detected in 20 of 34 samples with a concentration range of 60J µg/kg to 4400 µg/kg (80-MW03IW). Butyl benzyl phthalate and bis(2-ethylhexyl)phthalate were also detected in surface soil samples. The 12 semivolatiles detected in the surface soil would be considered site related contaminants as no semivolatiles were detected in the QA/QC blanks.

Pesticides appear to be the predominant contaminants at Site 80. Six of the eleven pesticides detected in surface soils at Site 80 were in at least 20 of the 55 samples analyzed. These pesticides were dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. Concentrations for pesticides ranged from 0.6J µg/kg (4,4'-DDE, location 80-OA-SB04) to 260,000

µg/kg (4,4'-DDD, location 80-DPA-SB03). The highest concentrations for most pesticides were exhibited in the detected pesticide area in the west/northwest section of the site.

Twenty-two of 23 inorganics (antimony was not detected) were detected in surface soils at Site 80. Concentrations were within one order of magnitude (or less) of base background levels.

Subsurface Soils

Forty-five subsurface soil samples were submitted for analysis. The only volatiles detected in subsurface soils were acetone and carbon disulfide. Acetone was detected in 4 samples at concentrations ranging from 11J µg/kg (80-OA-SB04, 5 to 7 feet) to 110J µg/kg (80-MW03IW, 5 to 7 feet). These concentrations were less than 10 times the highest concentration detected in QA/QC blanks. Carbon disulfide was detected in one subsurface soil sample (80-SM-SB02, 5 to 7 feet) at a concentration of 13 µg/kg. Carbon disulfide was not detected in any of the QA/QC blanks.

Four semivolatile organic compounds were detected in subsurface soils at Site 80. Three phthalate esters [di-n-butylphthalate, butyl benzyl phthalate and bis(2-ethylhexyl)phthalate] were detected in subsurface soil at concentrations ranging from 46J µg/kg [butyl benzyl phthalate (80-MW03IW, 5 to 7 feet)] to 3100 µg/kg [di-n-butylphthalate (80-MW03IW, 5 to 7 feet)]. Di-n-butylphthalate was detected in 17 of 32 subsurface soil samples submitted for analysis, and at the maximum concentration for phthalate esters for subsurface soils. The only other semivolatile detected in subsurface soils was the PAH constituent phenanthrene in one sample at a concentration of 53J µg/kg (80-MW03IW, 5 to 7 feet). Neither phenanthrene nor the phthalate esters were detected in QA/QC blanks.

Six pesticides were detected in subsurface soil at Site 80. Delta-BHC and aldrin were each detected in only one subsurface soil sample at concentrations of 0.63 µg/kg and 2.6 µg/kg, respectively. Dieldrin was detected in four subsurface soil samples at concentrations ranging from 0.73J µg/kg (80-MW05, 11 to 13 feet) to 1.4J µg/kg (80-OA-SB02, 13 to 15 feet). 4,4'-DDE was detected in seven subsurface soil samples at concentrations ranging from 1.4J µg/kg (80-SM-SB09, 5 to 7 feet) to 35 µg/kg (80-OA-SB02, 13 to 15 feet). 4,4'-DDD was the most frequently detected pesticide (12 of 45 samples) and exhibited the highest pesticide concentration (510J µg/kg, 80-MW04 at 11 to 13 feet). The maximum concentration for 4,4'-DDT (240 µg/kg) was also detected in sample 80-MW04 (11 to 13 feet).

Twenty of 23 inorganics (cadmium, silver, and thallium were not detected) were detected in the subsurface soils at Site 80. Arsenic, barium, chromium, manganese, mercury, and selenium exhibited concentrations above base background levels for inorganics in subsurface soils at only one location each. Concentrations were less than an order of magnitude different from the base background levels.

Groundwater

Two rounds of groundwater samples was collected from the eight shallow wells and one intermediate (upper portion of the Castle Hayne aquifer) well installed at the Paradise Point Golf Course Maintenance Area. Seven of the shallow wells and the intermediate well, which were sampled in December 1994, were analyzed for TCL organics and TAL metals (total and dissolved) using CLP protocols and Level IV data quality. The additional well installed in June 1995 was sampled in July 1995 for TCL pesticides using CLP protocols and Level IV data quality, with the

Groundwater

Two rounds of groundwater samples was collected from the eight shallow wells and one intermediate (upper portion of the Castle Hayne aquifer) well installed at the Paradise Point Golf Course Maintenance Area. Seven of the shallow wells and the intermediate well, which were sampled in December 1994, were analyzed for TCL organics and TAL metals (total and dissolved) using CLP protocols and Level IV data quality. The additional well installed in June 1995 was sampled in July 1995 for TCL pesticides using CLP protocols and Level IV data quality, with the results included as part of the Round One analytical results. In December 1995 groundwater samples were collected from eight shallow wells and one intermediate well. All groundwater samples were analyzed for TAL total metals only.

Shallow Groundwater

The only volatile detected in the shallow groundwater was carbon disulfide at a concentration of 1J µg/L (80-MW03). No Federal standard exists for this contaminant; however, the NCDEHNR has established an interim maximum allowable concentration of 700 µg/L. Carbon disulfide was not detected in QA/QC blanks.

Semivolatiles were detected at low levels in a limited number of shallow groundwater monitoring wells at Site 80. These semivolatiles included the polynuclear aromatic hydrocarbons (PAHs) acenaphthene, fluorene, carbozole, and pyrene. These contaminants were detected in well 80-MW03, located within the lawn area. NCDEHNR has established interim maximum allowable concentrations for acenaphthene (80 µg/L) and pyrene (210 µg/L). Acenaphthene was detected at a concentration of 4J µg/L and pyrene was detected at 1J µg/L. Fluorene was detected at a concentration of 3J µg/L, with an NCWQS of 280 µg/L. Bis(2-ethylhexyl)phthalate was detected in three samples above the NCWQS of 3 µg/L, at a maximum concentration of 5J µg/L. Di-n-octylphthalate was detected at a concentration of 1J µg/L in well 80-MW02. The NCWQS for di-n-octylphthalate is 140 µg/L. Well 80-MW03 exhibited a dibenzofuran concentration of 2J µg/L (no Federal or State standard exists for this contaminant). No semivolatiles were detected in QA/QC blanks.

The pesticides 4,4'-DDD and 4,4'-DDT were detected in monitoring well 80-MW04 at low levels (2.2J µg/L and 0.58J µg/L, respectively). No Federal and/or State standards exist for these pesticides.

Seventeen of 23 TAL total metals were detected in the shallow groundwater at Site 80. Concentrations for total metals were within an order of magnitude or less of the dissolved metal concentrations. For groundwater samples collected during Round One, arsenic, chromium, iron, lead, and manganese were detected above their respective State and/or Federal standards, generally within an order of magnitude or less. Total metal concentrations in the shallow groundwater at Site 80 were within the ranges for metals determined for MCB Camp Lejeune. Concentration of iron, manganese, and thallium were above State and/or Federal criteria in Round Two groundwater samples.

Groundwater field parameter values for pH, temperature, specific conductance, and turbidity 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.).

Upper Castle Hayne

No organics were detected in the intermediate well installed in the lawn area at the golf course maintenance area.

Total metals were not detected in intermediate well 80-MW03IW; however, six dissolved metals were detected. These metals included barium, calcium, magnesium, manganese, potassium, and sodium. None of these dissolved metals were detected above Federal and/or State standards.

Groundwater field parameter values for pH, temperature, specific conductance, and turbidity represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained from the intermediate well, which is representative of groundwater conditions following purging, pH value was 7.5 s.u., specific conductance value was 469 micromhos/cm, and the temperature was 19° C. Turbidity value was recorded as 2.6 NTU. 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 within the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.).

HUMAN HEALTH RISK ASSESSMENT

ICR and HI values associated with exposure to environmental media at Site 80 (soil and groundwater) are discussed below. Total carcinogenic and noncarcinogenic risks, per medium, for all relevant receptor groups, have been estimated.

Future Residential Children

Total ICR for future residential children (7.7E-04) exceeds the USEPA acceptable cancer risk range. Total HI (31) is greater than 1.0. The risk from groundwater exposure (ingestion) drives the total carcinogenic and noncarcinogenic risks for future residential children (88 percent and 93 percent contribution to risks, respectively). The risk from soil exposure (ingestion) contributes 7 percent to the total HI.

Future Residential Children after TCRA

The total ICR for future residential children (6.7E-04) exceeds the USEPAs acceptable risk range, and the total HI (5.8) is greater than 1.0. Exposure to groundwater, via ingestion, accounts for a majority of the total risk (98 percent of the carcinogenic and 88 percent of the noncarcinogenic).

Future Residential Adults

Total ICR for future residential adults (1.6E-03) exceeds the USEPA acceptable cancer risk range. Total HI, (9.3) is greater than 1.0. The risk from groundwater exposure (ingestion) drives the total carcinogenic and noncarcinogenic risks for future residential adults (94 percent and 97 percent contribution to risks, respectively).

Future Residential Adults after TCRA

The total ICR for future residential adults (1.4E-03) exceeds the USEPA acceptable risk range, the total HI (2.3) exceeds 1.0. Exposure to groundwater, via ingestion, accounts for nearly 100 percent of the total carcinogenic and noncarcinogenic risk.

Current Civilian Adult Base Personnel

Total ICR for current civilian adult base personnel (1.6E-04) exceeds the USEPA acceptable risk range. Because base personnel are not exposed to groundwater, the risk from soil exposure (ingestion) contributes 100 percent to this carcinogenic risk. Total HI (0.65) is less than 1.0. It can then be concluded that noncarcinogens in environmental media at Site 80 generate no health risks in excess of acceptable levels.

Current Civilian Adult Base Personnel after TCRA

The total ICR for current civilian adult base personnel (1.7E-05) is within the USEPAs acceptable risk range. Additionally the HI (0.22) is below 1.0. These values indicate that the removal of soils under the TCRA will reduce risks to an acceptable level.

Future Construction Workers

Total ICR for future construction workers (1.5E-07) is below the USEPA acceptable risk range. Total HI (0.02) is less than 1.0. It can then be concluded that COPCs in environmental media at Site 80 generate no health risks in excess of acceptable levels.

Soil

ICR values calculated for future residential children and adults and future construction workers fall within or below the USEPA acceptable risk range. In other words, carcinogens in Site 80 soil generate no risks beyond acceptable levels for these receptors. The ICR value calculated for current civilian base personnel, however, exceeds the acceptable risk range (ICR = 1.6E-04). This indicates that base personnel currently working at Site 80 may be at risk from carcinogens in the soil. Incidental soil ingestion drives this carcinogenic risk. Dieldrin is the COPC making the primary contribution to this risk (60 percent), and arsenic is a secondary contributor (23 percent).

HI values calculated for future residential adults, current civilian base personnel and future construction workers are less than 1.0, below the acceptable risk level for these receptors. In other words, noncarcinogens in Site 80 soil generate no risks beyond acceptable levels. The HI value calculated for future residential children, however, is greater than 1.0 (HI = 1.8). This indicates that future residential children may experience adverse systemic health effects from noncarcinogens in

Site 80 soil. Incidental soil ingestion drives this noncarcinogenic risk. Dieldrin is the COPC making the primary contribution to this risk (37 percent), and arsenic is a secondary contributor (36 percent).

Soil After TCRA

ICR values estimated for current civilian base personnel (1.7E-05) and future receptors (i.e., children 1.1E-05, adults 5.1E-06, and construction workers 1.5E-07) do not exceed the USEPAs acceptable risk range.

HI values for current civilian base personnel (0.22) and future receptors (i.e., children 0.67, adults 0.11, and construction workers 0.02) are less than 1.0. This indicates that current and future receptors will not experience systemic health effects from exposure to soil once the contaminated soil has been removed.

Groundwater

ICR values calculated for future residential children and adults exceed the USEPA acceptable risk range (Child ICR = 6.8E-04; Adult ICR = 1.5E-03). This indicates that future residents may be at risk from carcinogens in Site 80 groundwater. Groundwater ingestion drives these carcinogenic risks. Arsenic is the COPC making the primary contribution to these risks (96 percent).

HI values calculated for future residential children and adults are greater than 1.0 (Child HI = 29; Adult HI = 9.04). This indicates that future residents may experience adverse systemic health effects from noncarcinogens in Site 80 groundwater. Groundwater ingestion drives these noncarcinogenic risks. Arsenic is the COPC making the primary contribution to these risks (80 percent).

Groundwater Round Two

ICR values for future residential children and adults exceed the USEPA acceptable risk range (Child ICR = 6.6E-04; Adult ICR = 1.4E-03). This indicates that future residents may be at risk from carcinogens in the shallow groundwater at Site 80. The groundwater risk is driven by the ingestion of groundwater with arsenic contributing almost 100 percent of the risk.

HI values for future residential children and adults, although less than Round One, are greater than 1.0 (Children HI = 5.1; Adult HI = 2.2). This indicates that future residents may experience adverse systemic health effects from exposure to the shallow groundwater at Site 80. Ingestion of arsenic (76 percent) and aluminum (21 percent) account for a majority of the overall risk.

ECOLOGICAL RISK ASSESSMENT

Several of the COPCs detected in the surface soils at Site 80 exceed the SSSVs. Manyof these exceedences are located in gravel covered areas and are not expected to cause a significant reduction in the soil flora or fauna population. However, some of the exceedences are located in the open grass area and may cause significant reduction in the flora and invertebrate population in the area. Finally, the COPCs at Site 80 are not expected to cause significant adverse risk to terrestrial mammals or birds.

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), and 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 Fiscal Year 1995 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 16 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. 11, which is comprised of Sites 7 and 80. However, this report will only focus on Site 80. Site 7 has been addressed in a separate report. Figure 1-1 depicts the location of MCB Camp Lejeune and Site 80. Figure 1-2 depicts all of the OUs and corresponding sites present at MCB Camp Lejeune. [Note that all tables and figures are provided at the end 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. The RI investigation was conducted through the sampling of several media (soil both surficial and subsurface, and groundwater) at Site 80, evaluating the resultant analytical data, and performing a human health risk assessment (RA) and ecological RA. Furthermore, the RI report provides information to support the FS and record of decision (ROD) for a final remedial action.

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 characteristics and history of OU No. 11 (Site 80). In addition, Section 1.1 provides an overview of the RI Report's Organization.

1.1 Report Organization

This RI Report for Site 80 is comprised of the following sections:

- Section 1.0 - 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 80 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 33 Installation Restoration Program (IRP) sites at MCB, Camp Lejeune which have been grouped into 16 OUs. Sites 7 and 80 were grouped together as OU No. 11 due to there proximity. Site 7 is located on the northern bank of Northeast Creek and Site 80 is located on the southern bank of Northeast Creek. In addition to proximity, previous investigations at both sites detected the presence of pesticides and Poly Chlorinated Biphenyls (PCBs) in soils. Figure 1-2 depicts the locations of all 16 OUs and 33 sites at MCB Camp Lejeune.

OU No. 11 (Site 80) referred to as the Paradise Point Golf Course Maintenance Area is located in an area to the northwest of Brewster Boulevard within the Paradise Point Golf Course. Site 80 is located in the rear of a machine shop (Building 1916) and a maintenance wash area consisting of a concrete wash pad and sump. Golf course maintenance equipment is cleaned on the wash pad. The sump is used to collect the water and oil runoff generated from the cleaning of the equipment, the water and oil from the sump then travels into an oil/water separator located a few feet to the southeast of the wash pad (Baker, 1994).

Information on when the golf maintenance facility was started is unavailable, however, the facility is currently in operation.

1.3 Site Description and History

Site 80 consists of a one-acre area which is relatively flat, with a slight slope to the northeast. A drainage ditch is located to the southeast of the wash area. The drainage ditch enters the site from the machine shop road to the south, it then traverses the site on the eastern edge and leaves the site to the northeast. During a March 1994 site reconnaissance, surface water runoff was observed flowing southeast toward the ditch. Site elevations vary from 3 to approximately 26 feet above mean sea level (msl). Figure 1-3 depicts the location of Site 80 and the bordering areas.

There are several large soil mounds in the northeast portion of the site, behind the machine shop. The soil mounds are overgrown with small pines. There is an open area in front of the mounds where golf course maintenance debris (i.e., tree limbs, lawn clippings, wooden timbers, and brush piles) is deposited. Evidence of burning operations conducted within this open area was documented during the March 1994 site reconnaissance. These soil mounds were generated from the installation of golf course ponds along the fairways in the late 1980s. It has been reported that wastes were disposed of on or around the mounds. However, it is uncertain as to what type of wastes were disposed and the exact location of the wastes in this area. Additionally, employees of the maintenance garage were instructed not to use the soil from this area for fill material (Baker, 1994).

There is old maintenance equipment placed in the lawn and wooded areas around the maintenance Building (Building 600). Two drums identified during the March 1994 site reconnaissance, were

removed from the site by Activity personnel. At this time it is not known what the contents of the drums were. These drums were located northeast of Building 600 just across the dirt access road (Baker, 1994).

Golf course maintenance operations which include the machine shop (a potential source of waste oils) and the routine spraying of pesticides and herbicides may have contributed to potential contamination at this site. It is unknown when the wash pad was constructed, and what the exact procedure was for cleaning the maintenance equipment prior to the construction of the wash pad. The disposition of wash water may have been completely uncontrolled (Haliburton/NUS, 1991).

1.4 Previous Investigations

An investigation was conducted of Site 80 by Haliburton/NUS in June of 1991. This investigation encompassed the collection of surface and subsurface soil samples, and the installation of three shallow groundwater monitoring wells. In addition to the soil and groundwater investigation, a surface water and sediment investigation was conducted in the drainage ditch area. The following subsections present a description of the investigation along with the results. Information regarding procedures and methodologies can be obtained in the Haliburton/NUS Site Inspection Draft Report, 1991.

1.4.1 Soil Investigation

Three surface soil samples (0 to 6 inches below ground surface [bgs]), seven near surface soils samples (0 to 2 feet bgs), and seven subsurface soil samples (3 to 17 feet bgs) were collected. All samples were analyzed for full Target Compound List (TCL) organics and chlorinated herbicides. Analytical results for all soil samples are presented on Table 1-1. Soil sample locations are presented on Figure 1-4.

Several pesticides were detected in these samples, such as aldrin, chlordane, 4,4'-DDD and its metabolites (4,4'-DDE and 4,4'-DDT), and dieldrin. The pesticide 4,4'-DDD was reported at the greatest concentration (700 micrograms per kilogram [µg/kg] in sample SB02-0002). No herbicides were detected in any of the samples.

Aroclor (PCB)-1254 was detected in two discrete surface soil locations (SB02 and 80MW03) at concentrations of 830 µg/kg and 1,500 µg/kg, respectively.

1.4.2 Groundwater Investigation

Three shallow groundwater monitoring wells (80MW01, 80MW02, and 80MW03) were installed at the Paradise Point Golf Course in June 1991. These wells were installed to depths of 15 to 22.5 feet bgs. One round of groundwater samples were collected from each monitoring well and analyzed for full TCL organics, and chlorinated herbicides. Analytical results for groundwater samples are summarized on Table 1-2. Monitoring well locations are shown on Figure 1-4.

Four volatile organic compounds (VOCs), toluene (180 µg/L), ethylbenzene (5 µg/L), xylene (21 µg/L) and carbon disulfide (25 µg/L) were detected in the groundwater sample collected from monitoring well 80MW03. This well is located near the wash pad, sump area, and oil/water separator.

1.4.3 Surface Water and Sediment Investigation

Three surface water samples and five sediment samples were collected from the drainage ditch and analyzed for full TCL organics, chlorinated herbicides, and total petroleum hydrocarbons (TPH). It should be noted that originally five surface water samples were to be collected, however, when the investigation was conducted in June, no water was present at sampling locations 80SW01 and 80SW02. All of the surface water samples contained acetone, at concentrations ranging from 11 µg/L to 190 µg/L. Surface water samples from locations SW04 and SW05 also exhibited toluene at concentrations of 30 µg/L and 140 µg/L, respectively, and petroleum hydrocarbons (1.39 milligrams per kilogram [mg/L] and 1.66 mg/L). There were no chemical analytes or petroleum hydrocarbons that were detected in the sediment samples collected. Analytical results for surface water samples are summarized on Table 1-3. Surface water and sediment sampling locations are depicted on Figure 1-4.

1.5 Data Limitations

Upon review of the previous investigation and the subsequent analytical findings, it was determined that data limitations existed for soils, and groundwater, at Site 80. Contamination was detected in some soil and groundwater samples, however, the extent to which the contamination is present on-site was unknown. Listed below are the media types that were identified to determine the presence or absence, and extent of potential site related contamination:

- Surficial soil
- Subsurface soil
- Surficial groundwater
- Intermediate groundwater

Upon review of the previous investigation findings for the identified media, data limitations were generated, and are listed below:

The data limitations for the soil include the following:

- Extent of pesticide and PCB contamination.
- Extent of soil contamination in the lawn area, soil mounds, and drum area.
- Assessment of human health and ecological risks associated with exposure to surface soils at the site.
- Determination of whether organic and/or inorganic contamination is migrating from the soil to the groundwater.

The data limitations for the groundwater include the following:

- Extent (if any) of the health risks posed by the potential future usage of the shallow groundwater.
- Vertical and horizontal extent of shallow groundwater contamination.

- Presence or absence of shallow groundwater contamination migrating to deeper zones.

- Definitizing the hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation.

- Determination of whether current groundwater contamination is due to non-site related Underground Storage Tank (UST).

Upon review of the data limitations present for the soil, and groundwater, site-specific data requirements were generated, and are listed below:

- Determine the vertical and horizontal extent of contamination distribution in the lawn area and soil mounded area through sampling and analysis.

- Determine the effects on the soil mounds from reported disposal activities.

- Determine the presence or absence of site-related contaminants in the surface and subsurface soil in order to conduct a human health risk assessment.

- Determine the hydrogeologic parameters of the shallow and intermediate groundwater.

- The reliable information needed fo support assessment of risks to human health presented by current patterns of exposures to groundwater.

From these data requirements, RI objectives were established to meet the data deficiencies for Site 80. These RI objectives are discussed in the following section.

1.6 Remedial Investigation Objectives

The purpose of this section is to define the RI objectives for characterizing past operational activities at Site 80, assessing potential impacts to the 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 the public health and environment, and consideration of feasible remediation technologies and alternatives. Table 1-4 presents both the RI objectives identified for Site 80 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 80 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.

Haliburton/NUS, 1991. Preliminary Draft Site Inspection Report for Site 80 Paradise Point Golf Course. Marine Corps Base, Camp Lejeune, North Carolina.

SECTION 1.0 TABLES

TABLE 1-1

PREVIOUS INVESTIGATION
DETECTED CONTAMINANTS IN SOIL
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil (0-6 inches)		Near Subsurface Soil (0-2 feet)		Subsurface Soil (3-17 feet)	
	No. of Positive Detections/ No. of Samples	Range of Positive Detections	No. of Positive Detections/ No. of Samples	Range of Positive Detections	No. of Positive Detections/ No. of Samples	Range of Positive Detections
Methylene Chloride	1/3	7	0/7	ND	0/7	ND
Aldrin	0/3	ND	1/7	6.8-220	0/7	ND
alpha-Chlordane	0/3	ND	1/7	60	0/7	ND
4,4'-DDD	1/3	ND	3/7	20-700	0/7	ND
4,4'-DDE	0/3	ND	5/7	16-210	0/7	ND
4,4'-DDT	0/3	ND	4/7	15-290	0/7	ND
Dieldrin	0/3	ND	4/7	16-440	0/7	ND
PCB-1254	0/3	ND	2/7	830-1,500	0/7	ND

Concentrations expressed in µg/kg - microgram per kilogram
ND - Not detected.
Reference: Halliburton/NUS, 1991

TABLE 1-2

PREVIOUS INVESTIGATION
DETECTED CONTAMINANTS IN GROUNDWATER
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	North Carolina Standards	USEPA MCLs	No. of Positive Detections/ No. of Samples	Range of Positive Detections	Location of Maximum Concentration
Toluene	1,000	1,000	1/3	180	80MW03
Ethylbenzene	29	700	1/3	5	80MW03
Xylenes	400	10,000	1/3	21	80MW03
Carbon Disulfide	--	--	1/3	25	80MW03

-- = Criteria not established.
Concentrations expressed in µg/L - microgram per liter
Reference: Halliburton/NUS, 1991

TABLE 1-3

PREVIOUS INVESTIGATION
DETECTED CONTAMINANTS IN SURFACE WATER
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Near Site (SW03, SW04, SW05)	
	No. of Positive Detections/ No. of Samples	Range of Positive Detections
Acetone	3/3	11-190
Toluene	2/3	30-104
Carbon Disulfide	1/3	6
Total Petroleum Hydrocarbons	2/3	1390-1660

Concentrations expressed in µg/L - microgram per liter
Reference: Halliburton/NUS, 1991

TABLE 1-4

SUMMARRY OF REMEDIAL INVESTIGATION OBJECTIVES
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MARINE CORPS BASE, 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 lawn area, soil mounds, and drum area.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation
	1b. Assess human health and ecological risks associated with exposure to surface soils at the site.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation Risk Assessment
2. Groundwater	2a. Assess health risks posed by potential future usage of the shallow groundwater.	Evaluate groundwater quality and compare to Applicable or Relevant and Appropiate Requirements (ARARs) and health-based action levels.	Groundwater Investigation Risk Assessment
	2b. Assess the vertical and horizontal extent of shallow groundwater contamination.	Characterize downgradient shallow groundwater quality. Identify presence or absence of contamination in the deep aquifer.	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
	2d. Determine whether current groundwater contamination is due to non-site related UST.	Characterize flow direction. Evaluate migration pathways.	Groundwater Investigation

SECTION 1.0 FIGURES

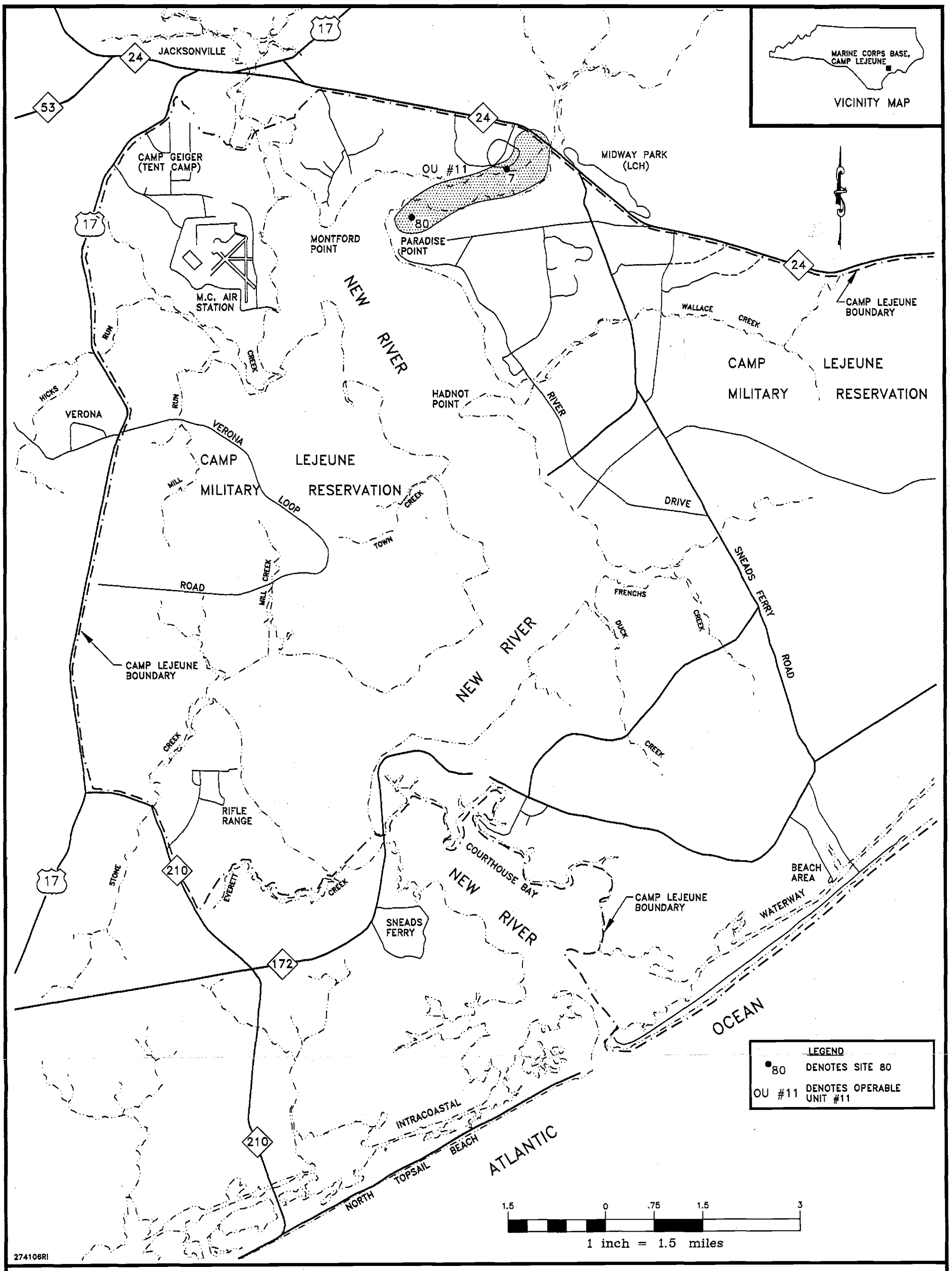

FIGURE 1–1
OPERABLE UNIT AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO–0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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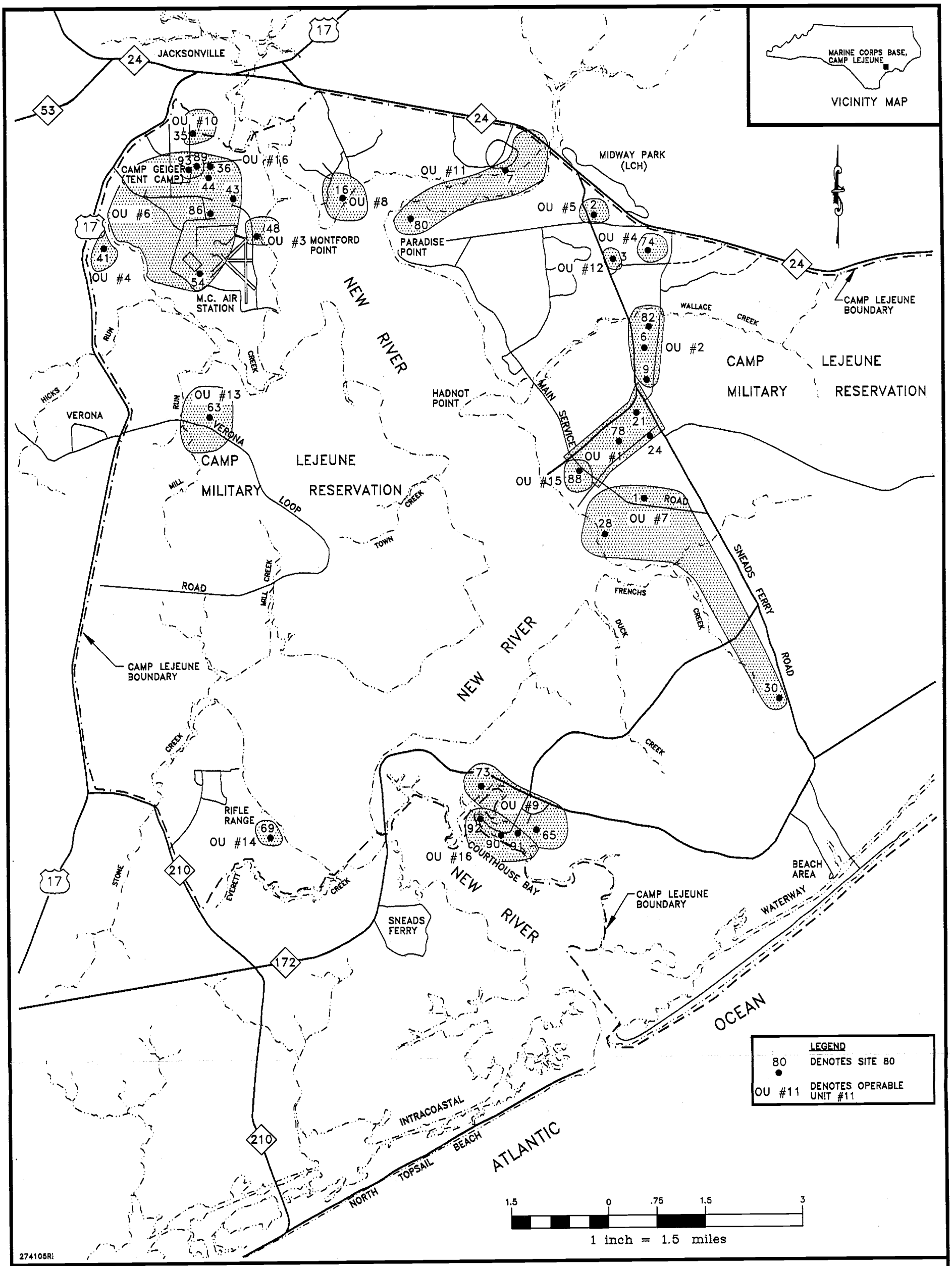


FIGURE 1-2
OPERABLE UNIT LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

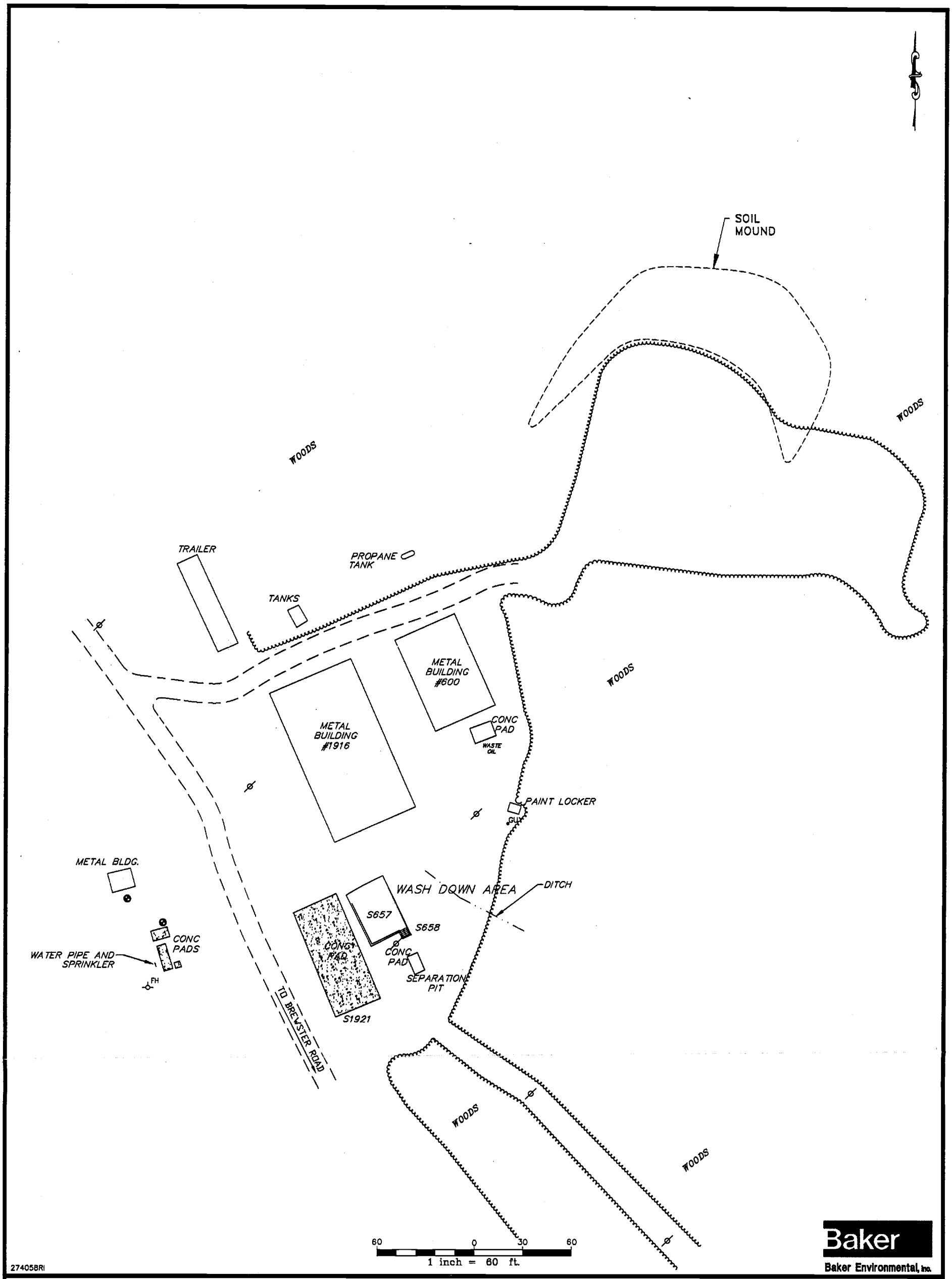
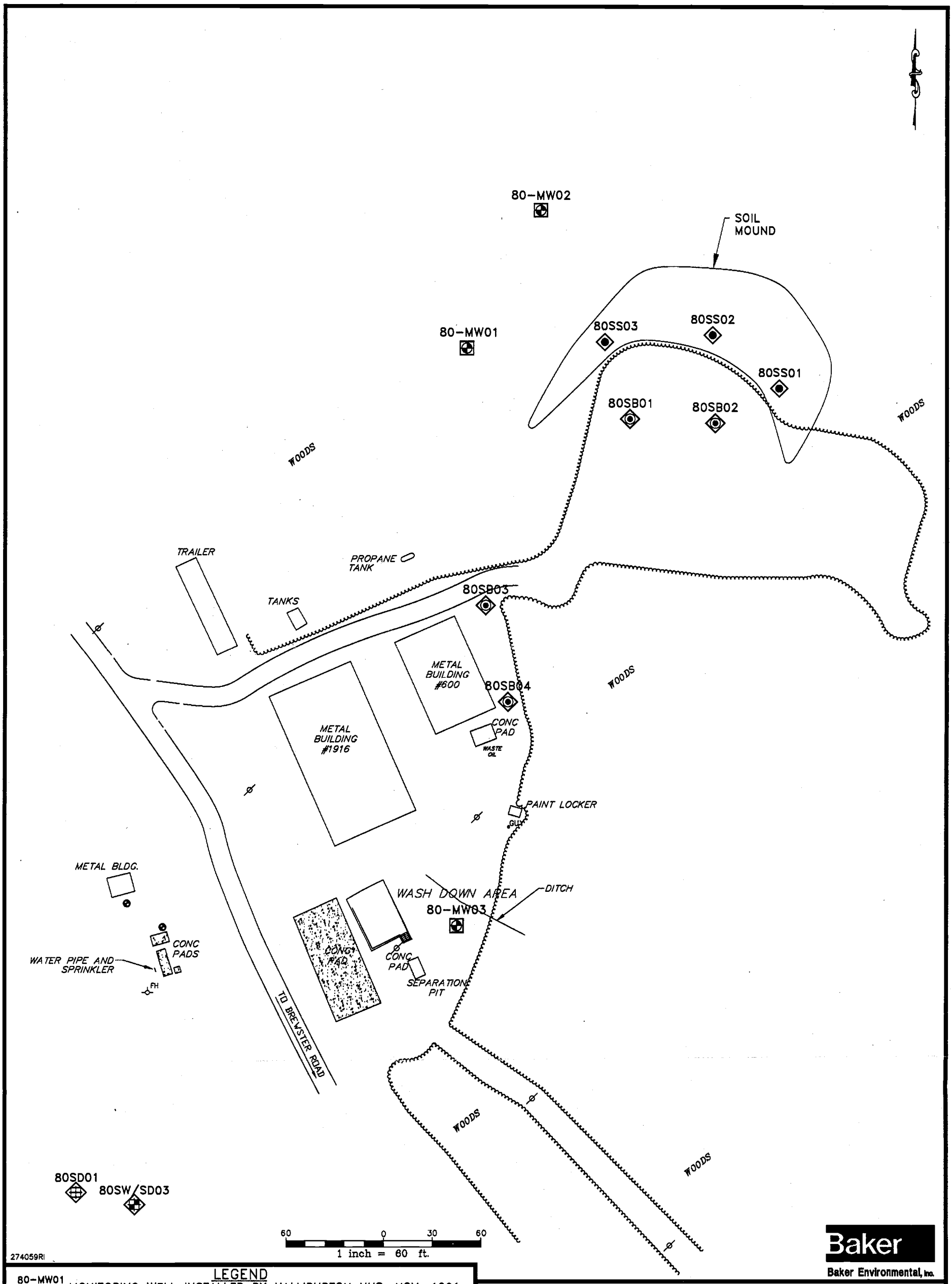


FIGURE 1-3
SITE LOCATION MAP
SITE 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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



LEGEND

- 80-MW01 — MONITORING WELL INSTALLED BY HALLIBURTON NUS, NOV. 1991
- 80SB01 — SOIL BORING INSTALLED BY HALLIBURTON NUS, NOV. 1991
- 80SS01 — SURFACE SOIL SAMPLE INSTALLED BY HALLIBURTON NUS, NOV. 1991
- 80SD01 — SEDIMENT SAMPLE INSTALLED BY HALLIBURTON NUS, NOV. 1991
- 80SW/SD03 — SURFACE WATER/SEDIMENT SAMPLE INSTALLED BY HALLIBURTON NUS, NOV. 1991

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

Baker Environmental, Inc.

FIGURE 1-4
PREVIOUS INVESTIGATION SAMPLING LOCATIONS
SITE 80 – PARADISE POINT GOLF COURSE MAINTENANCE AREA
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 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. During the week of January 30, 1995, investigation derived waste (IDW) generated during the RI was disposed of accordingly. In addition, a second soil and groundwater investigation at Site 80 commenced on June 12, 1995 and continued through July 15, 1995. The RI field program at Site 80 consisted of a site survey; a soil investigation which included drilling and soil sampling; a groundwater investigation which included groundwater monitoring well installation and sampling. The following sections detail the various investigation activities which were implemented during the RI.

Investigative procedures and methodologies for the RI conducted at Site 80 have been previously discussed in detail within Section 6.0 of the Final Field Sampling and Analysis Plan (FSAP), for OU Nos. 8, 11, and 12 (Baker, 1994).

2.1 Site Survey

The site survey task was performed in three phases: Phase I consisted of a initial survey of site features and proposed sample locations; and Phase II consisted of a 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 80 during the week of October 10, 1994. The proposed soil borings and monitoring well locations, provided in the Final RI/FS Work Plan for OU No. 11 (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 80 during the week of November 28, 1994. During Phase II, all soil borings and monitoring wells were surveyed. 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.

Phase III of the site survey task was completed at Site 80 during the week of July 10, 1995. The surveying firm of Brent A. Lanier was retained to perform the additional phase of the site survey. The latitude, longitude, and the elevation in feet above msl were recorded for each of the additional soil borings and one groundwater monitoring well.

2.2 Soil Investigation

A two part soil investigation consisting of an initial and subsequent investigation, was conducted at Site 80 to determine the presence or absence of contamination within the study area. The initial soil investigation involved the installation of soil borings and groundwater monitoring wells for the collection of surface and subsurface soils with a drill rig. The subsequent soil investigation involved the installation of additional soil borings and one groundwater monitoring well. A total of 37 locations, comprising soil borings and monitoring well borings were sampled during the initial soil investigation. The subsequent soil investigation had 21 locations, comprising soil borings and one monitoring well boring that were sampled. For discussion purposes, the sections detailing the

initial and subsequent surface soil investigations have been combined. This also is the case for the subsurface investigation.

Investigative procedures and methodologies for the RI conducted at Site 80 are provided within Section 6.0 of the Final FSAP (Baker, 1994). The following subsections describe both the surface and subsurface soil investigations conducted at Site 80.

2.2.1 Surface Soil Investigation

A total of 37 surface soil samples (i.e., samples collected from ground surface to one foot bgs)were collected at Site 80 during the initial investigation to evaluate the presence or absence of contamination within the study area. All of the surface soil samples were collected with a stainless steel spoon. Seven out of the 37 surface soil samples were collected from soil borings within the Lawn Area. Four out of the 37 surface soil samples were collected from soil borings within the Maintenance Area. Six out of the 37 surface soil samples were collected from soil borings within the Open Area. Ten out of the 37 surface soil samples were collected from soil borings within the Soil Mound Area. Three out of the 37 surface soil samples were collected from soil borings located in background locations (i.e., not known or suspected to be contaminated). Two surface soil samples were collected from the Drum Area, located north of the corner of Building 600. The drums were encountered during an earlier site visit, and removed prior to commencement of RI activities. The remaining five surface soils were collected from soil borings that were converted into groundwater monitoring wells (i.e., 80-MW03IW [intermediate monitoring well], 80-MW04, 80-MW05, 80-MW06, and 80-MW07). The locations of the surface soils collected during the initial soil investigation are provided on Figure 2-1. This investigation was conducted between November 1, 1994 through November 7, 1994.

A total of 21 surface soil samples were collected at Site 80 during the subsequent soil investigation. This investigation was conducted to delineate positive pesticide detections obtained in the initial investigation. Twenty out of the 21 surface soil samples were collected from soil borings within the Detected Pesticide Area (DPA). The remaining surface soil sample was collected from a soil boring that was converted into a groundwater monitoring well (i.e., 80-MW08). The locations of the surface soil samples collected during the subsequent soil investigation are provided on Figure 2-2. This investigation was conducted between June 12, 1995 through June 14, 1995. The following provides a summary of the number of surface soil samples collected during both the initial and subsequent soil investigations and the areas in which they were collected:

- Seven surface soils, Lawn Area (LA)
- Four surface soils, Maintenance Area (MA)
- Six surface soils, Open Area (OA)
- Ten surface soils, Soil Mound Area (SM)
- Three surface soils, Background Boring Locations (BB)
- Two surface soils, Drum Area (DA)
- Six surface soils, Groundwater Monitoring Well Locations (MW)
- Twenty surface soils, Detected Pesticide Area (DPA)

Table 2-1 identifies surficial soil samples collected during both the initial and subsequent investigations, the depth interval of the sample, depth of the borehole, and analytical parameters requested.

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 the American Society for Testing and Materials (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 and on Test Boring and Well Construction Records in Appendix A.

Laboratory services for both the initial and subsequent soil investigations were provided by Quanterra Environmental Services, Knoxville, Tennessee (Quanterra). During the initial soil investigation, 37 surface soil samples were collected and were analyzed for full TCL organics and Total Analyte List (TAL) metals During the subsequent soil investigation, 21 surface soil samples were collected and were analyzed for TCL pesticides.

Results of the surface soil investigation conducted at Site 80 are discussed in detail within Section 4.0 of this report. Chain-of-Custody (CoC) documentation, provided in Appendix B, accompanied the samples to the laboratory. Information such as sample number, collection date, analytical parameters requested, and time of sampling was included on the CoCs. Internal sample and analytical tracking forms for Site 80 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 quality assurance and quality control (QA/QC) samples were also collected during both the initial and subsequent surface soil investigations. 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 is equivalent to 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 (NEESA, 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 initial and subsequent surface soil investigations 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 10 percent of the 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 decontaminated. 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 conducted 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 environmental samples and sent for VOC 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 VOC analysis only). One set of trip blanks accompanied each cooler containing 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 Photo Ionization Detector (PID) to monitor for airborne contaminants. Also, a Lower Explosive Limit (LEL) meter was used to monitor the borehole during drilling activities. Samples (i.e., split-spoon samples) were screened with a PID to measure for volatile organic vapor. Readings obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records, and Test Boring and Well Construction Records 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.

2.2.2 Subsurface Soil Investigation

A total of 38 subsurface soil samples (i.e., samples collected from 1 foot bgs to just above the groundwater table) were collected from Site 80 during the initial soil investigation to evaluate the presence or absence of contamination within the study area. All of the subsurface soil samples were collected with a 2-inch split-spoon sampler from a drill rig. Twenty-nine out of the 38 subsurface soil samples were collected from soil borings. Eight out of the 29 subsurface soil samples were collected from the Lawn Area. Four out of the 29 subsurface soil samples were collected from the Maintenance Area. Eight out of the 29 subsurface soil surface samples were collected from the Open Area. Three out of the 29 subsurface soil samples were collected from the Soil Mound Area.

The remaining six out of the 29 subsurface soil samples were collected from three (i.e., two samples per boring) background locations, not known or suspected to be contaminated. Additionally, nine subsurface soil samples were collected from five soil borings that were converted into groundwater monitoring wells (i.e., 80-MW03IW, 80-MW04, 80-MW05, 80-MW06, and 80-MW07). Subsurface soil sample locations are provided on Figure 2-1. This investigation was conducted between November 1, 1994 through November 7, 1994.

Thirteen subsurface soil samples were collected during the subsequent soil investigation. This investigation was conducted to delineate positive pesticide detections obtained in the initial investigation. Twelve out of the 13 subsurface soil samples were collected from soil borings at the Detected Pesticide Area. It should be noted that subsurface soil samples were not collected from the following soil borings: SB05, SB06, SB07, SB10, SB11, SB14, SB15, and SB16 due to the remnants of a septic system absorption field. The remaining subsurface soil sample was collected from a soil boring that was converted into a groundwater monitoring well (i.e., 80-MW08). Figure 2-2 provides the locations of the subsurface soil samples and the groundwater monitoring well installed during the subsequent investigation. This investigation was conducted between June 12, 1995 through June 14, 1995. The following provides a summary of the number of subsurface soil samples collected during both the initial and subsequent soil investigation and the area in which they were collected:

- Eight subsurface soils, Lawn Area (LA)
- Four subsurface soils, Maintenance Area (MA)
- Eight subsurface soils, Open Area (OA)
- Three subsurface soils, Soil Mound Area (SM)
- Six subsurface soils, Background Boring Locations (BB)
- Ten subsurface soils, Groundwater Monitoring Well Locations (MW)
- Twelve subsurface soils, Detected Pesticide Area (DPA)

Table 2-1 identifies subsurface soil samples collected during both the initial and subsequent soil investigation, the depth interval of the sample, depth of the borehole, and analytical parameters requested.

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 and on Test Boring and Well Construction Records in Appendix A.

During the initial soil investigation, 38 subsurface samples were collected and were analyzed for full TCL organics and TAL metals. During the subsequent soil investigation, 13 subsurface soil samples were collected and were analyzed for TCL pesticides. Results of the initial and subsequent subsurface soil investigation conducted at Site 80 are provided within Section 4.0 of this report. Internal sample and analytical tracking forms and CoCs for Site 80 are provided in Appendix B. Subsurface samples were shipped overnight via Federal Express to Quanterra for analysis.

2.2.2.1 Quality Assurance and Quality Control

Field QA/QC samples were also collected during both the initial and subsequent subsurface soil investigation. These samples were obtained according to procedures and guidelines addressed in Section 2.2.1.1.

Field duplicate samples collected at Site 80 are identified on Table 2-1. In addition to field duplicates, additional QA/QC samples that were collected during both parts of 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, 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 PID to monitor for airborne contaminants. Also, a Lower Explosive Limit (LEL) meter was used to monitor the borehole during drilling activities. Samples (i.e., split-spoon samples) were screened with a PID to measure for volatile organic vapor. Readings obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records, and Test Boring and Well Construction Records 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 80 to determine the presence or absence of contamination in both the surficial aquifer and the deeper Castle Hayne aquifer, which may have resulted from past operational activities. During the initial soil investigation conducted from November 1, 1994 through November 7, 1994, four shallow groundwater monitoring wells (i.e., 80-MW04, 80-MW05, 80-MW06, and 80-MW07) were installed, then sampled during November 19, 1994 through December 3, 1994. In addition, one intermediate monitoring well 80-MW03IW (i.e., installed to the top of the Castle Hayne aquifer), was installed and sampled as part of this investigation. Three on-site existing shallow monitoring wells (80-MW01, 80-MW02, and 80-MW03) were also sampled during the ground water investigation. Existing monitoring wells 80-MW01, and 80-MW02 are located north of the Soil Mound Area. Newly installed monitoring wells 80-MW05, and 80-MW06 are located within the Open Area. Newly installed monitoring well 80-MW04 is located on the northwestern edge of the Maintenance Area. Existing monitoring well 80-MW03 and the newly installed intermediate monitoring well 80-MW03IW are located within the Lawn Area. The remaining well (80-MW07) is located southwest of the Lawn Area in a background location. Existing and newly installed groundwater monitoring well locations are provided on Figure 2-3. Depths of the newly installed wells ranged from 27 to 72 feet bgs. All newly installed groundwater monitoring wells were constructed with 2-inch inside diameter (I.D.) Poly Vinyl Chloride (PVC) pipe, with 15 feet of 0.01-inch slotted well screen. A summary of monitoring well construction details (i.e., well casing and ground surface elevations, boring depth, well depth, screen interval depth, sand pack depth, bentonite depth and PVC stick-up) are provided on Table 2-3.

An additional shallow groundwater monitoring well (80-MW08) was installed on June 13, 1995. This groundwater monitoring well was installed to delineate positive pesticide detections obtained during the initial soil investigation. The groundwater monitoring well is located northwest (i.e., downgradient) of the Detected Pesticide Area. Shallow monitoring well 80-MW08 location is provided on Figure 2-2. The depth of monitoring well 80-MW08 was 25 feet bgs. Monitoring well 80-MW08 was constructed with 2-inch I.D. PVC pipe, with 15 feet of 0.01-inch slotted well screen. A summary of monitoring well construction details (i.e., well casing and ground surface

elevations, boring depth, well depth, screen interval depth, sand pack depth, bentonite depth and PVC stick-up) is provided on Table 2-3.

All groundwater monitoring wells including the existing monitoring wells were developed and purged 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, development procedures, purging procedures, and groundwater sampling procedures are discussed in Section 6.0 of the Final FSAP, for OU No. 8 (Site 80) (Baker, 1994).

Groundwater from monitoring wells at Site 80 was sampled using USEPA Region IV's low flow purging and sampling technique. Although this technique has not yet been finalized, the Technical Compliance Branch of the USEPA Region IV, located in Athens Georgia, has set up preliminary procedures and guidelines. Procedurally this technique requires 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. It should be noted that existing wells 80-MW01 and 80-MW02 were purged and sampled with Teflon ® bailers, due to excessive amounts of silt within the monitoring well. The water quality readings collected during purging operations were: pH, conductivity, temperature, and turbidity. Water quality data is provided within Section 4.0 of this report. Once water quality readings had stabilized over three well volumes, a groundwater sample was collected. Groundwater sampling of the newly installed and existing monitoring wells was conducted during November 19, 1994 through December 3, 1994.

Groundwater from the additional monitoring well at Site 80 (80-MW08) was sampled using USEPA Region IV's low flow purging and sampling technique. Procedures followed the same as those identified above, with one exception. A peristaltic pump instead of the 2-inch submersible was used to purge and sample the monitoring well. In addition, water quality readings were collected during purging activities. A groundwater sample was collected once the water quality readings stabilized over three well volumes. The groundwater sample was collected on July 14, 1995.

In response to NC DEHNR concerns with elevated inorganics in the groundwater, a second round of groundwater samples were collected from the eight existing shallow wells and one existing intermediate well in December 1995.

All of the groundwater from the monitoring wells installed during the initial investigation were sampled and analyzed for full TCL organics, TAL metals (total and dissolved fractions). The groundwater from the monitoring well installed during the subsequent investigation was sampled and analyzed for TCL pesticides. The groundwater samples collected during the second round of sampling were analyzed for TAL total inorganics only.

Table 2-4 identifies all of the groundwater monitoring wells that were sampled and provides a summary of the analyses requested for each monitoring well. Internal sample and analytical tracking forms and CoCs for Site 80's groundwater investigation are provided in Appendix B. Results from the groundwater sampling are discussed in Section 4.0 of this report. All samples were shipped via Federal Express overnight to Quanterra for analysis.

2.3.1 Water Level Measurements

Static water level measurements were collected on three separate occasions. Measurements were recorded from top-of-casing reference points, marked on the PVC at each monitoring well. A complete round of static water level measurements were collected on December 11, 1994, March 27, 1995, July 31, 1995, and December 14, 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 investigations. These samples included trip blanks, equipment rinsates, and field duplicates. Equipment rinsates were collected from the submersible pump and peristaltic pump line prior to and during daily usage. Table 2-5 summarizes the QA/QC sampling program employed for the groundwater investigations conducted at Site 80.

2.3.3 Field Screening and Air Monitoring

Only one type of air monitoring and field screening procedure was implemented during groundwater sampling activities for health and safety and initial contaminant monitoring. The air monitoring and field screening procedure implemented at Site 80 included the screening of well heads and 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 readings were recorded in a field logbook and on calibration forms.

2.4 Habitat Evaluation

A habitat evaluation was performed at Site 80 during December 4, 1994 through December 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.

2.5 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, hollow-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 managed according to the procedures outlined in Section 2.6.

2.6 Investigation Derived Waste (IDW) Handling

Field investigation activities at Site 80 resulted in the generation of various IDW. This IDW included well development and purge water, solutions used to decontaminate non-disposable sampling equipment, and mud cuttings from intermediate monitoring well installation. 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.

During the initial investigation the development and purge water, along with the decontamination fluids, and mud cuttings did not show contamination at a concentration that would classify them hazardous. Therefore, the water, decontamination fluids, and mud cuttings were deposited back onto Site 80. During the subsequent investigation, IDW was not containerized, and was deposited back onto the site. Appendix D provides information regarding the management, results, and disposal of the IDW.

2.7 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 UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
Drum Area									
80-DA-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
80-DA-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
Lawn Area									
80-LA-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-LA-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-LA-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-LA-SB04	00	1.0	0.0 - 1.0	X	X	X	X	X	X
	06	13.0	11.0 - 13.0	X	X	X	X	X	X
80-LA-SB05	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 UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
80-LA-SB06	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-LA-SB07	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
Maintenance Area									
80-MA-SB01	00	1.0	0.0 - 1.0	X	X	X	X		X
	06	13.0	11.0 - 13.0	X	X	X	X		X
80-MA-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-MA-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-MA-SB04	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
Open Area									
80-OA-SB01	00	1.0	0.0 - 1.0	X	X	X	X	X	X
	07	15.0	13.0 - 15.0	X	X	X	X	X	

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
80-OA-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	07	15.0	13.0 - 15.0	X	X	X	X		
80-OA-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-OA-SB04	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-OA-SB05	00	1.0	0.0 - 1.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-OA-SB06	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
Soil Mound Area									
80-SM-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
80-SM-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
80-SM-SB03	00	1.0	0.0 - 1.0	X	X	X	X	X	X

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
80-SM-SB04	00	1.0	0.0 - 1.0	X	X	X	X		
80-SM-SB05	00	1.0	0.0 - 1.0	X	X	X	X		
80-SM-SB06	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
80-SM-SB07	00	1.0	0.0 - 1.0	X	X	X	X		
80-SM-SB08	00	1.0	0.0 - 1.0	X	X	X	X		
80-SM-SB09	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
80-SM-SB10	00	1.0	0.0 - 1.0	X	X	X	X		
Detected Pesticide Area									
80-DPA-SB01 [1]	00	1.0	0.0 - 1.0			X			
80-DPA-SB01 (1)	03	7.0	5.0 - 7.0			X			
80-DPA-SB02 [1]	00	1.0	0.0 - 1.0			X			
80-DPA-SB02 (1)	04	9.0	7.0 - 9.0			X			

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
80-DPA-SB03 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			
80-DPA-SB04 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			
80-DPA-SB05 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB06 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB07 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB08 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			
80-DPA-SB09 (1)	00	1.0	0.0 - 1.0			X		X	
	04	9.0	7.0 - 9.0			X		X	
80-DPA-SB10 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB11 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB12 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
80-DPA-SB13 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			
80-DPA-SB14 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB15 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB16 (1)	00	1.0	0.0 - 1.0			X			
80-DPA-SB17 (1)	00	1.0	0.0 - 1.0			X			
	03	7.0	5.0 - 7.0			X			
80-DPA-SB18 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			
80-DPA-SB19 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			
80-DPA-SB20 (1)	00	1.0	0.0 - 1.0			X			
	04	9.0	7.0 - 9.0			X			

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
Background Borings									
80-BB-SB01	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-BB-SB02	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-BB-SB03	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
Monitoring Wells									
80-MW03IW	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X	X	X
	06	13.0	11.0 - 13.0	X	X	X	X		
80-MW04	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
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth Interval Identification	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL Volatiles	TCL SemiVolatiles	TCL Pesticides/ PCBs	TAL Inorganics	Duplicate Samples	Matix Spike/Matrix Spike Duplicate
80-MW05	00	1.0	0.0 - 1.0	X	X	X	X		
	04	9.0	7.0 - 9.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-MW06	00	1.0	0.0 - 1.0	X	X	X	X		
	03	7.0	5.0 - 7.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-MW07	00	1.0	0.0 - 1.0	X	X	X	X		
	04	9.0	7.0 - 9.0	X	X	X	X		
	06	13.0	11.0 - 13.0	X	X	X	X		
80-MW08 [1]	00	1.0	0.0 - 1.0			X			
	05	11.0	9.0 - 11.0			X			

Note: [1] Sample was collected during the subsequent soil investigation (June 12 through June 14, 1995)

TABLE 2-2

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE AND SUBSURFACE SOIL INVESTIGATION PARADISE POINT GOLF COURSE MAINTENANCE AREA OPERABLE UNIT NO. 11 (SITE 80) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample [1]	Frequency of Collection	Number of Samples	Analytical Parameters [2]
Trip Blanks [3]	One per Cooler	6	TCL Volatiles
Field Blanks [4]	One per Event	1	TCL Organics/TAL Inorganics
Equipment Rinsates [5]	One per Day	6	TCL Organics/TAL Inorganics
		1	TCL Pesticides
Number of Environmental Samples		75	TCL Organics/TAL Inorganics [6]
		34	TCL Pesticides [7]
Field Duplicates [8] [9]	10% of Sample Frequency	6	TCL Organics/TAL Inorganics
		2	TCL Pesticides

Notes:
(1) QA/QC sample types defined in Section 2.2.1.1 in text.
(2) Parameters analyzed according to CLP Protocol.
(3) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(4) Field blanks collected during Site 80 soil investigation (October 17 through December 4, 1994).
(5) Equipment rinsates collected from various sampling equipment (e.g., submersible pump, and pump discharge hose. 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) Soil Samples collected during the initial (November 1, through November 7, 1994) surface and subsurface soil investigation.
(7) Soil samples collected during the subsequent (June 12, through June 14, 1995) surface and subsurface soil investigation.
(8) Refer to Table 2-1 for duplicate sample identification.
(9) Field duplicates were segregated into five areas (Lawn Area, Maintenance Area, Open Area, Soil Mound Area, and Detected Pesticide Area).

TABLE 2-3

SUMMARY OF WELL CONSTRUCTION DETAILS
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Monitoring 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)
80-MW03IW	11/5/94	16.98	14.41	72.5	72.0	72.0 - 57.0	72.5 - 54.0	54.0 - 52.0	2.57
80-MW04	11/3/94	16.07	13.70	27.0	26.5	26.5 - 11.5	27.0 - 9.0	9.0 - 7.0	2.37
80-MW05	11/4/94	18.54	16.22	27.5	27.0	27.0 - 12.0	27.5 - 10.0	10.0 - 8.0	2.32
80-MW06	11/5/94	19.42	17. 06	27.5	27.0	27.0 - 11.0	27.5 - 9.0	9.0 - 7.0	2.36
80-MW07	11/4/94	18.49	16.21	28.0	27.5	27.5 - 12.5	28.0 - 10.0	10.0 - 8.0	2.28
80-MW08	6/13/95	17.33	15.0	25.0	25.0	25.0 - 10.0	25.0 - 8.0	8.0 - 6.0	2.33

Note: [1] msl - mean sea level

TABLE 2-4

MONITORING WELL SAMPLING SUMMARY
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Date of Sampling	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Total Metals	TAL Dissolved Metals	Duplicate	Matrix Spike/ Matrix Spike Duplicate
Permanent Monitoring Wells								
80-MW01-01	11/21/94	X	X	X	X	X		
80-MW01-02	12/17/95				X			
80-MW02-01	11/21/94	X	X	X	X	X		
80-MW02-02	12/15/95				X			
80-MW03-01	11/20/94	X	X	X	X	X		
80-MW03-02	11/15/95				X			
80-MW03IW-01	12/3/94	X	X	X	X	X	X	
80-MW03IW-02	12/14/95				X			
80-MW04-01	11/19/94	X	X	X	X	X		
80-MW04-02	12/17/95				X			
80-MW05-01	11/20/94	X	X	X	X	X		
80-MW05-02	12/15/95				X			
80-MW06-01	11/20/94	X	X	X	X	X	X	X
80-MW06-02	12/15/95				X			
80-MW07-01	11/19/94	X	X	X	X	X		
80-MW07-02	12/14/95				X			
80-MW08-01	7/14/95			X [1]				
80-MW08-02	12/16/95				X			

Note:

[1]Sample was only analyzed for TCL Pesticides.

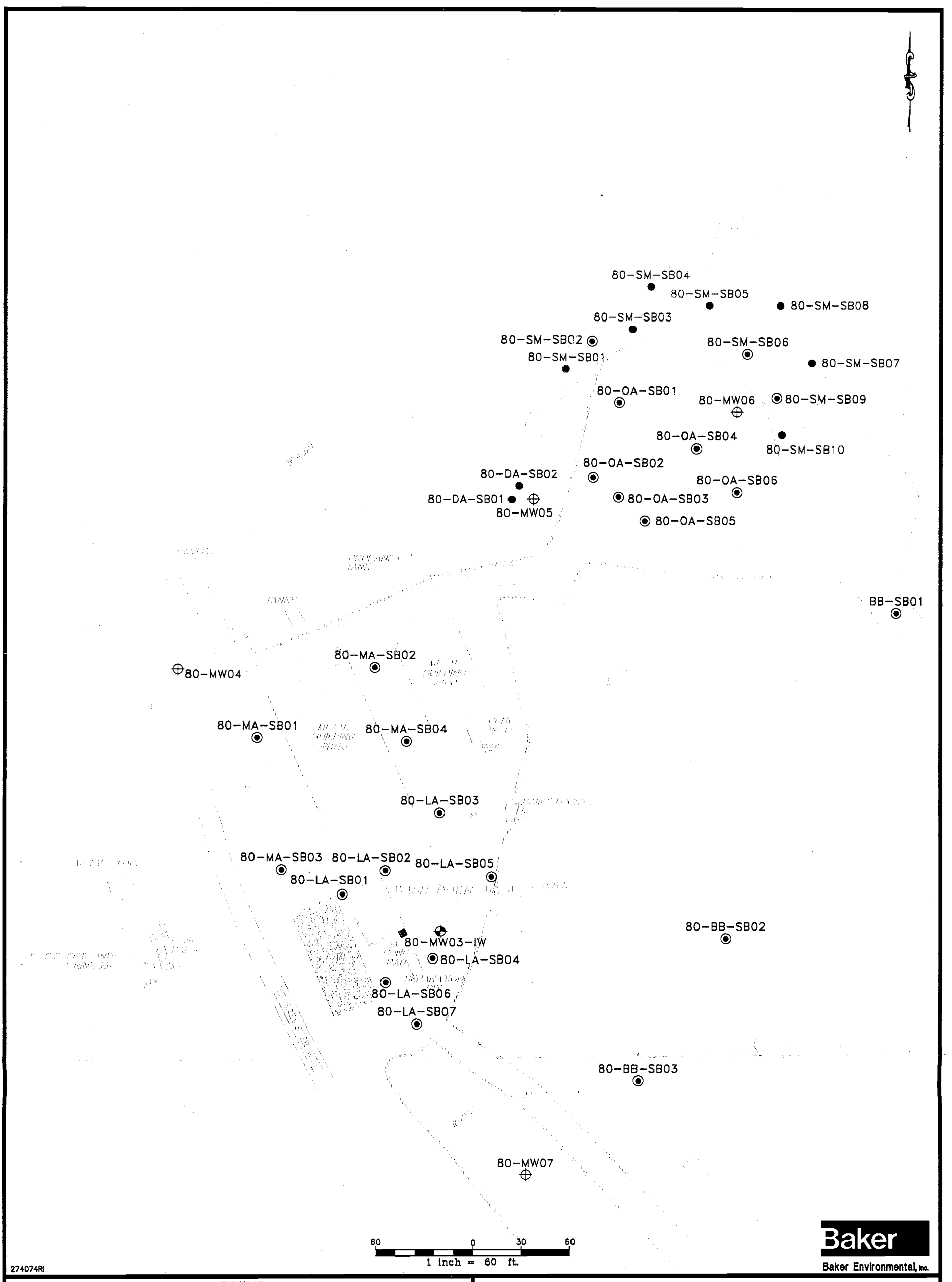
TABLE 2-5

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION PARADISE POINT GOLF COURSE MAINTENANCE AREA OPERABLE UNIT NO. 11 (SITE 80) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample [1]	Frequency of Collection	Number of Samples	Analytical Parameters [2]
Trip Blanks [3]	One per Cooler	2	TCL Volatiles
Field Blanks [4]	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates [5]	One per Day	4	TCL Organics/TAL Inorganics
		1	TCL Pesticides
Number of Environmental Samples		8	TCL Organics/TAL Inorganics [6]
		1	TCL Pesticides [7]
Field Duplicates [8] [9]	10% of Sample Frequency	2	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.2.1.1 in text.
(2) Parameters analyzed according to CLP Protocol.
(3) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(4) Field blanks collected during Site 80 soil investigation (October 17 through December 4, 1994).
(5) Equipment rinsates collected from various sampling equipment (e.g., submersible pump, and pump discharge hose. 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) Groundwater samples collected during the initial (November 19, through December 3, 1994) groundwater investigation.
(7) The groundwater sample was collected during the subsequent (July 14, 1995) groundwater investigation.
(8) Refer to Table 2-4 for duplicate sample identification.
(9) A duplicate sample was not collected during the second part of the groundwater investigation.

SECTION 2.0 FIGURES



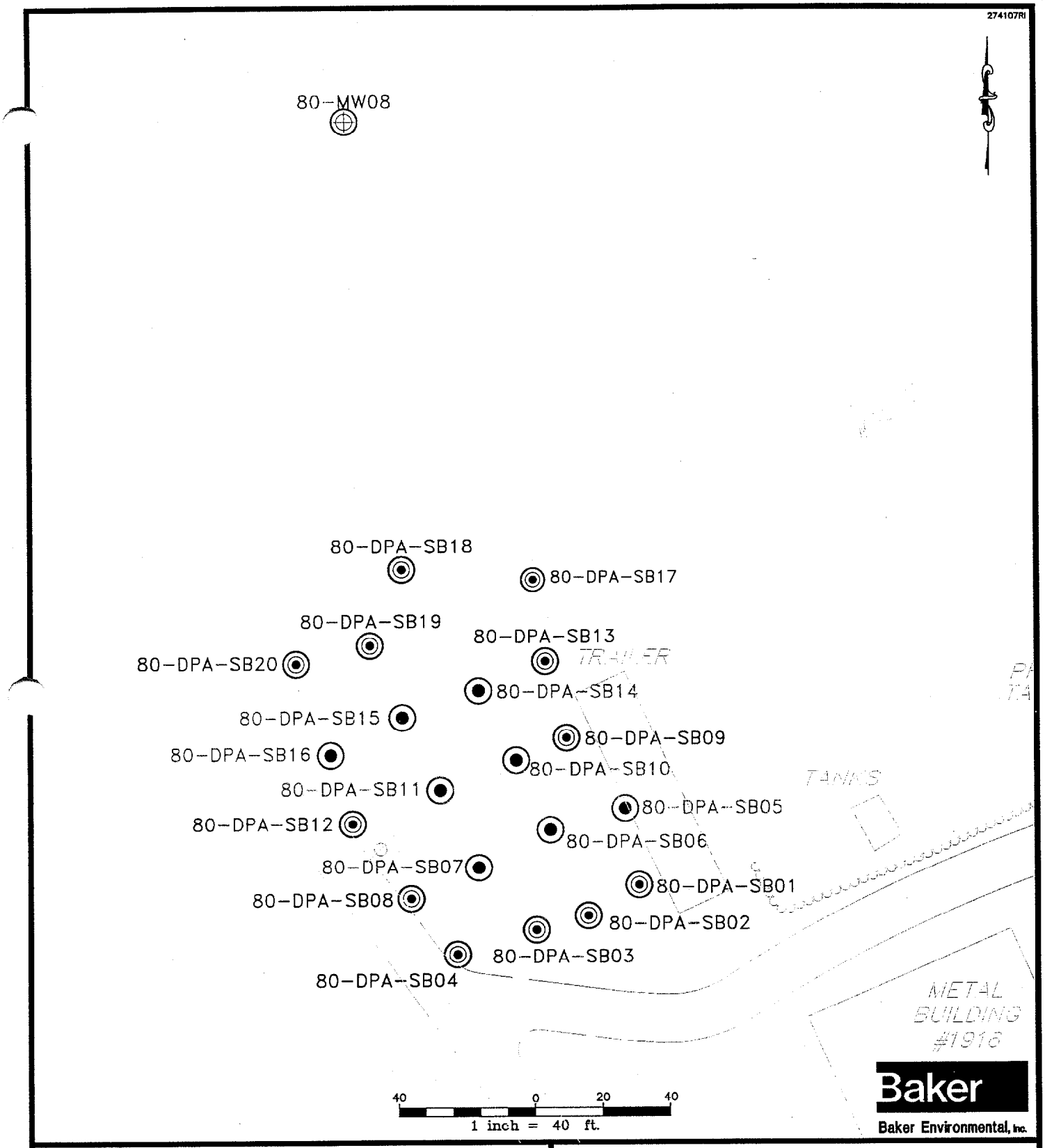
LEGEND

80-MW04 ⊖	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-MW03IW ⊕	INTERMEDIATE MONITORING WELL LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-MA-SB01 ◉	SOIL BORING LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-DA-SB01 ●	SURFACE SOIL BORING LOCATION (INSTALLED DURING THE FIRST PART OF THE SOIL INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).

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

FIGURE 2-1
SOIL SAMPLING LOCATIONS
SITE 80 - PARADISE POINT
GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA

01697X012

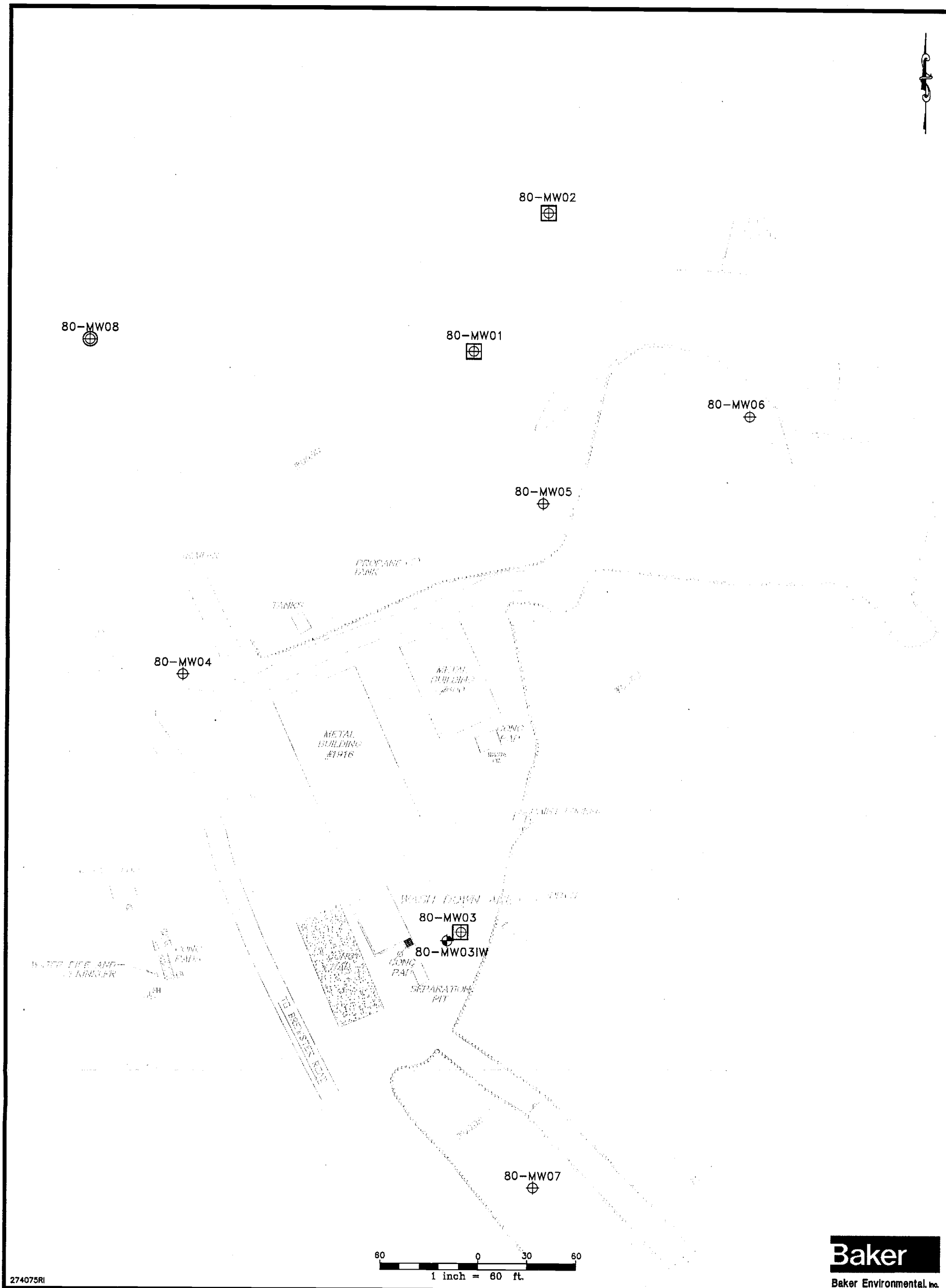


LEGEND

- 80-MW08 — SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE SECOND PART OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 14, 1995).
- 80-DPA-SB01 — SOIL BORING LOCATION (INSTALLED DURING THE SECOND PART OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 14, 1995).
- 80-DPA-SB05 — SURFACE SOIL SAMPLE LOCATION (INSTALLED DURING THE SECOND PART OF THE SOIL INVESTIGATION JUNE 12 THROUGH JUNE 14, 1995).

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

FIGURE 2-2
SOIL SAMPLING LOCATIONS
SITE 80 – PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLNA



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Baker

Baker Environmental, Inc.

LEGEND

80-MW01	SHALLOW MONITORING WELL LOCATION (INSTALLED PRIOR TO THE REMEDIAL INVESTIGATION CONDUCTED IN OCTOBER 1994).
80-MW04	SHALLOW MONITORING WELL LOCATION(INSTALLED DURING THE FIRST PART OF THE GROUNDWATER INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-MW03IW	INTERMEDIATE MONITORING WELL LOCATION(INSTALLED DURING THE FIRST PART OF THE GROUNDWATER INVESTIGATION NOVEMBER 1 THROUGH NOVEMBER 7, 1994).
80-MW08	SHALLOW MONITORING WELL LOCATION (INSTALLED DURING THE SECONG PART OF THE GROUNDWATER INVESTIGATION JUNE 12 THROUGH JUNE 14, 1995).

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

FIGURE 2-3
MONITORING WELL SAMPLING LOCATIONS
SITE 80 - PARADISE POINT
GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA

01697X022

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. 11 (Site 80). 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.

Figure 3-1 presents the general topography and surface features identified at Site 80. The study area at Site 80 is relatively flat, with a slight slope to the northeast. Site ground surface elevations obtained from the site survey conducted of the boring and well locations indicate a range from 13 feet (in the detected pesticide area) to approximately 17 feet (within the open area) above msl. Several large soil mounds are located in the northeast portion of the site, behind the machine shop. The soil mound area in the northeast portion of the site has ground surface elevations of between 21 and 26 feet msl. The golf course maintenance area is surrounded by woods, with an access road leading to Brewster Boulevard and into the golf course proper. During the March 1994 site reconnaissance, surface water runoff, in the wash down area, was observed flowing toward the southeast in the direction of a drainage ditch, located southeast of the wash area. Surface water flow within the ditch is intermittent, but is in a north/northeast direction away from the site.

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 which 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 length, 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 shellfishing)

and SA (estaurine waters suited for commercial shellfishing). 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 where flow is into 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 seven feet above msl in the upper reaches of the New River. Site 80 does not lie within the 100-year floodplain.

3.2.2 Site-Specific

The only standing water body located within the site is a drainage ditch southeast of the wash pad area. Observed following a heavy rain during the RI were isolated areas of ponded water, which did not remain for very long. Water flow in the drainage ditch is intermittent. The drainage ditch is shallow in the lawn area (approximately 2 to 4 feet deep) and groundwater would not appear to discharge to the ditch as groundwater level measurements in the surficial aquifer made during the RI indicate depths of between 12 and 16 feet below ground surface (bgs).

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).

3.3.2 Site-Specific

Site 80 is primarily underlain by silty sand, sand, and silty clay. Isolated zones of silt were also observed primarily in the upper portions of the borings. Percentage of sand increases with depth. 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) indicate 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 borehole locations in the lawn area, ranging in thickness from one to five feet. This fill material consisted of apparent replaced soil. One intermediate well (72.5 foot depth) was installed in the upper portion of the Castle Hayne aquifer. The Castle Hayne was encountered at a depth of approximately 53 feet. The lithology of the upper portion of the Castle Hayne is predominantly a fine grained sand with a trace of silt and shell fragments.

Geologic cross-sections were developed for the surficial and upper Castle Hayne sediments based on samples collected during the RI. As shown on Figure 3-2, two cross-sections were developed using groundwater monitoring well boreholes. Cross-section A-A' (Figure 3-3) depicts the site lithology from north to south and cross-section B-B' (Figure 3-4) depicts the lithology from southwest to northeast of the site soils.

Cross-section A-A' represents the typical surficial soils at Site 80. The surficial soils are comprised of fine grained sand with varying amounts of silt between two and four feet thick. Beneath the silty sand is a silty clay layer of fairly uniform thickness. This silty clay layer is not evident in the logs for wells 80-MW01 and 80-MW02, installed during a previous investigation, in the northern portion of the site. A silty sand unit was encountered in well 80-MW03IW beneath the silty clay with a thickness of 44 feet. This silty sand unit is comprised of fine to medium grained sand with decreasing silt content with depth. Traces of clay are found in the upper portion of this unit. Well 80-MW03IW also exhibited fill material to a depth of five feet. The silty sand above the silty clay unit was damp, indicating that the clay unit may inhibit but not preclude the downward groundwater flow due to its apparent lower permeability.

Cross-section B-B' shows the same surficial soil units as in cross-section A-A'. The upper silty sand thickens and dips to the west. The silty clay layer is uniform in thickness across the site and also dips to the west. Beneath the silty clay layer is the lower silty sand unit shown on cross-section A-A'. Well 80-MW06 on the eastern side of the site showed a clayey silt from the surface to a depth of 5.5 feet. Beneath the clayey silt is the silty clay and silty sand encountered over the site area. A 4.5 foot silty clay layer was identified within the lower silty sand unit. Groundwater elevations are similar throughout the shallow wells. The silty clay unit does not appear to inhibit the vertical movement of groundwater, based on moisture contents of samples above the unit and the similar groundwater elevations in the shallow monitoring wells.

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), and in Environmental Science and Engineering , Inc. (ESE) Site Summary Report (1988).

The aquifers of interest are the surficial aquifer and the aquifer immediately below it, the Castle Hayne aquifer. Other aquifers that occur beneath the facility include the Beaufort, Peedee, Black Creek, and the upper and lower Cape Fear aquifers; however, the aquifers are not of interest because they are not used to supply water for potable purposes. The combined thickness of the seven aquifers underlying MCB, Camp Lejeune is approximately 1500 feet. The following summary is a compilation of information which pertains to aquifer characteristics within the MCB, Camp Lejeune area. A generalized hydrogeologic cross-section illustrating the relationship between the aquifers in this area is presented on Figures 3-5 and 3-6.

The surficial aquifer consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells. The thickness of the surficial aquifer ranges from 0 to 73 feet and averages nearly 25 feet over the MCB, Camp Lejeune area. It is generally thickest in the interstream divide areas and presumed absent where it is cut by the New River and its tributaries. The beds are thin

and discontinuous, and have limited lateral continuity. This aquifer is not used for water supply at MCB, Camp Lejeune.

The general lithology of the surficial aquifer and the absence of any thick, continuous clay beds are indications of relatively high vertical conductivity within the aquifer. The estimated lateral hydraulic conductivity of the surficial aquifer in the MCB, Camp Lejeune area is 50 feet per day, and is based on a general composition of fine sand mixed with some silt and clay. However, data collected from a number of slug tests conducted by Baker at MCB, Camp Lejeune indicate much lower lateral hydraulic conductivity values. These values range from 7.2×10^{-4} feet per day to 6.4 feet per day. Table 3-2 presents a summary of hydraulic properties compiled during investigations at sites located within the developed portion of MCAS, New River, on the opposite side of the New River from Site 80.

Between the surficial and the Castle Hayne aquifers lies the Castle Hayne confining unit. This unit consists of clay, silt, and sandy clay beds. In general, the Castle Hayne confining unit may be characterized as a group of less permeable beds at the top of the Castle Hayne aquifer that have been partly eroded or incised in places. The Castle Hayne confining unit is discontinuous, and has a thickness ranging from 0 to 26 feet, averaging about 9 feet where present. There is no discernable trend in the thickness of the confining unit seen in these or related investigations, nor is there any information in the USGS literature regarding any trend of the depth of the confining unit.

Previously recorded data indicate that vertical hydraulic conductivity of the confining unit ranged from 0.0014 to 0.41 feet per day (Cardinell et al., 1993). Data obtained from a pump test conducted by ESE indicated a vertical hydraulic conductivity for this unit ranging from 1.4×10^{-3} to 5.1×10^{-2} feet per day (ESE, 1988). Based on the moderate conductivity values and the thin, discontinuous nature of the confining unit, this unit may only be partly effective in retarding the downward movement of groundwater from the surficial aquifer.

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

The Castle Hayne aquifer is about 150 to 350 feet thick, increasing in thickness towards the ocean. The top of the aquifer lies approximately 20 to 73 feet below ground surface. The top of the aquifer dips southward and is deepest near the Atlantic coast, east of the New River. The top of the aquifer also forms a basin in the vicinity of Paradise Point. Estimates of hydraulic conductivity indicate a wide variation in range, from 14 to 91 feet per day. Table 3-3 presents estimates of the Castle Hayne aquifer and confining unit hydraulic properties in the vicinity of MCB, Camp Lejeune.

Onslow County and MCB, Camp Lejeune lie in an area where the Castle Hayne aquifer generally contains freshwater; however, the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawls. Over-pumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer generally contains water having less than 250 milligrams per liter (mg/L) chloride (state criteria for classification of saltwater) throughout the base, except for one USGS well in the southern portion of the base that is

screened in the lower portion of the aquifer. Chloride was measured at 960 mg/L in a sample collected in 1989 from this well.

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

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

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

3.4.2 Site-Specific

Groundwater was encountered during drilling during the RI at elevations ranging from 2.16 to 3.34 feet above msl. Groundwater elevation measurements from December 11, 1994, March 27, 1995 and July 30, 1995 for Site 80 are presented in Table 3-4. Groundwater elevation contour maps for the surficial aquifer on December 11, 1994, March 27, 1995, July 30, 1995 and December 14-17, 1995 are presented on Figures 3-7, 3-8 and 3-9, respectively. The contour maps indicate a groundwater mound centered in the lawn area with linear flow in all directions. The mounding may be the result of fill placed in this area. From the installed monitoring wells at the site, the primary groundwater flow direction is northwest/north, towards Northeast Creek (located approximately one-half mile north of Site 80). Local recharge for this area would be from the south/southeast. The shallow groundwater gradient measured from well 80-MW03 to well 80-MW04 to the north for December 11, 1994 was 0.002 ft/ft and March 27, 1995 was 0.005 ft/ft. The hydraulic gradient for July 30, 1995 was 0.003 ft/ft, measured between wells 80-MW03 and 80-MW02. Shallow groundwater eventually discharges to Northeast Creek. The surficial aquifer exhibited seasonal variations in groundwater levels over the seven month period that groundwater level measurements were obtained. The December and July groundwater elevations are similar indicating recharge periods. There was greater rainfall than normal this past summer which would account for the higher groundwater elevations seen in the summer months than would be expected from the normal regional trends. Groundwater elevations were lower in March following the spring season trend from regional data.

The hydraulic properties of the surficial aquifer were characterized by performing in situ rising and falling head slug tests in four of the five newly installed monitoring wells. The tests were performed on December 7 through 9, 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 were 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 (ver. 1.1) computer program for performing quantitative groundwater assessments. Results for the falling head test at well 80-MW04 were analyzed, due to the fact that this shallow well exhibited a groundwater level at or above the top of the sand pack, making the falling head test valid at this location. 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 3-5 lists the hydraulic conductivity (K) values obtained from the data analysis, the average hydraulic gradient from the three groundwater elevation contour maps, the assumed effective porosity, and the calculated value for groundwater velocity. The average estimated K value from the four shallow wells [5 tests (four rising head and one falling head)] was 28 feet/day (1×10^{-2} cm/sec), which is within the typical range for silty sands (Freeze/Cherry, 1979). This average K value is one to two orders of magnitude higher than values calculated from slug tests for other areas of the base. The difference in the calculated transmissivity values from the slug tests and pump tests may be due to differences in specific lithologies at tested areas, as well as placement of the well screens in the tested wells within the lithologies. There are also inherent differences in procedures and responses for slug tests and pump tests, which can produce variations in calculated values for hydraulic conductivity and transmissivity. The average hydraulic gradient from groundwater measurements between wells 80-MW03 and 80-MW04 on December 11, 1994 and March 27, 1995, and between wells 80-MW03 and 80-MW02 on July 30, 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 sand, a value of 35 percent was used for effective porosity. The estimated average linear groundwater velocity was calculated by using a variation of Darcy's equation:

$$V=Ki/n_e$$

Where: V = groundwater velocity (feet/day)
K = hydraulic conductivity (feet/day)
i = hydraulic gradient (feet/feet)
n_e = effective porosity (dimensionless)

Using these variables, the groundwater velocity (V) is estimated to be 0.26 feet/day (94.9 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 by the saturated thickness (b) of the aquifer. Using a saturated thickness of 38 feet, which corresponds to the distance above the top of the Castle Hayne (53 foot depth) to the water table surface (average depth 15 feet), an approximate T value for the shallow aquifer in this direction is 1064 $feet^2$/day (8×10^3 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 ft^2/day (7.1×10^2 gallons/day/ft) and 6.3 feet/day (2.2×10^{-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 (5×10^2 gallons/day/ft). The average transmissivity value from these two pump tests is 85 $feet^2$/day (6×10^2 gallons/day/ft). The calculated transmissivity value of

1064 feet^2/day from the slug tests is two orders of magnitude higher than the average pump test value.

One intermediate depth well (80-MW03IW) was installed in the upper portion of the Castle Hayne aquifer at a depth of 72.5 feet. Groundwater levels for this well are presented in Table 3-4. Elevations for the intermediate well varied from 1.87 feet above msl (July 30, 1995) to 4.02 feet above msl (March 27, 1995). A groundwater contour map can not be constructed for the upper portion of the Castle Hayne at Site 80 due to the limited number of wells. There is a groundwater elevation difference between monitoring wells installed in the surficial aquifer and the upper portion of the Castle Hayne aquifer. This elevation difference produces a potential vertical gradient of 0.05 ft/ft downward from the shallow water-bearing zone to the upper Castle Hayne. The recharge area for the upper Castle Hayne aquifer may be to the northeast with the Castle Hayne potentially discharging to the New River where the Castle Hayne formation is near surface.

In situ falling and rising slug tests were performed in well 80-MW03IW on December 9, 1994. Both the falling head and rising head test data was analyzed using Geraghty & Miller's AQTESOLV (ver. 1.1) program, as with the shallow wells. The input parameters and plots generated are contained in Appendix E. Table 3-5 lists the K values obtained from the data analysis. The average hydraulic conductivity value for the Castle Hayne aquifer was 16 feet/day. USGS Water Resources report (Harned et al., 1989) lists a hydraulic conductivity range of 14 - 82 feet/day for the Castle Hayne aquifer. Calculated K values for Site 80 are within this range.

The lithology does not indicate a confining or semiconfining layer between the surficial water table aquifer and the Castle Hayne aquifer. This is substantiated by the similar groundwater elevations exhibited in the shallow and intermediate wells across the site. The differentiation between the two water bearing zones is based on lithology, groundwater parameters as seen from the evaluation of slug test data, and usage (the surficial aquifer is not used as a water supply on the base). Evaluation of groundwater elevations indicated a potential vertical gradient between the two aquifers of 0.05 ft/ft.

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

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 general habitat types are present at Site 80. These four include a deciduous forest, mixed forest, open area, and a transition area between the open area and the forests. In the deciduous

forest, pines are found along with the predominating oaks. Other leaf trees as well as shrubs are found in this forest. In the mixed forest, loblolly pines are prevalent. The open area covers most of the site and consists of grasses with herbaceous plants. The transition zone between the forested areas and the open area include saplings, herbaceous plants and vines. Several species of birds were identified in the area as was evidence of whitetail deer. No amphibians or reptiles were observed as the habitat evaluation was conducted during the winter. Site 80 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. Section 7 presents the ecological features in detail and Figure 7-1 presents a habitat map of the site area.

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

North of Hadnot Point are low-density family housing and recreational areas. These two uses make up approximately 94 percent (i.e., 343 acres and 610 acres, respectively) of all the developed areas on Paradise Point. The golf course, also located in this area, comprises the single largest land use. In the center of the Paradise Point shoreline is the Bachelor Officer's Housing Area and associated community facilities which are accessible from both troop and family housing areas.

The existing land use pattern for the various developed geographic areas within the MCB are listed, per geographic area, on Table 3-6. In addition, the number of acres comprising each land use category has been estimated and provided on the table. Site 80 is located in the northern central region of Paradise Point at MCB, Camp Lejeune.

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 34 to 54 degrees Fahrenheit (°F) in the winter (i.e., January) and 72 to 89 °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 3-7

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 15.8 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 two base supply wells within a one-mile radius of Site 80: HP-701 and ON-T2-87 (Harnad, et al., 1989). These wells are in an apparent upgradient direction from Site 80. It would not appear that Site 80 would impact these base supply wells. Table 3-8 presents a summary of the water supply wells within a one-mile radius of Site 80. 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.

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

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. 11 (SITE 80) 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 HYDRAULIC PROPERTIES
UNRELATED SITE INVESTIGATIONS
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity Falling Head Test		Hydraulic Conductivity Rising Head Test		Transmissivity	Storativity
	ft/day	cm/sec	ft/day	cm/sec	gal/day/ft	
MW-30A	1.18	4.16E-04	1.5	5.31E-04	--	--
MW-31A	0.346	1.22E-04	0.269	9.51E-05	--	--
MW-35A	0.119	4.20E-05	0.116	4.06E-05	--	--
MW-32B	6.22	2.20E-03	5.15	1.82E-03	--	--
MW-36B	2.91	1.03E-03	3.2	1.13E-03	--	--
MW-37B	7.06	2.49E-03	6.44	2.27E-03	--	--
GWD-1	6.8	2.40E-03	6.03	2.13E-03	--	--
122MW-3	0.25	8.80E-05	0.015	5.30E-06	--	--
122MW-5	0.47	1.70E-04	0.034	1.20E-05	--	--
122MW-12	0.068	2.40E-05	0.0085	3.00E-06	--	--
MW-13(1)	0.0554	1.96E-05	0.0032	1.13E-06	--	--
MW-14(1)	0.188	6.62E-05	7.26E-04	2.56E-07	--	--
MW-3(2)	--	--	0.75	2.60E-04	--	--
MW-4(2)	--	--	0.27	9.50E-05	--	--
MW-11(2)	--	--	0.37	1.30E-04	--	--
MW-21(2)	--	--	0.46	1.60E-04	5.5	0.028
RW-1(2)	--	--	--	--	54	--
MW-18(2)	--	--	--	--	790	0.014

Note: All data compiled from unrelated Baker Investigations with the MCAS, New River operations area.

(1) AS 527
(2) Campbell Street Fuel Farm
A = Upper Surficial Aquifer
B = Lower Surficial Aquifer

TABLE 3-3

HYDRAULIC PROPERTY ESTIMATES OF THE CASTLE HAYNE AQUIFER
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Hydraulic Properties	USGS Phase I Study[1]	USGS Aquifer Test[2]	ESE, Inc. [3]	DEHNR Aquifer Test[4]	RASA Estimate[5]
Aquifer transmissivity (cubic foot per day per square foot times foot of aquifer thickness)	4,300 to 24,500 average 9,500	1,140 to 1,325	820 to 1,740 average 1,280	900	10,140 to 26,000
Aquifer hydraulic conductivity (foot per day)	14 to 82 average 35	20 to 60	--	18 to 91 average 54	45 to 80 average 65
Aquifer storage coefficient (dimensionless)	--	0.0002 to 0.00022	0.0005 to 0.001 average 0.0008	0.0019	--
Confining-unit vertical hydraulic conductivity (foot per day)	--	0.03 to 0.41	0.0014 to 0.051 average 0.0035	--	--

Note:

(1) Analysis of specific capacity data from Harned and others (1989).
(2) Aquifer test at well HP-708.
(3) Aquifer test at Hadnot Point well HP-462 from Environmental Sciences and Engineering, Inc. (1988).
(4) Unpublished aquifer test data at well X24s2x, from DEHNR well records (1985).
(5) Transmissivities based on range of aquifer thickness and average hydraulic conductivity from Winner and Coble (1989).

Source: Cardinell, et al., 1993.

TABLE 3-4

SUMMARY OF WATER LEVEL MEASUREMENTS FROM MONITORING WELLS ON DECEMBER 11, 1994, MARCH 27, 1995, AND JULY 30, 1995
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
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) (03/27/95)	Groundwater Elevation (feet, above msl) (03/27/95)	Depth to Groundwater (feet, below top of casing) (07/30/95)	Groundwater Elevation (feet, above msl) (07/30/95)	Depth to Groundwater (feet, below top of casing) (12/14/95)	Groundwater Elevation (feet, above msl) (12/14/95)
Shallow Wells									
80-MW01	18.85	16.33	2.52	14.77	4.08	16.22	2.63	14.15	4.7
80-MW02	19.49	17.33	2.16	15.79	3.70	17.12	2.37	17.00	2.49
80-MW03	17.70	14.36	3.34	12.00	5.70	14.10	3.60	14.22	3.48
80-MW04	16.07	13.25	2.82	11.74	4.33	13.54	2.53	13.10	2.97
80-MW05	18.54	15.94	2.60	14.22	4.32	15.74	2.80	14.7	3.84
80-MW06	19.42	16.73	2.69	15.01	4.41	16.60	2.82	16.35	3.07
80-MW07	18.49	15.38	3.11	13.2	5.29	15.16	3.33	14.7	3.79
80-MW08	17.33	NA	NA	NA	NA	15.02	2.31	14.5	2.83
Intermediate Well									
80-MW03IW	16.98	14.4	2.58	12.96	4.02	15.11	1.87	14.10	2.88

NOTES: [1] Mean Sea Level (msl)
NA - Not Applicable

TABLE 3-5

AQUIFER HYDRAULIC CHARACTERISTICS
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity (K) (feet/day)	Hydraulic Gradient (i) (feet/feet)	Effective Porosity[1] (n_e)	Groundwater Velocity (V) (feet/day)
Shallow Wells				
80-MW04 (Rising Head)	51.11	0.003	0.35	0.46
80-MW04 (Falling Head)	1.71	0.003	0.35	0.02
80-MW05	79.24	0.003	0.35	0.71
80-MW06	3.92	0.003	0.35	0.04
80-MW07	7.84	0.003	0.35	0.07
Average	28	0.003	0.35	0.26
Intermediate Wells				
80-MW03IW (Falling Head)	1.44	-	-	-
80-MW03IW (Rising Head)	30.24	-	-	-
Average	15.84	-	-	-

[1] Freeze/Cheery, 1979

TABLE 3-6

LAND UTILIZATION: DEVELOPED AREAS ACRES/LAND USE (PERCENT)
OPERABLE UNIT NO. 11 (SITE 80)
PARADISE POINT GOLF COURSE MAINTENANCE AREA
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)**

Notes:

CM = Community Development
CO = Commercial Development

TABLE 3-7

CLIMATIC DATA SUMMARY
MARINE CORPS AIR STATION, NEW RIVER
OPERABLE UNIT NO. 11 (SITE 80)
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 3-8

SUMMARY OF WATER SUPPLY WELLS WITHIN A ONE-MILE RADIUS OF SITE 80[1]
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	USGS Identification Number	Total Depth (feet)	Screened Intervals (feet)	In/Out of Service[2]	Analytical Data[2]	Approximate Distance/ Direction from Site[3] (feet)
Site 80: HP-701	3442330772204.1	110	70-100	In	No Organics Detected	5150/southeast
ON-T2-87	3442410772240.1	260	Unknown	Out	NA	4750/southeast

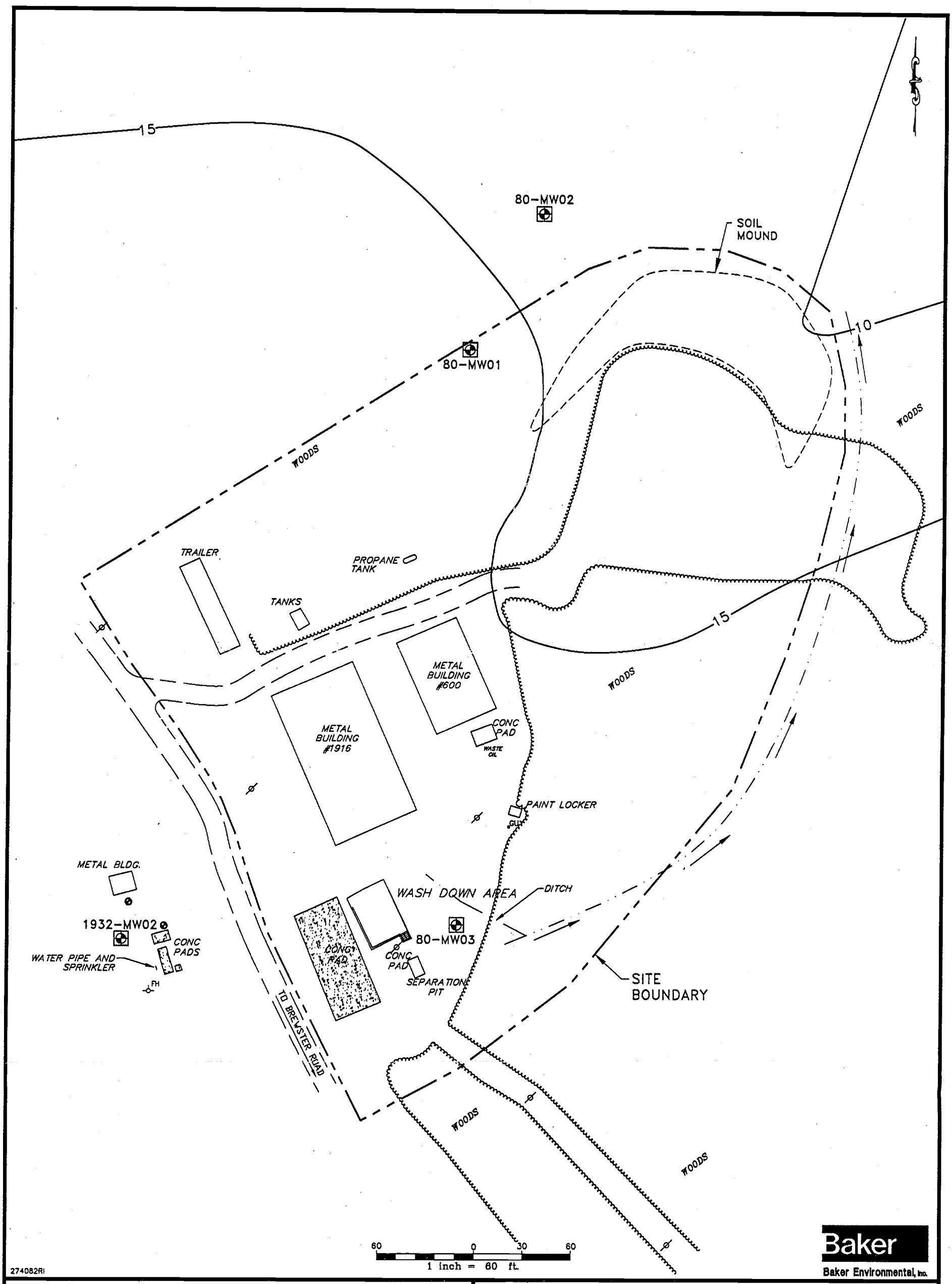
Notes: [1] Information obtained from "Assessment of Hydrogeologic and Hydraulic Data at Camp Lejeune Marine Corps Base, North Carolina," 1989.

[2] As per Greenhorne & O'Mara, Inc. Draft Report Wellhead Monitoring Study, December, 1992

[3] Distance measured from site location mark on Figure 3-10.

NA = Not applicable

SECTION 3.0 FIGURES



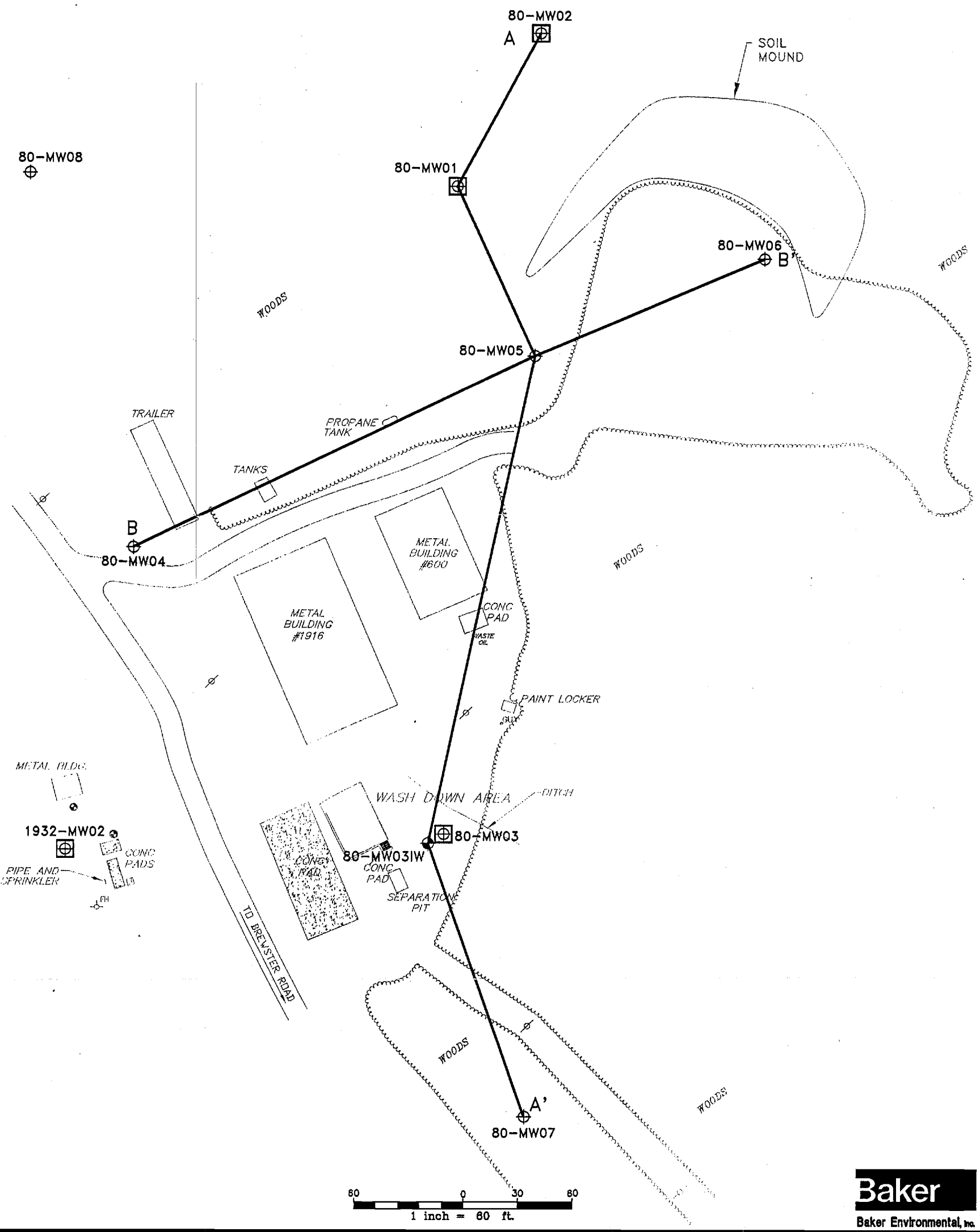
LEGEND

- 80-MW01 — EXISTING SHALLOW MONITORING WELL LOCATION
- —15— TOPOGRAPHIC ELEVATION LINES (FEET, MSL)
- IMPROVED ROAD
- DRAINAGE DITCH
- APPARENT FLOW DIRECTION OF DITCH
- UTILITY POLE
- WOODS LINE

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

FIGURE 3-1
TOPOGRAPHY AND SITE FEATURES
SITE 80 – PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA

01697X B2Z



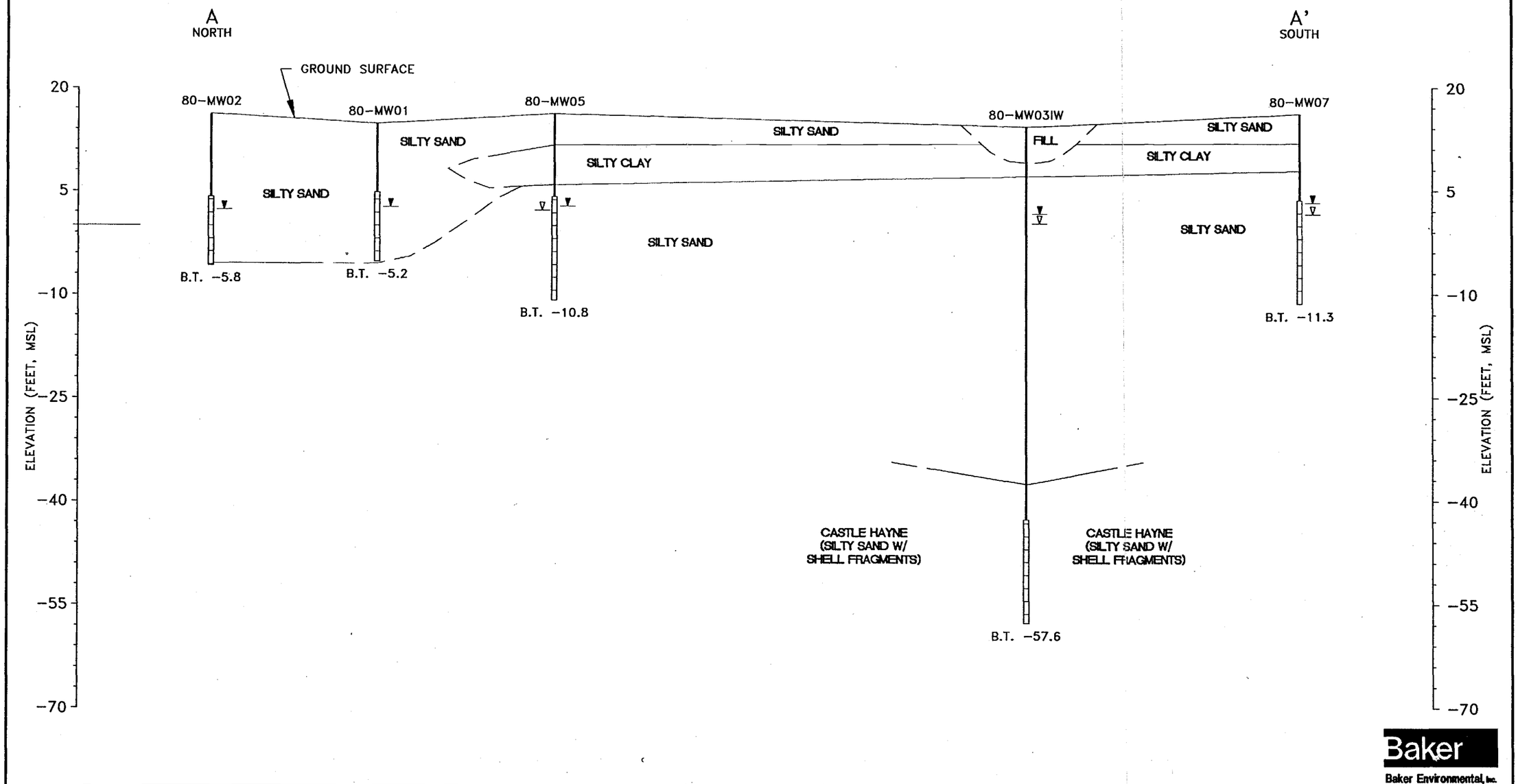
LEGEND

- 80-MW01 — EXISTING SHALLOW MONITORING WELL LOCATION
- 80-MW04 — NEWLY INSTALLED SHALLOW MONITORING WELL LOCATION
- 80-MW03IW — NEWLY INSTALLED INTERMEDIATE MONITORING WELL LOCATION

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

FIGURE 3-2
CROSS-SECTION LOCATION MAP
SITE 80 - PARADISE POINT
GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA

274016RI



Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION (7-30-95)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. -3.8 BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

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

15 0 7.5 15 30
Vertical Scale: 1 inch = 15 ft.

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

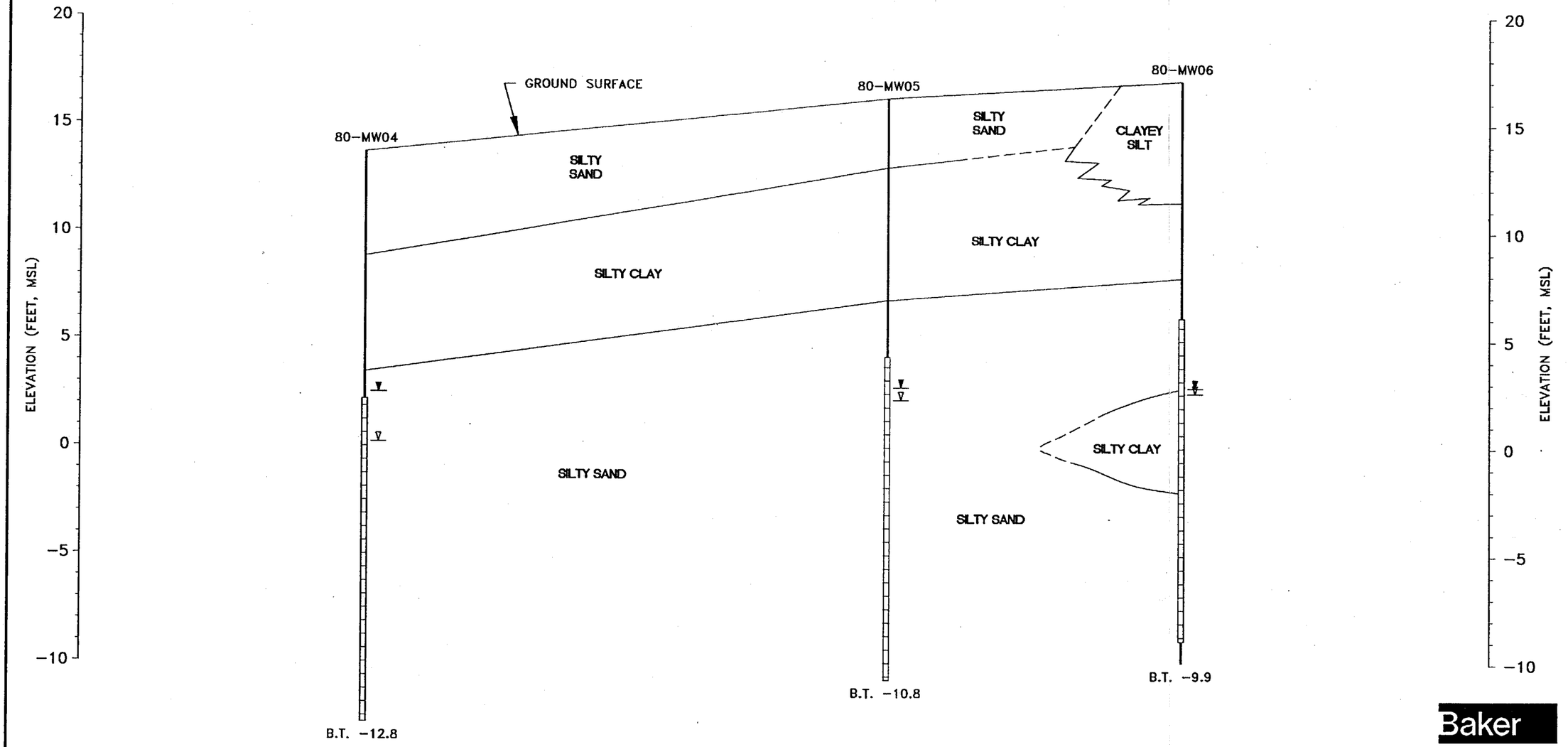
FIGURE 3-3
HYDROGEOLOGIC CROSS-SECTION A-A'
SITE 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

274017RI

B
WEST

B'
EAST



LEGEND

- GROUNDWATER ELEVATION (7/30/95)
- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. −10.0 BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

50 0 25 50 100
Horizontal Scale: 1 inch = 50 ft.

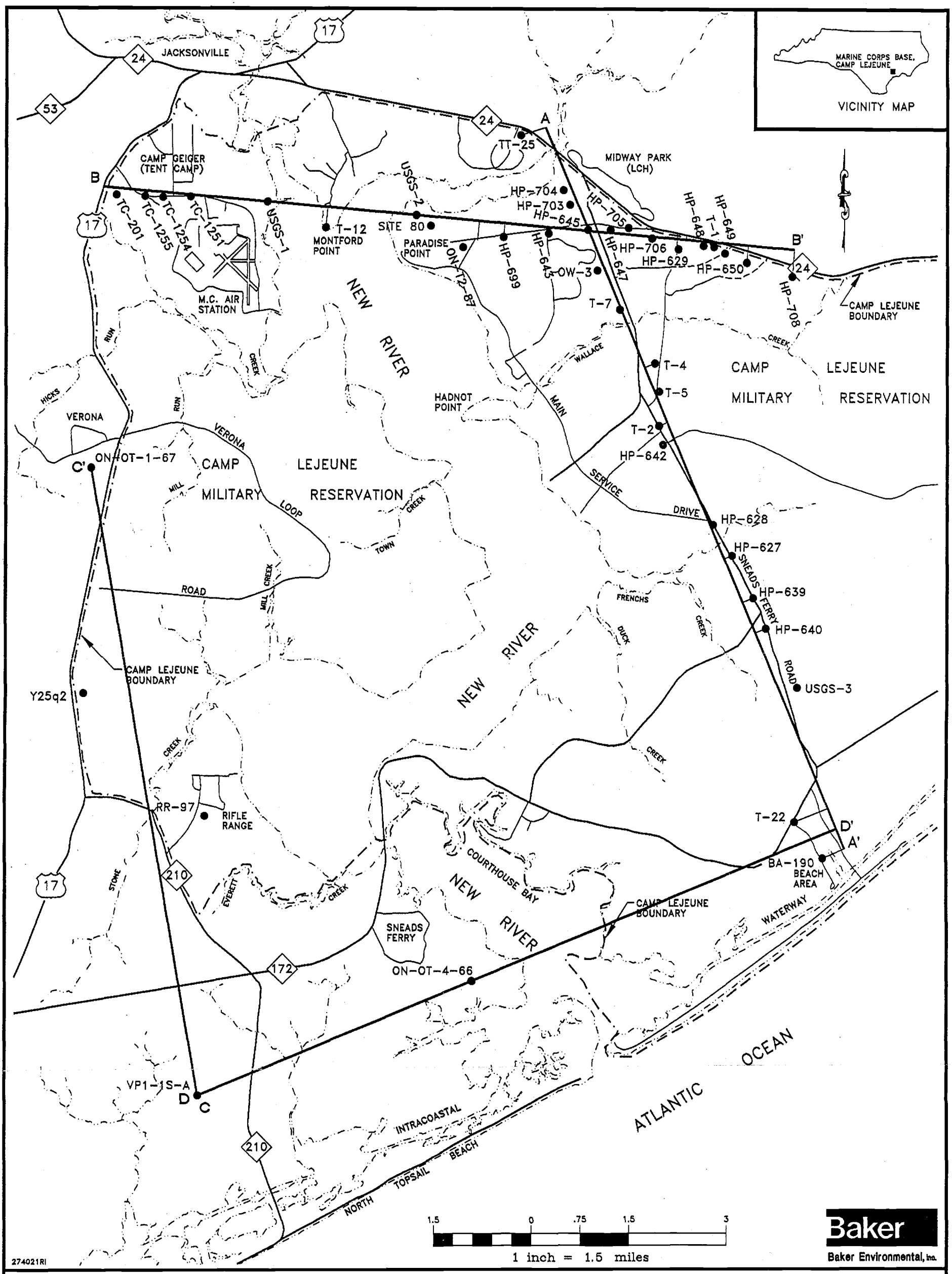
5 0 2.5 5 10
Vertical Scale: 1 inch = 5 ft.

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

Baker
Baker Environmental, Inc.

FIGURE 3−4
HYDROGEOLOGIC CROSS−SECTION B−B'
SITE 80 − PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO−0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



SOURCE: DEPT. OF INTERIOR, WATER-RESOURCES INVESTIGATIONS REPORT, 89-4096, PLATE 4

FIGURE 3-5
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

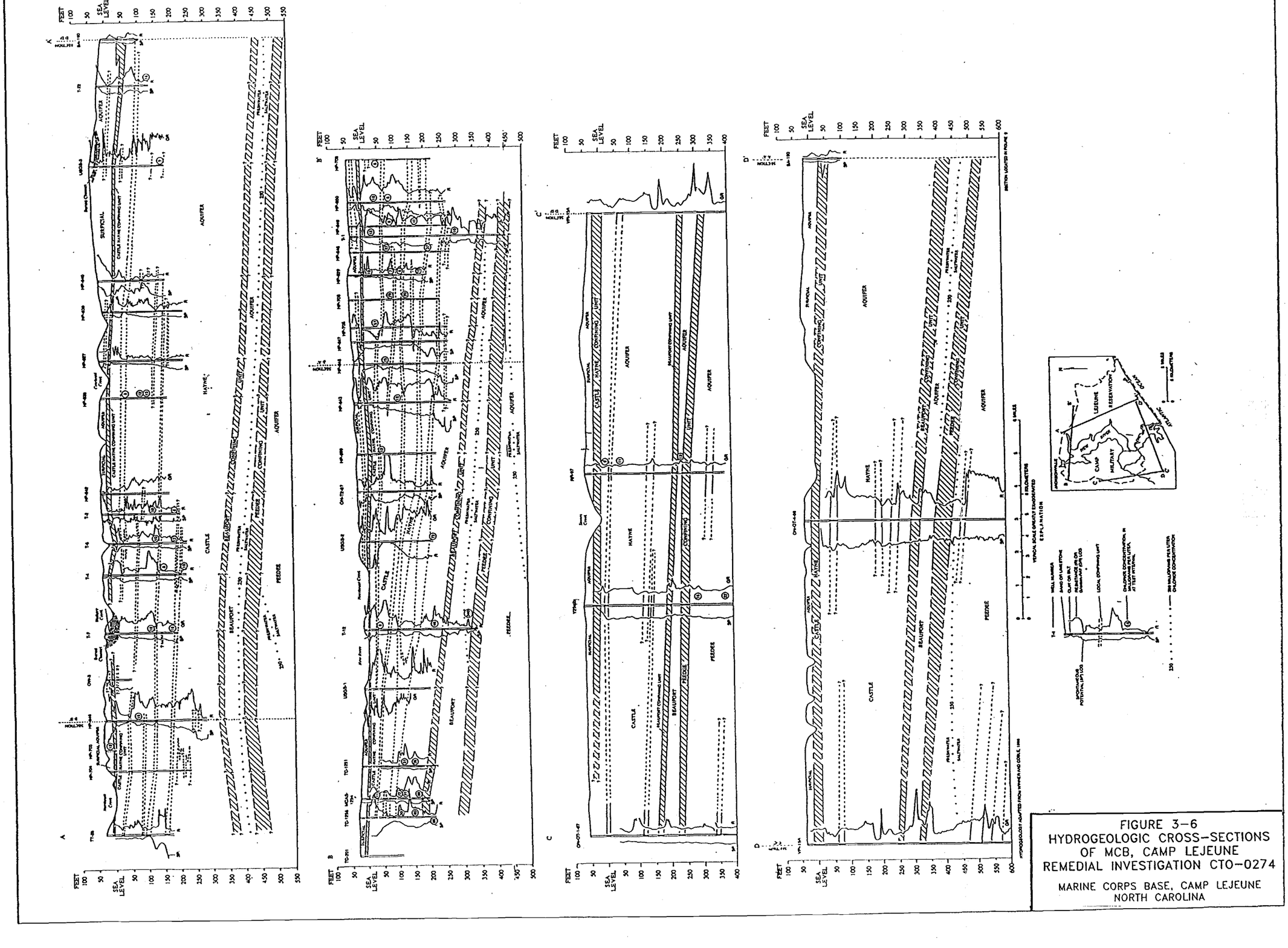
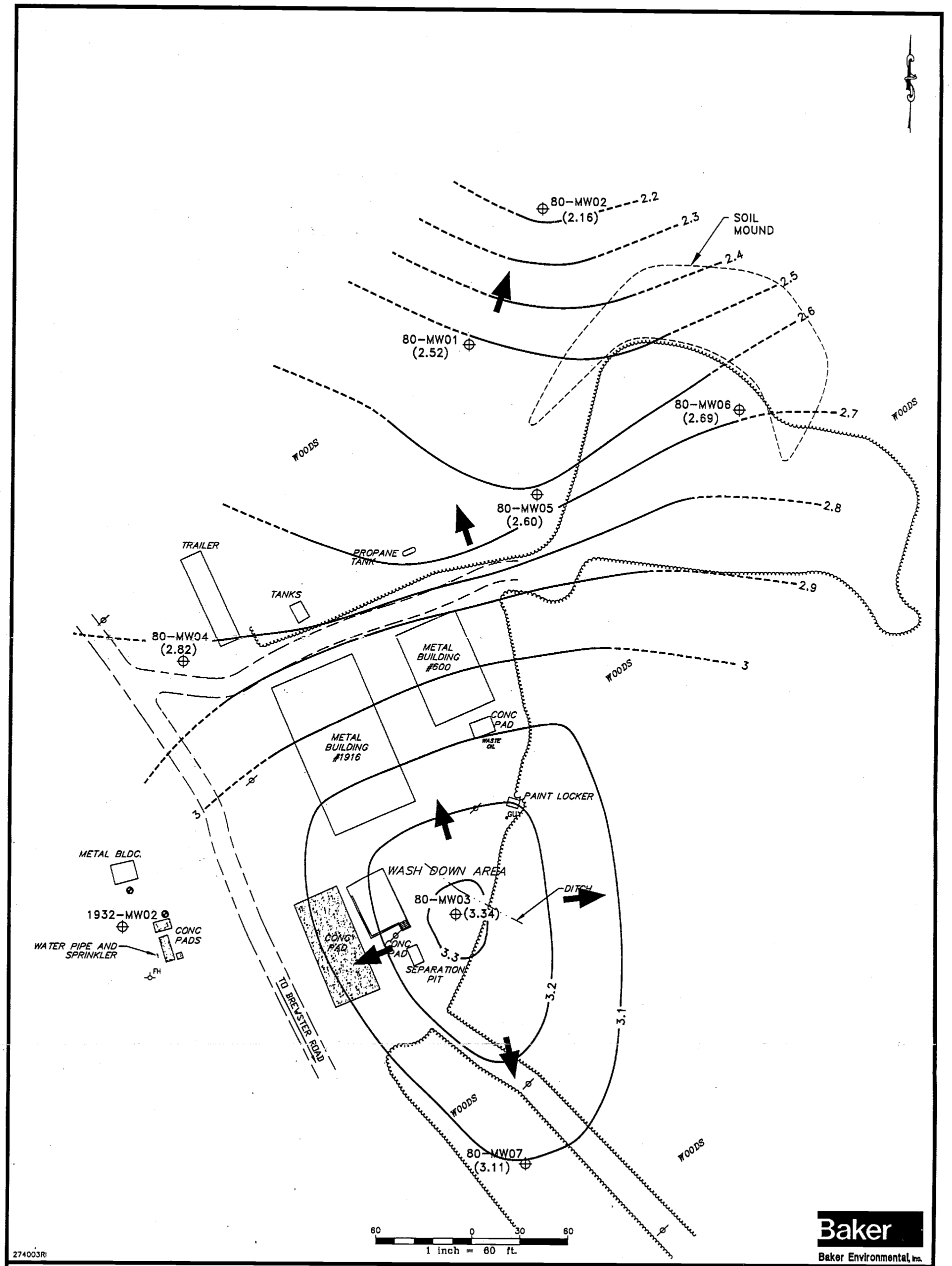


FIGURE 3-6
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

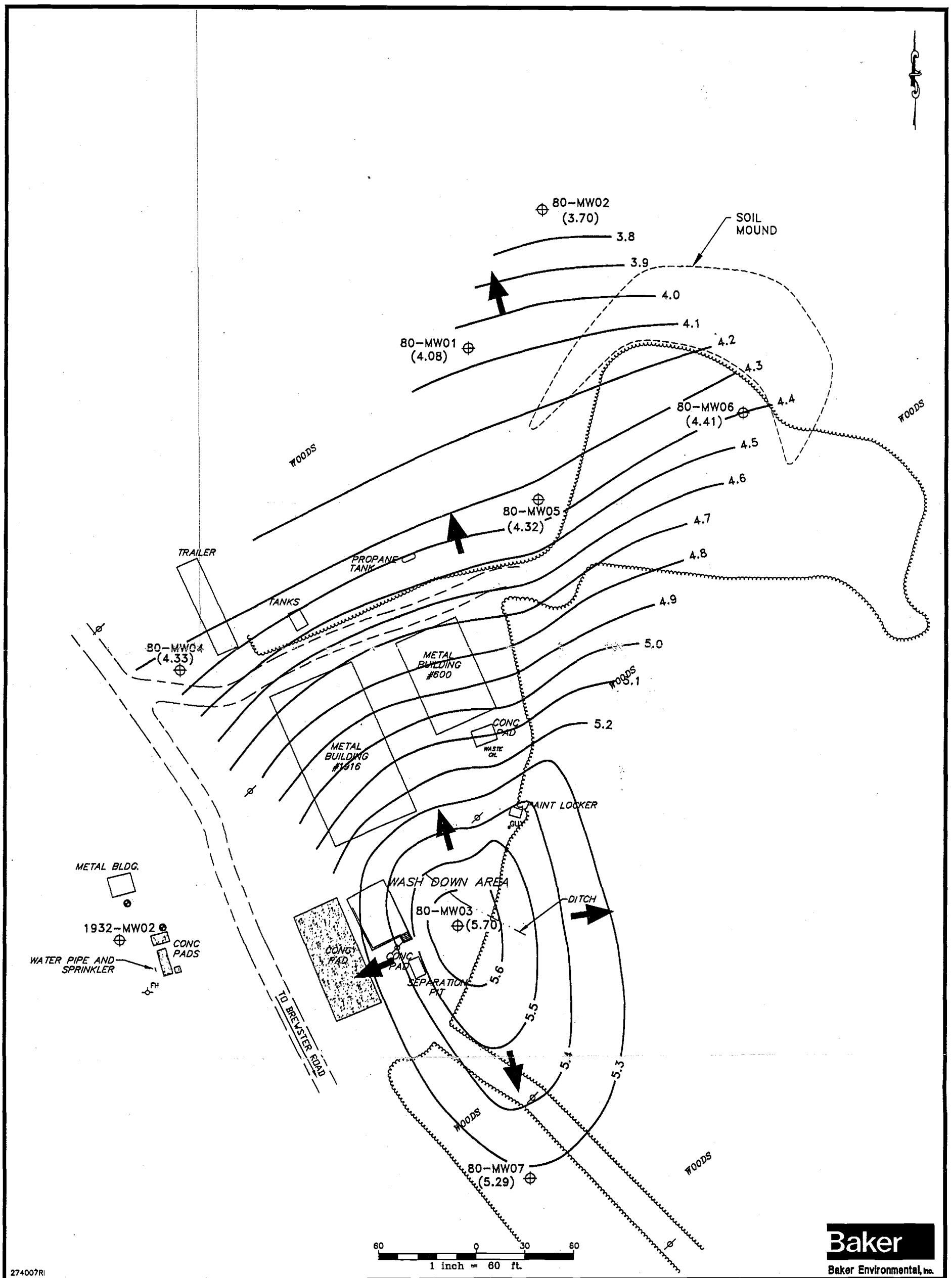


LEGEND

80-MW01 ⊕	EXISTING SHALLOW MONITORING WELL
(2.52)	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 80 – PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA

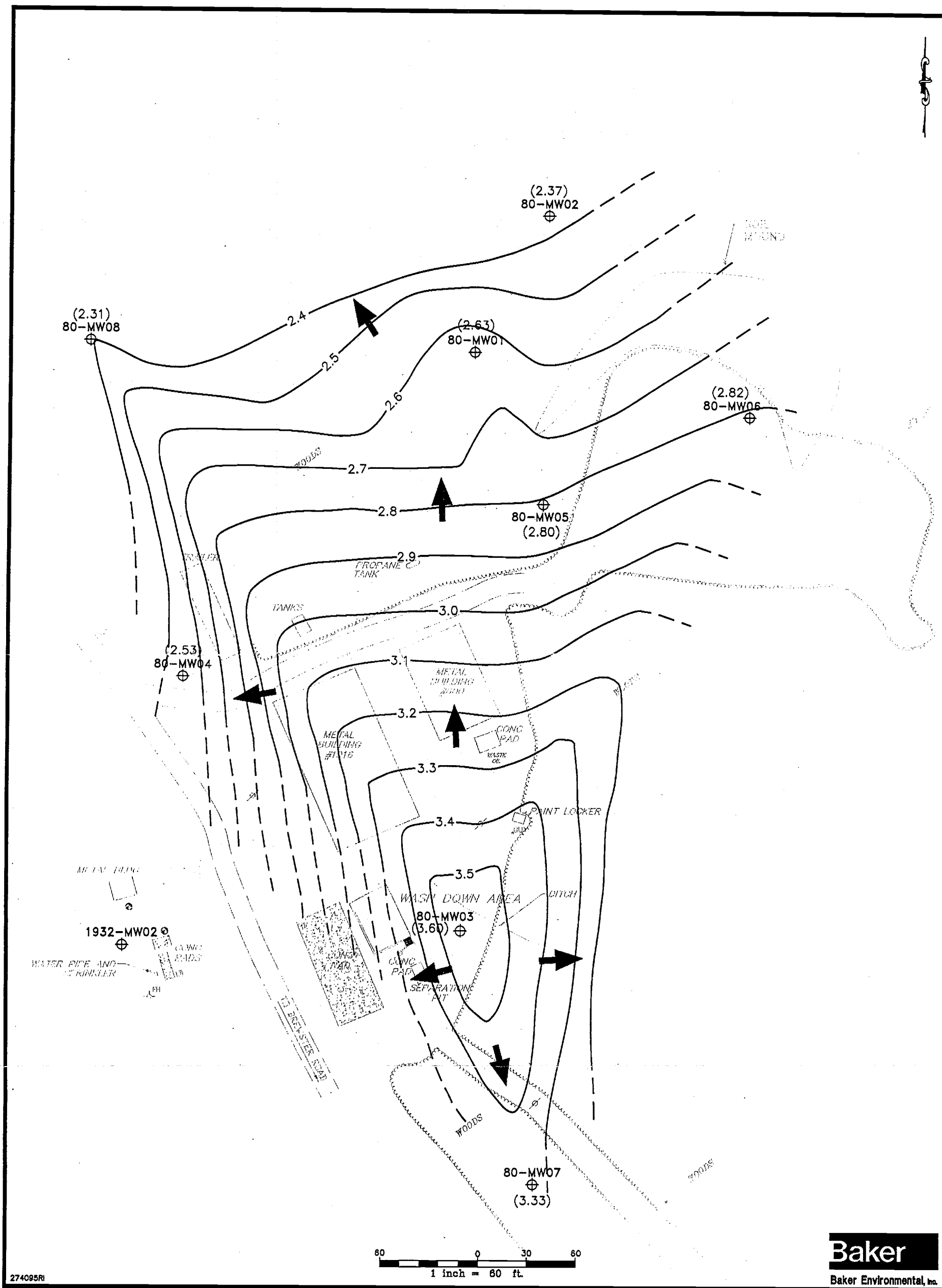


LEGEND

80-MW01 ⊕	EXISTING SHALLOW MONITORING WELL
(4.08)	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, 1995
SITE 80 – PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA

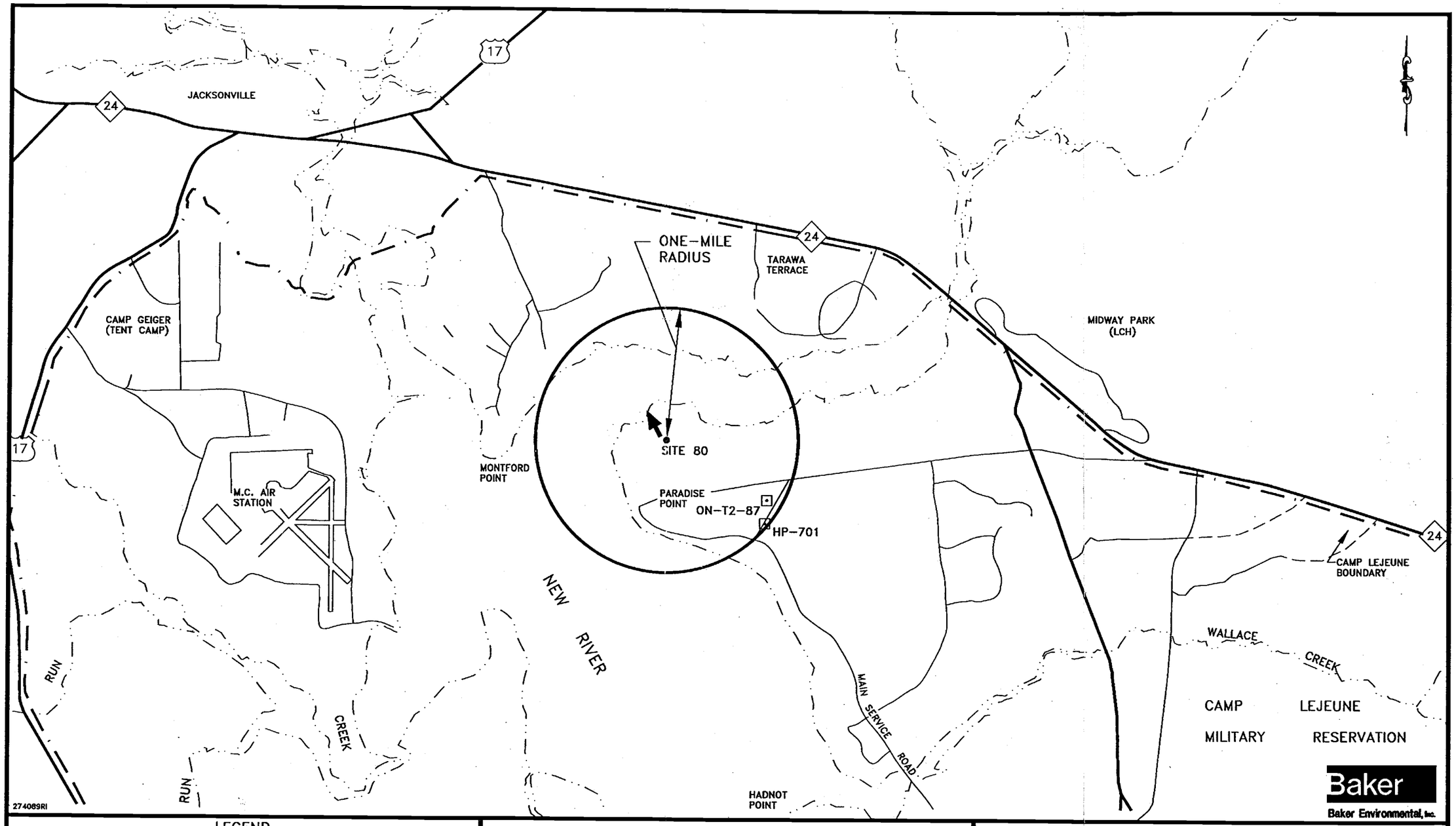


LEGEND

- 80-MW01 ⊕ — EXISTING SHALLOW MONITORING WELL LOCATION
- (2.63) — GROUNDWATER ELEVATION (FEET, MSL)
- —2.4— — GROUNDWATER ELEVATION CONTOUR
- — — — GROUNDWATER ELEVATION CONTOUR – INFERRED
- ➡ — GROUNDWATER FLOW DIRECTION

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

FIGURE 3-9
SHALLOW GROUNDWATER ELEVATION CONTOUR MAP – JULY 30, 1995
SITE 80 – PARADISE POINT
GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP, LEJEUNE
NORTH CAROLINA



LEGEND

T-12 WATER SUPPLY WELL

GROUNDWATER FLOW DIRECTION IN SURFICIAL AQUIFER

.75 0 .375 .75

1 INCH = .75 MILES

FIGURE 3-10
WATER SUPPLY WELL LOCATIONS - SITE 80
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents and evaluates the analytical results of the Remedial Investigation (RI) performed at Operable Unit (OU) No. 11, Site 80. The objectives of the section are to characterize the nature and extent of contamination at Site 80. This characterization was accomplished through environmental sample collection and laboratory analysis of soil and groundwater. The positive detection summary tables and 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 were 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 10,900 separate contaminants were included in the Site 80 RI. No data were rejected as unusable.

Additional data qualifiers were employed during the validation of data. The "NJ" qualifier denotes that a contaminant was tentatively identified, but the reported value may not be accurate or precise. Contaminants which were not detected and had inaccurate or imprecise quantitation limits were assigned the "UJ" qualifier. The "U" qualifier denotes that a contaminant was not detected at a concentration above the CRDL or CRQL. Data tables presented in Section 4.0 are for positive detections; therefore, contaminants that are not detected are shown as "ND".

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-Related Analytical Results

Many of the organic and inorganic constituents detected in soil and groundwater at Site 80 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 80 is provided in the following subsections.

4.2.1 Laboratory Contaminants

Blank samples (i.e., rinsate and 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 130J µg/L
- methylene chloride 14 µg/L
- 2-butanone 10 µg/L

Organic constituents contained in blanks that were 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:

- 1,2-dichloroethane 2J µg/L
- tetrachloroethene 3J 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

The following subsections address the various comparison criteria used to evaluate the analytical results from soil and groundwater samples collected at Site 80.

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. It is probable that organic contaminants, except for those organics associated with laboratory and/or field procedure (i.e., acetone, methylene chloride or phthalates), detected in the surface and subsurface soil are attributable to activities which have or are currently taking place within or surrounding the study area.

Typical 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 (80-MW07) was installed in an apparent upgradient direction, based on information from the IAS (Water and Air Research, 1983), to assess background groundwater conditions at Site 80. Based on current data (refer to Section 3.4.2) there is a groundwater mound centered in the lawn area of Site 80. Monitoring well 80-MW07 is actually in a downgradient direction from the main area of the site; however, the predominant groundwater flow direction is towards the north/northwest.

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 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 (i.e., unimpacted by human activities), 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 actually serve as control samples. The data collected from these control 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, Department of the Navy, Atlantic Division Naval Facilities Engineering Command.

Groundwater samples were analyzed for total and dissolved (i.e., "unfiltered" and "filtered") 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. 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 MCLs and NCWQS of 300 and 50 µg/L, respectively. Elevated levels of iron and manganese, at concentrations above the MCLs 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 80 exceeded the MCLs and NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. A potential concern with comparing the results of the base evaluation of metals in groundwater with new site results obtained from the "low-flow" purging and sampling is the difference in techniques. An intrinsic high bias in the base background levels exists because the bailed samples will have a high suspended solids content. The "low-flow" technique has shown consistently lower solids content with the associated lower total metals concentrations. Comparison between recent analytical results and the base background levels from the 1994 report should not necessarily be taken as conclusive because of the difference in sampling techniques. The results in the 1994 report does illustrate the effects of suspended solids in groundwater samples on total inorganics analyses. There is no record of any historical use of iron and manganese at Site 80. 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.

4.3 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. Regulatory guidelines were used for comparative purposes to infer the potential health risks and environmental impacts when necessary.

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 Site 80, are attributable to the practices which have or are currently taking place within the areas of concern. Additionally, in order to evaluate soil concentrations, the risk-based concentrations (RBCs) for residential soil ingestion developed by USEPA (Region III) were used as guidance criteria to evaluate soil concentrations. The RBCs were used as a benchmark for evaluating site investigation data and to assist in predicting single-contaminant health risks. These values were used in conjunction with other criteria in the selection of the COPCs.

A brief explanation of the criteria and standards used for the comparison of site groundwater 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.

4.4 Analytical Results

The analytical results of the soil and groundwater sampling performed at Site 80 are presented in the following sections. Summaries of site contamination, by media, are provided in Tables 4-3 through 4-5. The data and frequency summaries for all media at Site 80 are presented in Appendix H.

4.4.1 Soil Investigation

Surface soil positive detection summaries for organics and inorganics are presented in Tables 4-6 and 4-7, respectively. Positive detection summary tables for organics and inorganics in subsurface soils are presented in Tables 4-8 and 4-9, respectively.

Thirty-four surface and thirty-two subsurface soil samples submitted for analysis were analyzed for full TCL organics and TAL inorganics, using CLP protocols and Level IV data quality. Twenty-one surface and thirteen subsurface soil samples were submitted only for pesticide analysis from the detected pesticide area in the west/northwest section of the site.

4.4.1.1 Surface Soil

A total of 55 surface soil samples were collected and submitted from the lawn area, maintenance area, drum area, open area, soil mounds, detected pesticide area, and monitoring well locations at Site 80. Table 4-3 indicates that the only volatile detected was acetone in one surface soil sample. The highest concentration of acetone detected in a rinsate blank was 780 µg/L. The detected concentration of acetone in the surface soil sample at location 80-MW05 was 28 µg/kg, which is less than 10 times the highest QA/QC blank concentration. This low concentration detected in the surface soil sample indicates that acetone is not considered a site related contaminant, but a laboratory or field procedure contaminant.

The predominant semivolatiles detected in the surface soil at Site 80 included polynuclear aromatic hydrocarbons (PAH) compounds; phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)pyrene and benzo(a)pyrene. Sample 80-SM-SB04 exhibited the greatest number and maximum concentrations of PAHs. Phthalate esters were also detected in surface soil. Di-n-butylphthalate was detected in 20 of 34 samples with a concentration range of 60J µg/kg to 4400 µg/kg (80-MW03IW). Butyl benzyl phthalate and bis(2-ethylhexyl)phthalate were also detected in surface soil samples. The 12 semivolatiles detected in the surface soil would be considered site related contaminants as no semivolatiles were detected in the QA/QC blanks. Table 4-3 shows that specific semivolatiles were detected at few locations.

Pesticides appear to be the predominant contaminants at Site 80. Six of the eleven pesticides detected in surface soils at Site 80 were in at least 20 of the 55 samples analyzed. These pesticides were dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. Concentrations for pesticides ranged from 0.6J µg/kg (4,4'-DDE, location 80-OA-SB04) to 260,000 µg/kg (4,4'-DDD, location 80-DPA-SB03). The highest concentrations for most pesticides were exhibited in the detected pesticide area in the west/northwest section of the site.

Twenty-two of 23 inorganics (antimony was not detected) were detected in surface soils at Site 80. Concentrations were within one order of magnitude (or less) of base background levels (refer to Appendix F for a summary of base background concentrations of inorganics in soils at MCB, Camp Lejeune). A summary of detected inorganics and concentrations, and a comparison to base background levels for surface soils is presented in Table 4-3.

4.4.1.2 Subsurface Soils

Forty-five subsurface soil samples were submitted for analysis. Table 4-4 summarizes the analytical results for the subsurface soils. The only volatiles detected in subsurface soils were acetone and carbon disulfide. Acetone was detected in 4 samples at concentrations ranging from 11J µg/kg (80-OA-SB04, 5 to 7 feet) to 110J µg/kg (80-MW03IW, 5 to 7 feet). These concentrations were less than 10 times the highest concentration detected in QA/QC blanks. Carbon disulfide was detected in one subsurface soil sample (80-SM-SB02, 5 to 7 feet) at a concentration of 13 µg/kg. Carbon disulfide was not detected in any of the QA/QC blanks.

Four semivolatile organic compounds were detected in subsurface soils at Site 80. Three phthalate esters [di-n-butylphthalate, butyl benzyl phthalate and bis(2-ethylhexyl)phthalate] were detected in subsurface soil at concentrations ranging from 46J µg/kg [butyl benzyl phthalate (80-MW03IW, 5 to 7 feet)] to 3100 µg/kg [di-n-butylphthalate (80-MW03IW, 5 to 7 feet)]. Di-n-butylphthalate was detected in 17 of 32 subsurface soil samples submitted for analysis, and at the maximum concentration for phthalate esters for subsurface soils. The only other semivolatile detected in subsurface soils was the PAH constituent phenanthrene in one sample at a concentration of 53J µg/kg (80-MW03IW, 5 to 7 feet). Neither phenanthrene nor the phthalate esters were detected in QA/QC blanks.

Six pesticides were detected in subsurface soil at Site 80. Delta-BHC and aldrin were each detected in only one subsurface soil sample at concentrations of 0.63 µg/kg and 2.6 µg/kg, respectively. Dieldrin was detected in four subsurface soil samples at concentrations ranging from 0.73J µg/kg (80-MW05, 11 to 13 feet) to 1.4J µg/kg (80-OA-SB02, 13 to 15 feet). 4,4'-DDE was detected in seven subsurface soil samples at concentrations ranging from 1.4J µg/kg (80-SM-SB09, 5 to 7 feet) to 35 µg/kg (80-OA-SB02, 13 to 15 feet). 4,4'-DDD was the most frequently detected pesticide (12 of 45 samples) and exhibited the highest pesticide concentration (510J µg/kg, 80-MW04 at 11 to 13 feet). The maximum concentration for 4,4'-DDT (240 µg/kg) was also detected in sample 80-MW04 (11 to 13 feet).

Twenty of 23 inorganics (cadmium, silver, and thallium were not detected) were detected in the subsurface soils at Site 80. Arsenic, barium, chromium, manganese, mercury, and selenium exhibited concentrations above base background levels for inorganics in subsurface soils at only one location each. Concentrations were less than an order of magnitude different from the base background levels.

4.4.2 Groundwater Investigation

Two rounds of groundwater samples were collected from the eight shallow wells and one intermediate (upper portion of the Castle Hayne aquifer) well installed at the Paradise Point Golf Course Maintenance Area. Seven of the shallow wells and the intermediate well, which were sampled in December 1994, were analyzed for TCL organics and TAL metals (total and dissolved) using CLP protocols and Level IV data quality. The additional well installed in June 1995 was

sampled in July 1995 for TCL pesticides using CLP protocols and Level IV data quality, with the results included as part of the Round One analytical results. In December 1995 groundwater samples were collected from eight shallow wells and one intermediate well. All groundwater samples were analyzed for TAL total metals only. Table 4-5 summarizes the detected contaminants, minimum and maximum concentrations, location of the maximum concentration, applicable standards and criteria, frequency of detection, and detections above comparison criteria. Positive detection summaries for Round One TCL organics and TAL metals (total and dissolved) and Round Two TAL total metals are presented in Tables 4-10, 4-11, 4-12 and 4-12A, respectively.

4.4.2.1 Shallow Groundwater

The only volatile detected in the shallow groundwater was carbon disulfide at a concentration of 1J µg/L (80-MW03). No Federal standard exists for this contaminant; however, the NCDEHNR has established an interim maximum allowable concentration of 700 µg/L. Carbon disulfide was not detected in QA/QC blanks.

Semivolatiles were detected at low levels in a limited number of shallow groundwater monitoring wells at Site 80. These semivolatiles included the polynuclear aromatic hydrocarbons (PAHs) acenaphthene, fluorene, carbozole, and pyrene. These contaminants were detected in well 80-MW03, located within the lawn area. NCDEHNR has established interim maximum allowable concentrations for acenaphthene (80 µg/L) and pyrene (210 µg/L). Acenaphthene was detected at a concentration of 4J µg/L and pyrene was detected at 1J µg/L. Fluorene was detected at a concentration of 3J µg/L, with an NCWQS of 280 µg/L. Bis(2-ethylhexyl)phthalate was detected in three samples above the NCWQS of 3 µg/L, at a maximum concentration of 5J µg/L. Di-n-octylphthalate was detected at a concentration of 1J µg/L in well 80-MW02. The NCWQS for di-n-octylphthalate is 140 µg/L. Well 80-MW03 exhibited a dibenzofuran concentration of 2J µg/L (no Federal or State standard exists for this contaminant). No semivolatiles were detected in QA/QC blanks.

The pesticides 4,4'-DDD and 4,4'-DDT were detected in monitoring well 80-MW04 at low levels (2.2J µg/L and 0.58J µg/L, respectively). No Federal and/or State standards exist for these pesticides.

During Round One 17 of 23 TAL total metals were detected in the shallow groundwater at Site 80. Concentrations for total metals were within an order of magnitude or less of the dissolved metal concentrations. Aluminum, arsenic, chromium, iron, lead, and manganese were detected above their respective Federal and/or State standards, generally within an order of magnitude or less. Total metal concentrations in the shallow groundwater at Site 80 were within the ranges for metals determined for MCB Camp Lejeune (refer to Appendix G).

During Round Two 17 of the 23 TAL total metals were detected in the shallow groundwater at Site 80. Concentrations of iron, manganese, and thallium were detected above their respective Federal and/or State standards, generally within an order of magnitude or less.

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.).

4.4.2.2 Upper Castle Hayne

No organics were detected in the intermediate well installed in the lawn area at the golf course maintenance area.

Total metals were not detected in intermediate well 80-MW03IW; however, six dissolved metals were detected. These metals included barium, calcium, magnesium, manganese, potassium, and sodium. None of these dissolved metals were detected above Federal and/or State standards.

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 the intermediate well, which is representative of groundwater conditions following purging, pH value was 7.5 s.u., specific conductance value was 469 micromhos/cm, and the temperature was 19° C. Turbidity value was recorded as 2.6 NTU. 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 within the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.).

4.4.3 Quality Assurance/Quality Control

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

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 5 of 10 samples at concentrations ranging from 5J µg/L to 780J µg/L. Methylene chloride was detected in 5 of 10 QA/QC samples with concentrations ranging from 1J µg/L to 14 µg/L. Eight of 23 TAL metals were detected in QA/QC samples, with zinc being quantified with J qualifiers.

4.5 Extent of Contamination

4.5.1 Soil Investigation

4.5.1.1 Surface Soil

Figure 4-1 presents the positive detections of organic compounds in surface soils for Site 80. Figure 4-2 presents the positive detections of pesticides for the detected pesticide area in the west/northwest section of the site.

Acetone was the only volatile organic detected in the surface soil. Acetone was detected in surface soil samples at concentrations less than ten times the maximum detected concentration in QA/QC blanks. Because it was detected at less than 10 times the maximum concentration detected in QA/QC blanks, acetone is not considered a site related constituent.

Phthalate esters were the predominant semivolatile detected in the surface soil at Site 80. Di-n-butylphthalate was detected the most frequently and exhibited the highest concentrations. Bis(2-ethylhexyl)phthalate was also detected but less frequently and at concentrations one order of magnitude lower than di-n-butylphthalate. Butyl benzyl phthalate was detected in one sample at a low concentration (less than 100 µg/kg). Phthalate esters were not detected in QA/QC blanks. A source for these contaminants has not been identified. Phthalate esters are associated with rubber and plastics, and are components of the gloves used in the field for health and safety requirements, and in laboratories equipment. Eventhough these compounds were not detected in the QA/QC blanks, the source may be contamination from field and laboratory equipment

PAH constituents were also detected in the surface soil. These constituents were detected infrequently and at low levels (less than 100 µg/kg). PAH constituents were not detected in QA/QC blanks and may be related to current or past activities or practices at the site. The location with the most PAH constituents and the highest PAH concentrations was in the soil mound in the northeast area of the site. This is near the open area where burning operations of wood and leaves have taken place and is currently being carried out. The burning operations may be the source of the PAH concentrations detected in this area. Isolated individual PAH constituents were detected at few locations in the remainder of the site. No specific activities or practices have been identified to explain the occurrence of PAHs in other areas of the site.

Pesticides were the most frequently detected organic compounds at Site 80. They also exhibited the highest concentrations of all contaminants. Pesticides were detected in nearly all surface soil samples. The highest pesticide concentrations were detected in the detected pesticide area in the west/northwest section of the site. This area was investigated to further determine the extent of pesticide contamination in the surface soil following detection of high levels of pesticides in the surface soil at well location 80-MW04 during the initial field investigation. Elevated levels of pesticides were also detected in the lawn area where it was reported that the mixing and storing activities had taken place. Pesticide concentrations in the lawn area were one to three orders of magnitude lower than in the detected pesticide area. Pesticides in the other areas of the site were detected up to four orders of magnitude lower than in the detected pesticide area. Pesticide concentrations decreased as sampling progressed to the northwest from the area of well location 80-MW04. Pesticides were mixed and stored at Site 80 to be used as part of the maintenance program for the golf course. Concentrations are higher than base wide concentrations from the historical use of pesticides at MCB, Camp Lejeune (Water and Air Research, 1983).

Inorganics were detected in all areas of the site. Figure 4-3 presents the concentrations of inorganics above base background levels detected in the surface soil at Site 80. Concentrations detected above base background levels were widespread at site locations. The locations with the highest number of detected inorganics above base background were in the central portion of the site in the maintenance building and lawn areas.

4.5.1.2 Subsurface Soil

Figure 4-4 presents the positive detection of organic compounds in subsurface soil at Site 80. Pesticide concentrations in the subsurface soil in the detected pesticide area at Site 80 are presented on Figure 4-5.

Acetone was the most frequently detected volatile in the subsurface soil. Acetone was detected in QA/QC blanks. Detected concentrations of acetone in subsurface soil were less than ten times the maximum concentration in QA/QC blanks. Acetone was detected more frequently in subsurface than surface soil and at higher concentrations. Methylene chloride was detected in one sample in background boring 80-BB-SB02 in the southeast area of the site. Methylene chloride was detected in QA/QC blanks and the detected concentration was less than ten times the maximum concentration detected in the QA/QC blanks. Acetone and methylene chloride are not considered site related contaminants. Carbon disulfide was detected in one subsurface soil sample in the soil mound area at a low concentration. Carbon disulfide was not detected in QA/QC blanks. A source for this constituent has not been identified. Methylene chloride and carbon disulfide were not detected in the surface soil at Site 80.

Phthalate esters were the most frequently detected semivolatiles in the subsurface soil at Site 80. Di-n-butylphthalate was detected most frequently and at the highest concentrations. Bis(2-ethylhexyl)phthalate and butyl benzyl phthalate were also detected but infrequently and at lower concentrations (by an order of magnitude). The highest phthalate concentrations were detected in background sample 80-BB-SB01 in the northeast corner of the site. Phthalates were also detected in the other two background borings installed at the site. As noted for the surface soil, phthalate esters are associated with field and laboratory equipment and this may be the source for the detected phthalates in subsurface soil samples. The PAH constituent phenanthrene was detected in one subsurface soil sample in the lawn area of Site 80 at a low level.

Pesticides were the predominant organic contaminants detected in the subsurface soil at Site 80. Concentrations were one to two orders of magnitude less than those reported for the surface soil. Pesticides were detected over the entire site with the highest concentrations detected in the west/northwest section near well 80-MW04. Slightly elevated levels of pesticides were detected over the remainder of the site at similar concentrations. These levels were one to two orders of magnitude lower than in the detected pesticide area. Monitoring well location 80-MW08 (northwest of the site) exhibited the highest pesticide concentrations in subsurface soil. Subsurface soil concentrations were within the same order of magnitude as in surface soil. Well 80-MW08 is located just inside the woods line along the golf course proper (tee area), which would have been treated by maintenance. The RI originally focused on the lawn area as the most probable area for pesticide contamination based on historical records of mixing and storing pesticides, and data from previous investigations (Halliburton NUS, 1991). The pesticide levels detected in the west/northwest section of Site 80 may be the result of localized releases or maintenance activities (i.e., mixing and storage).

The only inorganics detected in the subsurface soil above base background levels were arsenic (80-MW05, 7 to 9 feet), barium (80-MW06, 11 to 13 feet), chromium and selenium (80-LA-SB06, 11 to 13 feet), manganese (80-LA-SB01, 5 to 7 feet), and mercury (80-LA-SB03, 11 to 13 feet). Figure 4-6 presents the detected inorganics above base background levels in subsurface soil at Site 80.

4.5.2 Groundwater Investigation

Shallow Groundwater

Figure 4-7 presents the positive detections of organics above Federal and/or State standards in the shallow groundwater at Site 80. Bis(2-ethylhexyl)phthalate was the only organic detected above Federal and/or State standards. The highest concentration of bis(2-ethylhexyl)phthalate was detected in well 80-MW01 in the north area of the site. Figure 4-7 illustrates that the bis(2-ethylhexyl)phthalate detections are isolated and at low levels which supports the belief that phthalate detections are due to contamination from field and/or laboratory equipment and not associated with site activities. No soil samples were collected from the area of well 80-MW01 during this RI.

For groundwater samples collected during Round One arsenic, chromium, iron, lead and manganese were detected above State and/or Federal standards. Iron, manganese, and thallium were the only metals detected in Round Two groundwater samples that exceeded State and/or Federal standards shown on Figure 4-8 are the exceedences of State and/or Federal groundwater standards from Rounds One and Two. The highest concentration of iron was detected in well 80-MW04 (northwest area of site). Well 80-MW02 (north area of site) exhibited the highest concentrations of chromium and lead. Arsenic and manganese were detected at their highest concentrations in well 80-MW03 (lawn area). Arsenic is a component of some pesticides which may be the source of the arsenic detected in the groundwater at Site 80. The maximum concentration of arsenic was detected in the lawn area where mixing and storage of pesticides occurred. Iron and manganese are naturally occurring inorganics in groundwater at MCB, Camp Lejeune. A specific source for lead and chromium has not been identified. These metals were detected in the surface and subsurface soils and their detection in the shallow groundwater appears to be naturally occurring.

Upper Castle Hayne Aquifer

No organics or total metals were detected in the upper Castle Hayne aquifer. Detected dissolved metal concentrations were below Federal and/or State standards for inorganics in drinking water.

4.6 Summary

Pesticides were the most frequently detected organic compounds and exhibited the highest concentrations in both soil and groundwater. These constituents are associated with past pesticide mixing and storing practices at the golf course maintenance area. The original area associated with pesticides (lawn area) from historical records and past investigations exhibited elevated concentrations; however, the area northwest of well location 80-MW04 exhibited the highest concentrations of pesticides. No specific information is available which would explain the high levels of pesticides associated with this area. It is likely that random spills occurred in this area, based on the elevated pesticide levels in surface soils.

Semivolatiles, primarily phthalate esters, were detected over most of the site. These organic compounds are generally considered field or laboratory contaminants. Bis(2-ethylhexyl)phthalate was the only semivolatile detected above Federal and/or State standards in shallow groundwater at Site 80. PAH constituents were detected in the soil mound, lawn, and central areas of the site in the surface and/or subsurface soil. The highest concentrations were detected in the soil mound near the open area where burning activities of wood debris are carried out. These activities could be the

source of PAH compounds detected in this area. Over the rest of the site, PAHs were only detected as isolated constituents at low levels.

Total metals detected in the shallow groundwater above Federal and/or State standards were iron, manganese, chromium, lead and arsenic. Iron and manganese are naturally occurring metals in the soil and groundwater at MCB, Camp Lejeune. Arsenic is a component in some pesticides and was detected in well 80-MW03 in the lawn area where reported mixing and storing of pesticides have taken place. Lead and chromium were detected in two of the eight shallow wells at Site 80. A specific source for these metals is not known; however, they do occur naturally in shallow groundwater at MCB, Camp Lejeune.

No organics or total metals were detected in the Castle Hayne aquifer.

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.

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. 11 (SITE 80) REMEDIAL INVESTIGATION, CTO - 0274 MCB, CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	2,240 - 7,770	17.7 - 9,570
Antimony	ND	0.33 - 8
Arsenic	ND - 3.2	0.065 - 3.9
Barium	9.9 - 13	0.65 - 20.8
Beryllium	0.02 - 0.1	0.02 - 0.26
Cadmium	ND	0.04 - 0.6
Calcium	239 - 997	4.25 - 10,700
Chromium	1.2 - 10	0.33 - 12.5
Cobalt	ND - 1.3	0.185 - 2.355
Copper	0.92 - 2.2	0.5 - 87.2
Iron	604 - 5,550	69.7 - 9,640
Lead	7.5 - 8.9	0.47 - 142
Magnesium	94.2 - 289	2.55 - 610
Manganese	12.8 - 66	0.87 - 66
Mercury	ND	0.01 - 0.08
Nickel	1.4 - 2.7	0.6 - 3.55
Potassium	ND - 416	1 - 416
Selenium	ND	0.075 - 1.3
Silver	ND	0.0435 - 4.3
Sodium	24.1 - 77.1	4.7 - 126
Vanadium	2.3 - 14.7	0.305 - 18.2
Zinc	3.5 - 12.9	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. 11 (SITE 80) REMEDIAL INVESTIGATION, CTO - 0274 MCB, CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	1,060 - 11,000	16.9 - 11,000
Antimony	ND - 6.2	0.355 - 6.9
Arsenic	ND - 15.4	0.033 - 15.4
Barium	4.3 - 22.3	0.65 - 22.6
Beryllium	ND - 0.31	0.01 - 0.31
Cadmium	ND	0.155 - 1.2
Calcium	34.2 - 323	4.75 - 4,410
Chromium	2.1 - 66.4	0.65 - 66.4
Cobalt	ND - 7	0.175 - 7
Copper	0.63 - 9.5	0.47 - 9.5
Iron	557 - 90,500	63.3 - 90,500
Lead	2.9 - 21.4	0.465 - 21.4
Magnesium	50.7 - 852	2.85 - 852
Manganese	1.8 - 19.9	0.395 - 19.9
Mercury	ND	0.01 - 0.68
Nickel	ND - 2.2	0.45 - 4.7
Potassium	130 - 1,250	1.05 - 1,250
Selenium	ND - 2.4	0.085 - 2.4
Silver	ND	0.175 - 1
Sodium	18.3 - 124	5.4 - 141
Thallium	ND - 2.7	--
Vanadium	2.3 - 69.4	0.34 - 69.4
Zinc	1.7 - 26.6	0.32 - 26.6

ND = Not Detected
"--" Not Available

TABLE 4-3

SUMMARY OF SITE CONTAMINATION - SURFACE SOILS
OPERABLE UNIT NO. 11 (SITE 80)
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	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Surface Soils	Volatile Organic Compounds	Acetone	NE	NE	28	28	80-MW-05-00	1/34	NA	NA	Drum Area
	Semivolatile Organic Compounds	Phenanthrene	NE	NE	100J	100J	80-SM-SB04-00	1/34	NA	NA	Soil Mounds
		di-n-Butyl-phthalate	NE	NE	60J	4,400	80-MW03IW-00	20/34	NA	NA	Open Area and Soil Mounds
		Fluoranthene	NE	NE	100J	100J	80-SM-SB04-00	1/34	NA	NA	Soil Mounds
		Pyrene	NE	NE	60J	92J	80-SM-SB04-00	2/34	NA	NA	Soil Mounds
		Butyl benzyl phthalate	NE	NE	96J	96J	80-SM-SB04-00	1/34	NA	NA	Lawn Area
		Benzo(a)anthracene	NE	NE	47J	47J	80-MW03IW-00	1/34	NA	NA	Soil Mound
		Chrysene	NE	NE	40J	53J	80-SM-SB04-00	2/34	NA	NA	Soil Mound
		bis(2-Ethylhexyl)Phthalate	NE	NE	38J	66J	80-LA-SB01-00	4/34	NA	NA	Lawn Area, Open Area, Soil Mounds
		Benzo(b)fluoranthene	NE	NE	40J	48J	80-MW04-00	2/34	NA	NA	Soil Mounds
		Benzo(k)fluoranthene	NE	NE	38J	38J	80-SM-SB04-00	1/34	NA	NA	Soil Mounds
		Benzo(a)pyrene	NE	NE	43J	43J	80-SM-SB04-00	1/34	NA	NA	Soil Mounds
		Benzo(g,h,i)perylene	NE	NE	180J	180J	80-LA-SB01-00	1/34	NA	NA	Lawn Area
	Pesticides/ PCBs	delta-BHC	NE	NE	1.2J	2.1J	80-DPA-SB13-00	2/55	NA	NA	Open Area, Northwest Area
		Aldrin	NE	NE	5.4	49	80-DPA-SB10-00	7/55	NA	NA	Lawn Area and Open Area, Northwest Area
		Heptachlor Epoxide	NE	NE	2.7J	9.9	80-DPA-SB05-00	2/55	NA	NA	Open Area, Northwest Area
		Dieldrin	NE	NE	1.1J	5,600	80-DPA-SB10-00	38/55	NA	NA	Widespread, Northwest Area
		4,4'-DDE	NE	NE	0.6J	1,500J	80-MW04-00	45/55	NA	NA	Widespread, Northwest Area
		4,4'-DDD	NE	NE	1.5J	260,000	80-DPA-SB03-00	41/55	NA	NA	Widespread, Northwest Area
		4,4'-DDT	NE	NE	1.3J	40,000	80-MW04-00	44/55	NA	NA	Widespread, Northwest Area
		Endrin Ketone	NE	NE	7.7J	7.7J	80-LA-SB07-00	1/55	NA	NA	Lawn Area
		Endrin Aldehyde	NE	NE	5.2J	5.2J	80-DPA-SB05-00	1/55	NA	NA	Northwest Area

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION - SURFACE SOILS
OPERABLE UNIT NO. 11 (SITE 80)
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	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Surface Soil (Cont.)		alpha-Chlordane	NE	NE	0.82J	670J	80-DPA-SB10-00	29/55	NA	NA	Scattered, Northwest Area
		gamma-Chlordane	NE	NE	1.2J	640J	80-DPA-SB10-00	22/55	NA	NA	Scattered, Northwest Area
				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	17.7 - 9,570	1,740	12,000J	80-LA-SB04-00	34/34	NA	1[a]	Lawn Area
		Arsenic	NE	0.065 - 3.9	0.845	63.3	80-LA-SB01-00	28/34	NA	11	Scattered
		Barium	NE	0.65 - 20.8	5.1	71.3	80-LA-SB03-00	34/34	NA	5	Widespread
		Beryllium	NE	0.02 - 0.26	0.03	0.25	80-MW06-00	20/34	NA	0	--
		Cadmium	NE	0.04 - 0.6	0.39	2.8J	80-LA-SB03-00	6/34	NA	2	Lawn Area
		Calcium	NE	4.25 - 10,700	29.8	91,200J	80-MA-SB04-00	33/34	NA	7	Lawn Area, Maintenance Area
		Chromium	NE	0.33 - 12.5	1.5J	22.7	80-MA-SB04-00	34/34	NA	5	Lawn Area, Maintenance Area
		Cobalt	NE	0.185 - 2.355	0.4	1.4	80-LA-SB07-00	6/34	NA	0	--
		Copper	NE	0.5 - 87.2	0.44J	30.2	80-LA-SB03-00	27/34	NA	0	--
		Iron	NE	69.7 - 9,640	565	7,420J	80-LA-SB06-00	34/34	NA	0	--
		Lead	NE	0.47 - 142	3.1	211J	80-LA-SB06-00	33/34	NA	1	Lawn Area
		Magnesium	NE	2.55 - 610	65.1	2,030	80-MA-SB04-00	34/34	NA	9	Lawn Area, Maintenance Area, Open Area
		Manganese	NE	0.87 - 66	2.7	133	80-LA-SB07-00	34/34	NA	3	Lawn Area, Maintenance Area
		Mercury	NE	0.01 - 0.08	0.13	2.7	80-LA-SB03-00	16/34	NA	16	Scattered
		Nickel	NE	0.6 - 3.55	1.1J	5.2J	80-LA-SB03-00	10/34	NA	2	Lawn Area, Maintenance Area
		Potassium	NE	1 - 416	90.7J	1,110	80-MA-SB04-00	24/34	NA	5	Lawn Area, Maintenance Area, Open Area, Soil Mounds
		Selenium	NE	0.075 - 1.3	1.2	1.7	80-LA-SB02-00	2/34	NA	1	Lawn Area
		Silver	NE	0.0435 - 4.3	1.1	6.6	80-LA-SB03-00	2/34	NA	1	Lawn Area
		Sodium	NE	4.7 - 126	21.6	176	80-MA-SB04-00	28/34	NA	1	Maintenance Area
		Thallium	NE	--	0.9	0.9	80-0A-SB05-00	1/34	NA	--	

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION - SURFACE SOILS
OPERABLE UNIT NO. 11 (SITE 80)
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	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Surface Soil (Cont.)	Inorganics (Cont.)	Vanadium	NE	0.305 - 18.2	2.1	39	80-MA-SB04-00	34/34	NA	1	Maintenance Area
		Zinc	NE	0.3 - 28.3	4.4	210J	80-LA-SB03-00	20/34	NA	8	Lawn Area, Maintenance Area

(1) Detections compared to maximum base background concentrations
(2) Shaded boxes indicate detections above comparison criteria

NE = No Criteria Established
NA = Not Applicable
J = estimated value
µg/kg = microgram per kilogram (ppb)
mg/kg = milligram per kilogram (ppm)
"--" = Undefined

TABLE 4-4

SUMMARY OF SITE CONTAMINATION - SUBSURFACE SOILS
OPERABLE UNIT NO. 11 (SITE 80)
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	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Sub-surface Soils	Volatile Organic Compounds	Acetone	NE	NE	11J	110J	80-MW03IW-03	4/32	NA	NA	Lawn Area, Drum Area, Open Area
		Carbon Disulfide	NE	NE	13	13	80-SM-SB02-03	1/32	NA	NA	Soil Mounds
	Semi-volatile Organic Compounds	Phenanthrene	NE	NE	53J	53J	80-MW03IW-03	1/32	NA	NA	Soil Mounds
		di-n-Butyl-phthalate	NE	NE	56J	3100	80-MW03IW-03	17/32	NA	NA	Scattered
		Butyl benzyl phthalate	NE	NE	46J	46J	80-MW03IW-03	1/32	NA	NA	Lawn Area
		bis(2-Ethylhexyl)phthalate	NE	NE	81J	85J	80-MW07-06	2/32	NA	NA	Lawn Area
	Pesticides/ PCBs	delta-BHC	NE	NE	0.63J	0.63J	80-SM-SB06-03	1/45	NA	NA	Soil Mounds
		Aldrin	NE	NE	2.6	2.6	80-LA-SB04-06	1/45	NA	NA	Lawn Area
		Dieldrin	NE	NE	0.73J	1.4J	80-OA-SB02-07	4/45	NA	NA	Drum Area, Open Area, Soil Mounds
		4,4'-DDE	NE	NE	1.4J	35	80-0A-SB02-07	7/45	NA	NA	Open Area, Soil Mounds, Northwest
		4,4'-DDD	NE	NE	1.1J	510J	80-MW-04-06	12/45	NA	NA	Lawn Area, Drum Area, Open Area, Soil Mounds, Northwest
		4,4'-DDT	NE	NE	4.7	240	80-MW-04-06	9/45	NA	NA	Lawn Area, Open Area, Northwest
				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	16.9 - 11,000	477	9,900	80-MW05-04	32/32	NA	0[1]	--
		Antimony	NE	0.355-6.9	3.1J	3.1J	80-MW07-04	1/32	NA	0	--
		Arsenic	NE	0.033 - 15.4	0.53	27.8	80-MW05-04	11/32	NA	1[2]	Drum Area
		Barium	NE	0.65 - 22.6	2	29.8	80-MW06-06	32/32	NA	1	Open Area
		Beryllium	NE	0.01 - 0.31	0.02	0.26	80-MA-SB01-06	15/32	NA	0	--
		Calcium	NE	4.75 - 4,410	28.5J	821J	80-MW03-IW-03	28/32	NA	0	--

TABLE 4-4 (Continued)

SUMMARY OF SITE CONTAMINATION - SUBSURFACE SOILS
OPERABLE UNIT NO. 11 (SITE 80)
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	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Sub-surface Soils (Cont.)	Inorganics (Cont.)	Chromium	NE	0.65 - 66.4	2J	88.1J	80-LA-SB06-06	32/32	NA	1	Lawn Area
		Cobalt	NE	0.175-7	0.47J	2.4J	80-MW05-04	10/32	NA	0	--
		Copper	NE	0.47 - 9.5	0.43J	5.5	80-MW05-04	18/32	NA	0	--
		Iron	NE	63.3 - 90,500	255	56,100J	80-LA-SB06-06	32/32	NA	0	--
		Lead	NE	0.465 - 21.4	2.5	13.2	80-MW05-04	30/32	NA	0	--
		Magnesium	NE	2.85 - 852	21	516	80-MW05-04	31/32	NA	0	--
		Manganese	NE	0.395 - 19.9	2.2J	43.3	80-LA-SB01-03	32/32	NA	1	Lawn Area
		Mercury	NE	0.01 - 0.68	0.93J	0.93	80-MA-SB03-06	1/32	NA	1	Maintenance Area
		Nickel	NE	0.45-4.7	1J	1.6J	80-MW05-04	4/32	NA	0	--
		Potassium	NE	1.05 - 1,250	82.4J	696	80-MW05-04	22/32	NA	0	--
		Selenium	NE	0.085 - 2.4	0.94	3.3	80-LA-SB06-06	6/32	NA	1	Lawn Area
		Sodium	NE	5.4 - 141	17.5	83.6	80-MW07-04	28/32	NA	0	--
		Vanadium	NE	0.34 - 69.4	1.5	56.7J	80-MW05-04	32/32	NA	0	--
		Zinc	NE	0.32 - 26.6	1.6	18.1J	80-LA-SB06-06	9/32	NA	0	--

(1) Detections compared to maximum base background concentrations
(2) Shaded boxes indicate detections above comparison criteria

NE = No Criteria Established
NA = Not Applicable
J = estimated value
µg/kg = microgram per kilogram (ppb)
mg/kg = milligram per kilogram (ppm)
"--" = Undefined

TABLE 4-5

SUMMARY OF SITE CONTAMINATION - GROUNDWATER
OPERABLE UNIT NO. 11 (SITE 80)
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	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Ground-water	Volatile Organic Compounds	Carbon Disulfide	NE	700[4]	1J	1J	80-MW03-01	1/8	NA	NA	Central Area
	Semi-volatile Organic Compounds	Acenaphthene	NE	80[4]	4J	4J	80-MW03-01	1/8	NA	NA	Central Area
		Dibenzofuran	NE	NE	2J	2J	80-MW03-01	1/8	NA	NA	Central Area
		Fluorene	NE	280	3J	3J	80-MW03-01	1/8	NA	0	Central Area
		Carbazole	NE	NE	3J	3J	80-MW03-01	1/8	NA	NA	Central Area
		Pyrene	NE	210[4]	1J	1J	80-MW03-01	1/8	NA	NA	Central Area
		bis(2-Ethylhexyl)phthalate	6.0	3.0	2J	5J	80-MW01-01	4/8	0	3[3]	Scattered
		di-n-octyl-phthalate	NE	140	1J	1J	80-MW02-01	1/8	NA	0	North Area
	Pesticides/ PCBs	4,4'-DDD	NE	NE	2.2J	2.2J	80-MW04-01	1/9	NA	NA	Northwest Area
		4,4'-DDT	NE	NE	0.58J	0.58J	80-MW04-01	1/9	NA	NA	Northwest Area
	Inorganics	Aluminum	50-200[1]	NE	274	43,000	80-MW02-01	7/8	7[3]	NA	Widespread
		Arsenic	50	50	13.6	102	80-MW03-01	2/8	1	1	Lawn Area
		Barium	2,000	2,000	19.6J	252	80-MW04-01	7/8	0	0	--
		Beryllium	4.0	NE	1.2	1.5	80-MW02-01	2/8	0	NA	--

TABLE 4-5 (continued)

SUMMARY OF SITE CONTAMINATION - GROUNDWATER
OPERABLE UNIT NO. 11 (SITE 80)
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	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Ground-water (Cont.)	Inorganics (Cont.)		MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
		Calcium	NE	NE	2,360	64,900	80-MW03-01	7/8	NA	NA	Widespread
		Chromium	100	50	53.3	65	80-MW02-01	2/8	0	2	Downgradient Areas
		Copper	1,300(2)	1,000	13.5	14.5	80-MW02-01	2/8	0	0	--
		Iron	300(1)	300	9,460	23,800	80-MW04-01	3/8	3	3	Scattered
		Lead	15(2)	15	5.7J	30J	80-MW02-01	3/8	2	2	Downgradient Areas
		Magnesium	NE	NE	3,330	21,000	80-MW02-01	7/8	NA	NA	Widespread
		Manganese	50(1)	50	43.9	369	80-MW03-01	5/8	3	3	Scattered
		Mercury	2.0	1.1	0.42	0.42	80-MW02-01	1/8	0	0	--
		Nickel	100	100	24	24	80-MW04-01	1/8	0	0	--
		Potassium	NE	NE	1,680	14,600	80-MW03-01	6/8	NA	NA	Widespread
		Sodium	NE	NE	6,260	23,100	80-MW05-01	7/8	NA	NA	Widespread
		Vanadium	NE	NE	40.7	44.9	80-MW02-01	2/8	NA	NA	--
		Zinc	5,000(1)	2,100	76.5J	106	80-MW06-01	2/8	0	0	--

(1) SMCL = Secondary Maximum Contaminant Level
(2) Action Level
(3) Shaded boxes indicate detections above comparison criteria
(4) NCDEHNR Interim maximum allowable concentration
NE = No Criteria Established
NA = Not Applicable
J = estimated value
MCL = Maximum Contaminant Level
NCWQS = North Carolina Water Quality Standard
µg/L = microgram per liter (ppb)
"--" = Undefined

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-DA-SB01-00	80-DA-SB02-00	80-LA-SB01-00	80-LA-SB02-00	80-LA-SB03-00	80-LA-SB04-00
Laboratory Sample ID:		Q41118111	Q41118110	AC7800	AC6661	AC6679	AC6885
Date Sampled:		11/03/94	11/03/94	11/05/94	11/01/94	11/01/94	11/02/94
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	ND	ND	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	150 J	60 J	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	66 J	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	180 J	ND	ND	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	18	ND	ND	11
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	8.6	17 J	29	60	300	630 J
4,4'-DDE	UG/KG	11	7.4 J	69	240	740	130
4,4'-DDD	UG/KG	ND	ND	62	780	650	24
4,4'-DDT	UG/KG	6.4	4.4 J	5.7	33	210	29
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	32	ND	130 J	92 J
gamma-Chlordane	UG/KG	ND	ND	31	ND	100 J	91 J

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-LA-SB05-00	80-LA-SB06-00	80-LA-SB07-00	80-MA-SB01-00	80-MA-SB02-00	80-MA-SB03-00
Laboratory Sample ID:		AC6684	AC6930	Q41118001	AC6904	AC6881	AC6914
Date Sampled:		11/01/94	11/02/94	11/02/94	11/02/94	11/01/94	11/02/94
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	ND	ND	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	94 J	ND	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	58 J	38	20	ND	84	ND
4,4'-DDE	UG/KG	68 J	110	620	89	470	210
4,4'-DDD	UG/KG	2.1 J	7.6 J	17 J	ND	510	8.6 J
4,4'-DDT	UG/KG	13 J	110	100	68	79	450
Endrin ketone	UG/KG	ND	ND	7.7 J	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	3.7 J	4.3 J	ND	ND	27	ND
gamma-Chlordane	UG/KG	1.2 J	2.2 J	ND	ND	18 J	2.9

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-MA-SB04-00	80-MW03IW-00	80-MW04-00	80-MW05-00	80-MW06-00	80-MW07-00
Laboratory Sample ID:		AC6690	Q41118707	Q41118401	Q41118506	AC7806	Q41118604
Date Sampled:		11/01/94	11/05/94	11/03/94	11/04/94	11/05/94	11/04/94
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	28	ND	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	4400	150 J	79 J	ND	110 J
Fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Pyrene	UG/KG	ND	ND	60 J	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	96 J	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	ND	ND	ND	ND	ND
Chrysene	UG/KG	ND	ND	40 J	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	ND	48 J	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	69 J	370 J	ND	99 J	7.2 J	ND
4,4'-DDE	UG/KG	280 J	73	1500 J	81	37	21
4,4'-DDD	UG/KG	610 J	16 J	87000	3.9 J	15	ND
4,4'-DDT	UG/KG	870 J	ND	40000	53	ND	6.7
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	30 J	68	ND	ND	24	ND
gamma-Chlordane	UG/KG	15 J	54	ND	ND	20 J	ND

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-MW08-00	80-OA-SB01-00	80-OA-SB02-00	80-OA-SB03-00	80-OA-SB04-00	80-OA-SB05-00
Laboratory Sample ID:		AF6668	Q41118112	Q41118118	Q41118302	Q41118509	Q41118501
Date Sampled:		06/13/95	11/03/94	11/03/94	11/03/94	11/04/94	11/04/94
	UNITS						
VOLATILES							
Acetone	UG/KG	NA	ND	ND	ND	ND	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	NA	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	NA	130 J	67 J	510	130 J	95 J
Fluoranthene	UG/KG	NA	ND	ND	ND	ND	ND
Pyrene	UG/KG	NA	ND	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	NA	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	NA	ND	ND	ND	ND	ND
Chrysene	UG/KG	NA	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	NA	ND	ND	58 J	ND	42 J
Benzo[b]fluoranthene	UG/KG	NA	ND	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	NA	ND	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	NA	ND	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	NA	ND	ND	ND	ND	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	1.2 J	ND	ND	ND
Aldrin	UG/KG	ND	ND	15	5.5 J	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	2.7 J	ND	ND	ND
Dieldrin	UG/KG	23	6.3	460	50	ND	ND
4,4'-DDE	UG/KG	180	26	80	36	0.6 J	ND
4,4'-DDD	UG/KG	52 J	6.4	20	31	ND	12
4,4'-DDT	UG/KG	140	2.1 J	8.3	2.2 J	ND	5.9
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	3 J	2.1	27	4.8	ND	ND
gamma-Chlordane	UG/KG	ND	ND	21	4.9	ND	ND

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-OA-SB06-00	80-SM-SB04-00	80-SM-SB05-00	80-SM-SB06-00	80-SM-SB07-00	80-SM-SB08-00
Laboratory Sample ID:		Q41118503	Q41118101	Q41118102	Q41118103	Q41118105	Q41118106
Date Sampled:		11/04/94	11/03/94	11/03/94	11/03/94	11/03/94	11/03/94
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	ND	ND	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	100 J	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	97 J	60 J	140 J	120 J	86 J	79 J
Fluoranthene	UG/KG	ND	100 J	ND	ND	ND	ND
Pyrene	UG/KG	ND	92 J	ND	ND	ND	ND
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[a]anthracene	UG/KG	ND	47 J	ND	ND	ND	ND
Chrysene	UG/KG	ND	53 J	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND
Benzo[b]fluoranthene	UG/KG	ND	40 J	ND	ND	ND	ND
Benzo[k]fluoranthene	UG/KG	ND	38 J	ND	ND	ND	ND
Benzo[a]pyrene	UG/KG	ND	43 J	ND	ND	ND	ND
Benzo[g,h,i]perylene	UG/KG	ND	ND	ND	ND	ND	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	21	ND	ND	ND	ND	1.1 J
4,4'-DDE	UG/KG	13	0.9 J	ND	ND	ND	2.7 J
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND	1.7 J
4,4'-DDT	UG/KG	1.6 J	1.3 J	ND	ND	ND	1.5 J
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	5	ND	ND	ND	0.82 J	ND
gamma-Chlordane	UG/KG	4.2	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-SM-SB09-00	80-SM-SB10-00	80-DPA-SB01-00	80-DPA-SB02-00	80-DPA-SB03-00	80-DPA-SB04-00
Laboratory Sample ID:		Q41118107	Q41118109	AF6787	AF6789	AF6790	AF6793
Date Sampled:		11/03/94	11/03/94	06/13/95	06/13/95	06/13/95	06/13/95
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	NA	NA	NA	NA
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	NA	NA	NA	NA
di-n-Butylphthalate	UG/KG	110 J	120 J	NA	NA	NA	NA
Fluoranthene	UG/KG	ND	ND	NA	NA	NA	NA
Pyrene	UG/KG	ND	ND	NA	NA	NA	NA
Butyl benzyl phthalate	UG/KG	ND	ND	NA	NA	NA	NA
Benzo[a]anthracene	UG/KG	ND	ND	NA	NA	NA	NA
Chrysene	UG/KG	ND	ND	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	UG/KG	ND	38 J	NA	NA	NA	NA
Benzo[b]fluoranthene	UG/KG	ND	ND	NA	NA	NA	NA
Benzo[k]fluoranthene	UG/KG	ND	ND	NA	NA	NA	NA
Benzo[a]pyrene	UG/KG	ND	ND	NA	NA	NA	NA
Benzo[g,h,i]perylene	UG/KG	ND	ND	NA	NA	NA	NA
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	2 J	ND	63	ND	30 J
4,4'-DDE	UG/KG	ND	2.9 J	ND	130	ND	140
4,4'-DDD	UG/KG	ND	1.5 J	130000	1300	260000	13 J
4,4'-DDT	UG/KG	ND	ND	8400	100	29000	100
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	ND	11 J
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	11

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-DPA-SB05-00	80-DPA-SB06-00	80-DPA-SB07-00	80-DPA-SB08-00	80-DPA-SB09-00	80-DPA-SB10-00
Laboratory Sample ID:		AF7014	AF7016	AF7018	AF6799	AF7022	AF7019
Date Sampled:		06/14/95	06/14/95	06/14/95	06/13/95	06/14/95	06/14/95
	UNITS						
VOLATILES							
Acetone	UG/KG	NA	NA	NA	NA	NA	NA
SEMIVOLATILES							
Phenanthrene	UG/KG	NA	NA	NA	NA	NA	NA
di-n-Butylphthalate	UG/KG	NA	NA	NA	NA	NA	NA
Fluoranthene	UG/KG	NA	NA	NA	NA	NA	NA
Pyrene	UG/KG	NA	NA	NA	NA	NA	NA
Butyl benzyl phthalate	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[a]anthracene	UG/KG	NA	NA	NA	NA	NA	NA
Chrysene	UG/KG	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[b]fluoranthene	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[k]fluoranthene	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[a]pyrene	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[g,h,i]perylene	UG/KG	NA	NA	NA	NA	NA	NA
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	21	49
Heptachlor epoxide	UG/KG	9.9	ND	ND	ND	ND	ND
Dieldrin	UG/KG	590	1700	800	43 J	1000	5600
4,4'-DDE	UG/KG	240	510	600	180	200	460
4,4'-DDD	UG/KG	420 J	8400 J	10000 J	64 J	160 J	150 J
4,4'-DDT	UG/KG	400	1200	5500	220 J	130	260
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	5.2 J	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	130 J	130	100 J	42 J	300 J	670 J
gamma-Chlordane	UG/KG	33 J	ND	ND	45 J	240	640 J

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-DPA-SB11-00	80-DPA-SB12-00	80-DPA-SB13-00	80-DPA-SB14-00	80-DPA-SB15-00	80-DPA-SB16-00
Laboratory Sample ID:		AF7020	AF7314	AF6802	AF7021	AF7027	AF7028
Date Sampled:		06/14/95	06/18/95	06/14/95	06/14/95	06/14/95	06/14/95
	UNITS						
VOLATILES							
Acetone	UG/KG	NA	NA	NA	NA	NA	NA
SEMIVOLATILES							
Phenanthrene	UG/KG	NA	NA	NA	NA	NA	NA
di-n-Butylphthalate	UG/KG	NA	NA	NA	NA	NA	NA
Fluoranthene	UG/KG	NA	NA	NA	NA	NA	NA
Pyrene	UG/KG	NA	NA	NA	NA	NA	NA
Butyl benzyl phthalate	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[a]anthracene	UG/KG	NA	NA	NA	NA	NA	NA
Chrysene	UG/KG	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[b]fluoranthene	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[k]fluoranthene	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[a]pyrene	UG/KG	NA	NA	NA	NA	NA	NA
Benzo[g,h,i]perylene	UG/KG	NA	NA	NA	NA	NA	NA
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	2.1 J	ND	ND	ND
Aldrin	UG/KG	ND	ND	5.4	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	24	4.5	550	1400	470	96 J
4,4'-DDE	UG/KG	120	13	250	310	400	920
4,4'-DDD	UG/KG	50 J	11	150	23 J	1300 J	65 J
4,4'-DDT	UG/KG	96	18	87	210	3100	570
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	2.2	80 J	72 J	35 J	54 J
gamma-Chlordane	UG/KG	ND	ND	59	27 J	22	46

UG/KG - miccrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-DPA-SB17-00	80-DPA-SB18-00	80-DPA-SB19-00	80-DPA-SB20-00
Laboratory Sample ID:		AF6805	AF7029	AF7031	AF6800
Date Sampled:		06/14/95	06/14/95	06/14/95	06/14/95
	UNITS				
VOLATILES					
Acetone	UG/KG	NA	NA	NA	NA
SEMIVOLATILES					
Phenanthrene	UG/KG	NA	NA	NA	NA
di-n-Butylphthalate	UG/KG	NA	NA	NA	NA
Fluoranthene	UG/KG	NA	NA	NA	NA
Pyrene	UG/KG	NA	NA	NA	NA
Butyl benzyl phthalate	UG/KG	NA	NA	NA	NA
Benzo[a]anthracene	UG/KG	NA	NA	NA	NA
Chrysene	UG/KG	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	UG/KG	NA	NA	NA	NA
Benzo[b]fluoranthene	UG/KG	NA	NA	NA	NA
Benzo[k]fluoranthene	UG/KG	NA	NA	NA	NA
Benzo[a]pyrene	UG/KG	NA	NA	NA	NA
Benzo[g,h,i]perylene	UG/KG	NA	NA	NA	NA
PESTICIDES/PCBs					
delta-BHC	UG/KG	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND
Dieldrin	UG/KG	12	ND	76	12 J
4,4'-DDE	UG/KG	38	16	250	280
4,4'-DDD	UG/KG	15	9	27 J	77 J
4,4'-DDT	UG/KG	12	16	130	260
Endrin ketone	UG/KG	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND
alpha-Chlordane	UG/KG	3.1 J	ND	7.9 J	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-DA-SB01-00	80-DA-SB02-00	80-LA-SB01-00	80-LA-SB02-00	80-LA-SB03-00	80-LA-SB04-00	80-LA-SB05-00	80-LA-SB06-00
Laboratory Sample ID:		Q41118111A	Q41118110A	AC7800	AC6661	AC6679	AC6885	AC6684	AC6930
Date Sampled:		11/03/94	11/03/94	11/05/94	11/01/94	11/01/94	11/02/94	11/01/94	11/02/94
	UNITS								
Aluminum	MG/KG	1860 J	2140 J	2510	2470 J	3040 J	12000 J	5390 J	5720 J
Arsenic	MG/KG	1.1	0.84 J	63.3	3	7.9	37.7 J	8.5	41.5 J
Barium	MG/KG	8.4	11.1	20.3	21.6	71.3	29.1	18	35.1
Beryllium	MG/KG	0.03	0.14	ND	ND	ND	ND	ND	0.24
Cadmium	MG/KG	ND	ND	ND	1.6	2.8 J	ND	ND	ND
Calcium	MG/KG	309	179	26400	33500 J	62700 J	6310 J	1600 J	7380 J
Chromium	MG/KG	1.5 J	1.5	9.7	11.3	18.8	19.8 J	7.6	12.9 J
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Copper	MG/KG	ND	0.44 J	8.8	9.6	30.2	6.7	3.5	12.2 J
Iron	MG/KG	713 J	821 J	3190	2050	2550	5320 J	2800	7420 J
Lead	MG/KG	7.2 J	7.8 J	31.1	42.7	51.2	63 J	22.8	211 J
Magnesium	MG/KG	76.1	70.2	1240	990	1890	785	271	1590
Manganese	MG/KG	13	11.1	39.7	58.3	42	89.7 J	33.5	60.9 J
Mercury	MG/KG	0.15	ND	0.4	ND	2.7	1.8	0.68	1.1
Nickel	MG/KG	ND	ND	ND	ND	5.2 J	ND	ND	ND
Potassium	MG/KG	ND	ND	ND	465	ND	561 J	ND	ND
Selenium	MG/KG	ND	ND	ND	1.7	ND	ND	ND	1.2
Silver	MG/KG	ND	ND	ND	ND	6.6	ND	ND	1.1
Sodium	MG/KG	70.2	57.5	54.2	89.4	69.4	33 J	29.1	43.5
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	2.1	2.3	8.8	6.3	7.3	14.9 J	7.1	12.8
Zinc	MG/KG	ND	ND	70.6	103 J	210 J	44.4 J	ND	94.1 J
Moisture	%	N/A	N/A	14.23	21.68	14.07	13.58	13.4	12.04

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-LA-SB07-00	80-MA-SB01-00	80-MA-SB02-00	80-MA-SB03-00	80-MA-SB04-00	80-MW031W-00	80-MW04-00	80-MW05-00
Laboratory Sample ID:		Q41118001A	AC6904	AC6881	AC6914	AC6690	Q41118707	Q41118401	Q41118506
Date Sampled:		11/02/94	11/02/94	11/01/94	11/02/94	11/01/94	11/05/94	11/03/94	11/04/94
	UNITS								
Aluminum	MG/KG	9370 J	3390 J	4500 J	5520 J	5000 J	9270	2200	2170
Arsenic	MG/KG	15.3	ND	5.5 J	3.8 J	3.2	25.9	2.3	5.4
Barium	MG/KG	35.7	13.2	13	12.3	10.5	20.6	10.2	10.8
Beryllium	MG/KG	0.25	0.23	ND	ND	ND	0.16	0.07	0.05
Cadmium	MG/KG	0.39	ND	ND	ND	ND	0.52 J	0.39	ND
Calcium	MG/KG	3510	23800 J	55200 J	49800 J	91200 J	3110 J	6470	463
Chromium	MG/KG	9 J	5 J	11.5 J	12.1 J	22.7	16	4.8	2.5
Cobalt	MG/KG	1.4	ND	ND	ND	ND	1.3	ND	ND
Copper	MG/KG	5.2	3.2	2.4	ND	2.4	5.9	3.3	1.2
Iron	MG/KG	3440 J	1360 J	2050 J	4230 J	3770	6210	857	1000
Lead	MG/KG	27.9 J	6.9 J	9.3 J	5.8 J	ND	46.4	25.1	19.1
Magnesium	MG/KG	422	528	1270	1310	2030	580	207	112
Manganese	MG/KG	133	31.4 J	32.9 J	28.5 J	76.6	37.9	15.4 J	16.2 J
Mercury	MG/KG	2.3	ND	0.53	ND	0.25	1.1	0.64	0.29
Nickel	MG/KG	3.4 J	ND	ND	ND	4.3	2.7 J	1.5	1.2 J
Potassium	MG/KG	237	ND	265 J	344	1110	485	166 J	147 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	51.1	123	87.9	176	35.7	28.7	71.6
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	9.3	5.5	8.2	12.2	39	14.8	3.5 J	3.1 J
Zinc	MG/KG	48.3 J	18.9 J	37.9 J	22.7 J	ND	28.8	22.2	18.4
Moisture	%	N/A	6.02	5.59	20.71	7.15	N/A	N/A	N/A

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-MW06-00	80-MW07-00	80-OA-SB01-00	80-OA-SB02-00	80-OA-SB03-00	80-OA-SB04-00	80-OA-SB05-00	80-OA-SB06-00
Laboratory Sample ID:		AC7806	Q41118604	Q41118112A	Q41118118A	Q41118302A	Q41118509	Q41118501	Q41118503
Date Sampled:		11/05/94	11/04/94	11/03/94	11/03/94	11/03/94	11/04/94	11/04/94	11/04/94
	UNITS								
Aluminum	MG/KG	3170	4380	3150 J	2840 J	1820 J	5970	1740	3000
Arsenic	MG/KG	ND	2.3	1.4	17.9	4.8	1.3	ND	2.1
Barium	MG/KG	6.6 J	14.4	7.6	10.9	7.7	9.8	7	7.6
Beryllium	MG/KG	0.25	0.12	0.04	0.05	0.05	0.05	0.05	0.05
Cadmium	MG/KG	ND	ND	ND	0.53	ND	ND	ND	ND
Calcium	MG/KG	655	283 J	1260	1270	1260	2700	145	1040
Chromium	MG/KG	4.6	5.2	4.1 J	11.2 J	2.3 J	7.3	1.6 J	4.6
Cobalt	MG/KG	ND	0.61	0.55 J	ND	ND	0.74	ND	ND
Copper	MG/KG	ND	1.4	1.3	2.3	1.5	1.9	0.79 J	1.4
Iron	MG/KG	1370	5050	1900 J	1190 J	769 J	6080	565	1440
Lead	MG/KG	12.2 J	6.7	7.4 J	30 J	11.8 J	6.2	3.1	10.6
Magnesium	MG/KG	98	154	431	268	153	1290	81.1	236
Manganese	MG/KG	7.9 J	25.1	12.6	12.7	8.8	8.5 J	5.9 J	10.3 J
Mercury	MG/KG	ND	ND	ND	0.84	0.85	ND	ND	0.13
Nickel	MG/KG	ND	2	ND	ND	ND	1.9 J	1.1 J	1.1 J
Potassium	MG/KG	ND	184	132 J	90.7 J	102 J	303	139 J	455
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	48.7	21.6	ND	62.5	ND	29.9	70	30.8
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	0.9	ND
Vanadium	MG/KG	6.1	10.3	5.7	3.2	2.3	10.9 J	2.2 J	6 J
Zinc	MG/KG	ND	4.4	13.9 J	15.3 J	12.1 J	10.9	ND	7.1
Moisture	%	13.74	N/A	N/A	N/A	N/A	N/A	N/A	N/A

MG/KG - milligram per kilogram
J - value is estimated
N/A - not analyzed
ND - [illegible]etected

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-SM-SB01-00	80-SM-SB02-00	80-SM-SB03-00	80-SM-SB04-00	80-SM-SB05-00	80-SM-SB06-00	80-SM-SB07-00	80-SM-SB08-00
Laboratory Sample ID:		AC6891	AC6893	AC6897	Q41118101A	Q41118102A	Q41118103A	Q41118105A	Q41118106A
Date Sampled:		11/02/94	11/02/94	11/02/94	11/03/94	11/03/94	11/03/94	11/03/94	11/03/94
	UNITS								
Aluminum	MG/KG	2840 J	2370 J	2250 J	3790 J	2820 J	1920 J	3150 J	2410 J
Arsenic	MG/KG	ND	ND	ND	1.5	0.9	1.6	1.5	0.93
Barium	MG/KG	6.1	6.8	6.4	7.8	7.1	5.7	7.8	5.9
Beryllium	MG/KG	ND	ND	ND	0.03	0.03	ND	0.04	ND
Cadmium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	40.1 J	47.3 J	45 J	41.3	32.1	29.8	41	38.2
Chromium	MG/KG	4.4 J	4.4 J	4.2 J	5.3	4.4 J	3.6 J	4.9 J	3.7 J
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	0.4	ND
Copper	MG/KG	ND	ND	ND	0.6 J	0.44	0.57	0.69	ND
Iron	MG/KG	1340 J	1790 J	1700 J	2090 J	1840 J	1440 J	1810 J	1540 J
Lead	MG/KG	4.6 J	4.4 J	4.7 J	4.5 J	3.9 J	3.4 J	4.3 J	4 J
Magnesium	MG/KG	90.7	103	75.9	169	121	65.1	144	100
Manganese	MG/KG	4 J	4.9 J	3.3 J	5.3	5.4	2.7	5.1	3.2
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	252 J	ND	200	130 J	102	187 J	117 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	30.4	26.7	35.2 J	ND	58.3	72	ND	78.5
Thallium	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	5.6	6.8	6.1	8.1	6.7	5.8	7.4	5.8
Zinc	MG/KG	ND	10.2 J	11.4 J	ND	ND	ND	ND	ND
Moisture	%	6.72	5.57	5.22	N/A	N/A	N/A	N/A	N/A

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-SM-SB09-00	80-SM-SB10-00
Laboratory Sample ID:		Q41118107A	Q41118109A
Date Sampled:		11/03/94	11/03/94
	UNITS		
Aluminum	MG/KG	2560 J	2760 J
Arsenic	MG/KG	1.1	1.6 J
Barium	MG/KG	5.1	6.5
Beryllium	MG/KG	ND	0.03
Cadmium	MG/KG	ND	ND
Calcium	MG/KG	ND	65.8
Chromium	MG/KG	3.7 J	4.3 J
Cobalt	MG/KG	ND	ND
Copper	MG/KG	0.51 J	0.67 J
Iron	MG/KG	1320 J	2000 J
Lead	MG/KG	3.2 J	4.7 J
Magnesium	MG/KG	102	111
Manganese	MG/KG	3.1	3.7
Mercury	MG/KG	ND	0.64
Nickel	MG/KG	ND	ND
Potassium	MG/KG	122 J	179 J
Selenium	MG/KG	ND	ND
Silver	MG/KG	ND	ND
Sodium	MG/KG	61.6	ND
Thallium	MG/KG	ND	ND
Vanadium	MG/KG	5.6	7
Zinc	MG/KG	ND	ND
Moisture	%	N/A	N/A

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

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-LA-SB03-06	80-LA-SB04-06	80-LA-SB07-06	80-MW031W-03	80-MW03IW-06	80-MW04-06
Laboratory Sample ID:		AC6682	AC6922	Q41118002	Q41118708	AC7812	Q41118402
Date Sampled:		11/01/94	11/02/94	11/02/94	11/05/94	11/07/94	11/03/94
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	110 J	ND	ND
Carbon Disulfide	UG/KG	ND	ND	ND	ND	ND	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	53 J	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	56 J	3100	ND	120 J
Butyl benzyl phthalate	UG/KG	ND	ND	ND	46 J	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	81 J	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	2.6	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND	14
4,4'-DDD	UG/KG	ND	ND	ND	2.5 J	ND	510 J
4,4'-DDT	UG/KG	4.7	ND	ND	ND	ND	240

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-MW05-04	80-MW05-06	80-MW07-04	80-MW07-06	80-MW08-05	80-OA-SB01-07
Laboratory Sample ID:		Q41118507	Q41118508	Q41118605	Q41118606	AF6665	Q41118116
Date Sampled:		11/04/94	11/04/94	11/04/94	11/04/94	06/13/95	11/03/94
	UNITS						
VOLATILES							
Acetone	UG/KG	35 J	ND	40	ND	NA	ND
Carbon Disulfide	UG/KG	ND	ND	ND	ND	NA	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	ND	NA	ND
di-n-Butylphthalate	UG/KG	150 J	270 J	150 J	170 J	NA	70 J
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	NA	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	85 J	NA	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	0.73 J	ND	ND	ND	1 J
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND	1.4 J
4,4'-DDD	UG/KG	ND	1.3 J	ND	ND	300	1.1 J
4,4'-DDT	UG/KG	ND	ND	ND	ND	21	ND

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-OA-SB02-07	80-OA-SB03-06	80-OA-SB04-03	80-OA-SB04-06	80-OA-SB05-06	80-OA-SB06-03
Laboratory Sample ID:		Q41118301	Q41118303	Q41118510	Q41118511	Q41118502	Q41118504
Date Sampled:		11/03/94	11/03/94	11/04/94	11/04/94	11/04/94	11/04/94
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	11 J	ND	ND	ND
Carbon Disulfide	UG/KG	ND	ND	ND	ND	ND	ND
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	330 J	170 J	93 J	170 J	220 J	220 J
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	1.4 J	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	35	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	9.9	ND	ND	ND	ND	ND

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-OA-SB06-06	80-SM-SB02-03	80-SM-SB06-03	80-SM-SB09-03	80-DPA-SB01-03	80-DPA-SB03-04
Laboratory Sample ID:		Q41118505	AC6895	Q41118104	Q41118108	AF6786	AF6791
Date Sampled:		11/04/94	11/02/94	11/03/94	11/03/94	06/13/95	06/13/95
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	ND	NA	NA
Carbon Disulfide	UG/KG	ND	13	ND	ND	NA	NA
SEMIVOLATILES							
Phenanthrene	UG/KG	ND	ND	ND	ND	NA	NA
di-n-Butylphthalate	UG/KG	170 J	ND	150 J	89 J	NA	NA
Butyl benzyl phthalate	UG/KG	ND	ND	ND	ND	NA	NA
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	NA	NA
PESTICIDES/PCBs							
delta-BHC	UG/KG	ND	ND	0.63 J	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	1.3 J	ND	ND	ND
4,4'-DDE	UG/KG	ND	ND	4.6	1.4 J	ND	ND
4,4'-DDD	UG/KG	ND	4.6	5.2	1.4 J	38	94
4,4'-DDT	UG/KG	ND	ND	ND	ND	8.8	22

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-DPA-SB08-04	80-DPA-SB17-03	80-DPA-SB18-04	80-DPA-SB20-04
Laboratory Sample ID:		AF6794	AF6804	AF7030	AF6801
Date Sampled:		06/13/95	06/14/95	06/14/95	06/14/95
	UNITS				
VOLATILES					
Acetone	UG/KG	NA	NA	NA	NA
Carbon Disulfide	UG/KG	NA	NA	NA	NA
SEMIVOLATILES					
Phenanthrene	UG/KG	NA	NA	NA	NA
di-n-Butylphthalate	UG/KG	NA	NA	NA	NA
Butyl benzyl phthalate	UG/KG	NA	NA	NA	NA
bis(2-Ethylhexyl)phthalate	UG/KG	NA	NA	NA	NA
PESTICIDES/PCBs					
delta-BHC	UG/KG	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	ND
4,4'-DDE	UG/KG	7.3	ND	19	ND
4,4'-DDD	UG/KG	6 J	27	ND	ND
4,4'-DDT	UG/KG	42	ND	9.9	5.8

UG/KG - micrograms per kilogram
J - value is estimated
NA - not analyzed
ND - not detected

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-LA-SB01-03	80-LA-SB01-06	80-LA-SB02-06	80-LA-SB03-06	80-LA-SB04-06	80-LA-SB05-06	80-LA-SB06-06	80-LA-SB07-06
Laboratory Sample ID:		AC7802	AC7804	AC6673	AC6682	AC6922	AC6687	AC6932	Q41118002A
Date Sampled:		11/05/94	11/05/94	11/01/94	11/01/94	11/02/94	11/01/94	11/02/94	11/02/94
	UNITS								
Aluminum	MG/KG	4750	1830	2190 J	1560 J	1530 J	2330 J	4410 J	3890 J
Antimony	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	MG/KG	3.6	3.2	ND	ND	ND	ND	ND	ND
Barium	MG/KG	8.4 J	4.8 J	4.9	4.8	2.6	6.2	5.6	6.8
Beryllium	MG/KG	0.24	ND	ND	ND	ND	ND	ND	0.07
Calcium	MG/KG	689	167	ND	ND	191 J	ND	171 J	85.3
Chromium	MG/KG	7.1	6.4	7.3	5.5	4.6 J	5.3	88.1 J	8.6 J
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND	ND	0.9 J
Copper	MG/KG	ND	ND	ND	ND	ND	ND	3.2	0.89 J
Iron	MG/KG	7640	8230	11700	5700	33000 J	1350	56100 J	11700 J
Lead	MG/KG	5.4 J	4.5 J	ND	ND	3.2 J	5.3	6.4 J	4.1 J
Magnesium	MG/KG	251	114	99.4	116	ND	110	55.6	214
Manganese	MG/KG	43.3	5.6 J	3.9	4.8	2.2 J	5.2	5.6 J	4.6
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	ND	265 J	238	ND	413	ND	258
Selenium	MG/KG	1.2	ND	ND	ND	2	ND	3.3	ND
Sodium	MG/KG	53	40.4	27.8	33.6	39.4	33.3	36.2	59.4
Vanadium	MG/KG	13.7	7.1	9.5	6.4	7.7	4.2	14.1	4.8
Zinc	MG/KG	ND	ND	ND	ND	ND	ND	18.1 J	ND
Moisture	%	14.22	19.91	19.5	18.42	16.13	13.06	18.07	N/A

MG/KG - milligram per kilogram
J - value is estimated
N/A - not analyzed
ND - [illegible]tected

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-MA-SB01-06	80-MA-SB02-06	80-MA-SB03-06	80-MA-SB04-06	80-MW031W-03	80-MW03IW-06	80-MW04-06	80-MW05-04
Laboratory Sample ID:		AC6910	AC6883	AC6916	AC6692	Q41118708	AC7812	Q41118402	Q41118507
Date Sampled:		11/02/94	11/01/94	11/02/94	11/01/94	11/05/94	11/07/94	11/03/94	11/04/94
	UNITS								
Aluminum	MG/KG	6430 J	2440 J	4800 J	3060 J	5650	1600	1240	9900
Antimony	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	MG/KG	5.5 J	ND	4.3 J	ND	11.2	ND	ND	27.8
Barium	MG/KG	11.3	6.2	7.7	6.5	5.3	4.3 J	4.2	12.6
Beryllium	MG/KG	0.26	ND	0.25	ND	0.05	ND	0.04	0.17
Calcium	MG/KG	264 J	45 J	52.2 J	ND	821 J	211	51.9	44
Chromium	MG/KG	25.4 J	7.8 J	11.3 J	8.7	11	6.3	4.3	36.6
Cobalt	MG/KG	ND	ND	ND	ND	0.82 J	ND	0.58	2.4 J
Copper	MG/KG	3.4	ND	ND	ND	2.2	ND	1.1 J	5.5
Iron	MG/KG	14400 J	5300 J	11000 J	5810	7330	5530	2520	33000
Lead	MG/KG	8.9 J	4.9 J	5.7 J	5.9	5.6	3 J	3.1	13.2
Magnesium	MG/KG	342	211	391	271	220	73.3	88.2	516
Manganese	MG/KG	5.3 J	9.5 J	9.6 J	5.9	9.1	4.2 J	5.4 J	4.7 J
Mercury	MG/KG	ND	ND	0.93	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	ND	ND	ND	ND	1.6 J
Potassium	MG/KG	399 J	ND	447 J	569	472	ND	268 J	696
Selenium	MG/KG	1.3	ND	ND	ND	ND	ND	ND	0.94
Sodium	MG/KG	34	39.8	39.4	37.6	28.5	42.5	73.9	42.7
Vanadium	MG/KG	15.8	6.2	17.8	6.3	15.1	4.8	3.3 J	56.7 J
Zinc	MG/KG	ND	ND	ND	ND	3.6	ND	ND	7.1
Moisture	%	22.57	18.05	20.16	19.7	N/A	17.63	N/A	N/A

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

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-MW05-06	80-MW06-03	80-MW06-06	80-MW07-04	80-MW07-06	80-OA-SB01-07	80-OA-SB02-07	80-OA-SB03-06	80-OA-SB04-03
Laboratory Sample ID:		Q41118508	AC7808	AC7810	Q41118605	Q41118606	Q41118116A	Q41118301A	Q41118303A	Q41118510
Date Sampled:		11/04/94	11/05/94	11/05/94	11/04/94	11/04/94	11/03/94	11/03/94	11/03/94	11/04/94
	UNITS									
Aluminum	MG/KG	793	6240	1510	7950	2250	1270 J	913 J	2890 J	6900
Antimony	MG/KG	ND	ND	ND	3.1 J	ND	ND	ND	ND	ND
Arsenic	MG/KG	ND	ND	ND	3.8	ND	ND	ND	ND	0.78
Barium	MG/KG	2.6	7.2 J	29.8	10	4.3	4.9	7.2	4.6	8.5
Beryllium	MG/KG	ND	0.23	ND	0.11	0.03	ND	ND	ND	0.04
Calcium	MG/KG	33.6	181	110	67.4 J	28.5 J	67.3 J	37.4	62.6	34.5
Chromium	MG/KG	3.7	10.3	5.2	12.7	4.2	4.2 J	2 J	4.7 J	10.7
Cobalt	MG/KG	ND	ND	ND	1.2	ND	ND	ND	ND	0.55 J
Copper	MG/KG	1	ND	ND	2.3	0.67	0.43 J	ND	0.66	1.9
Iron	MG/KG	2990	5210	2060	9670	665	786 J	269 J	661 J	2590
Lead	MG/KG	4.5	6 J	6.6 J	7	2.5	3.8 J	3.3 J	3.5 J	6.6
Magnesium	MG/KG	58	152	69.1	337	99.4	58.1	30.7	114	241
Manganese	MG/KG	4.6 J	3.2 J	3.3 J	6.3	5.4	6.5	5.6	8.3	4.7 J
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	ND	ND	ND	1.5 J	ND	ND	ND	ND	1 J
Potassium	MG/KG	192 J	324	ND	415	226	82.4 J	ND	127 J	387
Selenium	MG/KG	ND	1.2	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	72.4	27.1	25.6	83.6	70.9	ND	63.8	ND	81.4
Vanadium	MG/KG	6.1 J	17.8	6.4	17.7	2.7	2.9	1.5	3.9	16.6 J
Zinc	MG/KG	ND	ND	ND	4.6	2.5	8.7 J	12 J	ND	ND
Moisture	%	N/A	15.04	7.76	N/A	N/A	N/A	N/A	N/A	N/A

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

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
SUBSURFACE SOIL
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:		80-OA-SB04-06	80-OA-SB05-06	80-OA-SB06-03	80-OA-SB06-06	80-SM-SB02-03	80-SM-SB06-03	80-SM-SB09-03
Laboratory Sample ID:		Q41118511	Q41118502	Q41118504	Q41118505	AC6895	Q41118104A	Q41118108A
Date Sampled:		11/04/94	11/04/94	11/04/94	11/04/94	11/02/94	11/03/94	11/03/94
	UNITS							
Aluminum	MG/KG	477	2100	4620	1620	2980 J	3040 J	3880 J
Antimony	MG/KG	ND	ND	ND	ND	ND	ND	ND
Arsenic	MG/KG	ND	ND	0.53	ND	ND	1.4	0.93
Barium	MG/KG	2	7.2	6.8	5.2	5.9	6.3	7.8
Beryllium	MG/KG	ND	ND	0.04	0.02	ND	0.04	0.05
Calcium	MG/KG	103	41.4	35.6	48.9	339 J	152	272
Chromium	MG/KG	2.2	4.7	7.8	3.7	4.8 J	4.7	5.1
Cobalt	MG/KG	ND	ND	0.61 J	0.47 J	ND	0.71	0.88 J
Copper	MG/KG	0.7	0.69 J	1.7	0.66	ND	0.68 J	0.96
Iron	MG/KG	255	726	3250	1030	1870 J	1880 J	2160 J
Lead	MG/KG	2.5	4.8	7.7	3.5	4.7 J	3.9 J	4.5 J
Magnesium	MG/KG	21	123	185	100	119	135	193
Manganese	MG/KG	4.9 J	8.1 J	5.2 J	3.8 J	15.6 J	13.3	19.5
Mercury	MG/KG	ND	ND	ND	ND	ND	ND	ND
Nickel	MG/KG	1.2 J	ND	ND	ND	ND	ND	ND
Potassium	MG/KG	ND	215 J	311	179 J	ND	135 J	201 J
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	17.5	67.4	24.1	67.5	37.1	ND	ND
Vanadium	MG/KG	1.9 J	4.5 J	16.2 J	3.1 J	6.2	6.5	7.1
Zinc	MG/KG	1.6	ND	ND	ND	ND	ND	9.5 J
Moisture	%	N/A	N/A	N/A	N/A	14.95	N/A	N/A

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

TABLE 4-10
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TCL ORGANICS

Client Sample ID:		80-MW01-01	80-MW02-01	80-MW03-01	80-MW04-01	80-MW05-01	80-MW06-01	80-MW07-01
Laboratory Sample ID:		AD0580	AD0586	AD0577	AD0600	AD0574	AD0566	AD0603
Date Sampled:		11/20/94	11/21/94	11/20/94	11/19/94	11/20/94	11/20/94	11/19/94
	UNITS							
VOLATILES								
Carbon Disulfide	UG/L	ND	ND	1 J	ND	ND	ND	ND
SEMIVOLATILES								
Acenaphthene	UG/L	ND	ND	4 J	ND	ND	ND	ND
Dibenzofuran	UG/L	ND	ND	2 J	ND	ND	ND	ND
Fluorene	UG/L	ND	ND	3 J	ND	ND	ND	ND
Carbazole	UG/L	ND	ND	3 J	ND	ND	ND	ND
Pyrene	UG/L	ND	ND	1 J	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/L	5 J	ND	ND	ND	4 J	2 J	4 J
di-n-Octylphthalate	UG/L	ND	1 J	ND	ND	ND	ND	ND
PESTICIDES/PCBs								
4,4'-DDD	UG/L	ND	ND	ND	2.2 J	ND	ND	ND
4,4'-DDT	UG/L	ND	ND	ND	0.58 J	ND	ND	ND

UG/L - microgram per liter
J - value is estimated
ND - [illegible]tected

TABLE 4-11
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL TOTAL METALS

Client Sample ID:		80-MW01-01	80-MW02-01	80-MW03-01	80-MW04-01	80-MW05-01	80-MW06-01	80-MW07-01
Laboratory Sample ID:		AD0581	AD0587	AD0578	AD0601	AD0575	AD0567	AD0604
Date Sampled:		11/20/94	11/21/94	11/20/94	11/19/94	11/20/94	11/20/94	11/19/94
	UNITS							
Aluminum	UG/L	743	43000	757	26900	274	840	663
Arsenic	UG/L	ND	13.6	102	ND	ND	ND	ND
Barium	UG/L	49.5	229	19.6 J	252	67.1	80.1	70.2
Beryllium	UG/L	ND	1.5	ND	1.2	ND	ND	ND
Calcium	UG/L	2360	21700	64900	6810	9190	15700	6460
Chromium	UG/L	ND	65	ND	53.3	ND	ND	ND
Copper	UG/L	ND	14.5	ND	13.5	ND	ND	ND
Iron	UG/L	ND	21500	9460	23800	ND	ND	ND
Lead	UG/L	ND	30 J	ND	28.2 J	ND	5.7 J	ND
Magnesium	UG/L	3330	21000	3590	7280	5820	11400	3770
Manganese	UG/L	ND	103	369	43.9	47.7	81.7	ND
Mercury	UG/L	ND	0.42	ND	ND	ND	ND	ND
Nickel	UG/L	ND	ND	ND	24	ND	ND	ND
Potassium	UG/L	ND	13800	14600	4320	2170	8720	1680
Sodium	UG/L	7470	8040	6910	6260	23100	8980	20300
Vanadium	UG/L	ND	44.9	ND	40.7	ND	ND	ND
Zinc	UG/L	ND	76.5 J	ND	ND	ND	106	ND

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

TABLE 4-12
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11 (Site 80)
GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL DISSOLVED METALS

Client Sample ID:		80-MW01D-01	80-MW02D-01	80-MW03D-01	80-MW03IWD-01	80-MW04D-01	80-MW05D-01	80-MW06D-01	80-MW07D-01
Laboratory Sample ID:		AD0613	AD0615	AD0611	AD2090	AD0617	AD0609	AD0607	AD0618
Date Sampled:		11/21/94	11/21/94	11/20/94	12/01/94	11/19/94	11/20/94	11/20/94	11/19/94
	UNITS								
Aluminum	UG/L	751	13400	ND	ND	231	ND	753	491
Antimony	UG/L	ND	51.1	ND	ND	ND	ND	ND	ND
Arsenic	UG/L	ND	ND	79.8	ND	ND	ND	ND	ND
Barium	UG/L	50.4	122	11.8 J	22.5 J	127	58.4	81.9	67.8
Beryllium	UG/L	ND	1.3	ND	ND	ND	ND	ND	ND
Calcium	UG/L	2610	26300	73600	72800	7420	8680	16500	6500
Cobalt	UG/L	ND	12.7	ND	ND	ND	ND	ND	ND
Copper	UG/L	ND	ND	ND	ND	12.4	17.4	17.2	14.5
Iron	UG/L	ND	ND	6780	ND	ND	ND	ND	ND
Lead	UG/L	4.6 J	ND	ND	ND	4.1 J	ND	ND	ND
Magnesium	UG/L	3490	24800	4080	3120	6310	5410	11800	3760
Manganese	UG/L	ND	121	414	51.3	ND	45.3	85.5	ND
Potassium	UG/L	ND	16000	17000	1030	2910	2140	8580	2320
Sodium	UG/L	7940	9690	7990	20300	7930	21400	9260	20300
Zinc	UG/L	ND	ND	ND	ND	ND	93.7 J	ND	ND

UG/L - microgram per liter
J - value is estimated
ND - [illegible]etected

TABLE 4-12A
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11
SITE 80 - ROUND 2 - GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:	80-MW01-02	80-MW02-02	80-MW03-2	80-MW03IW-02	80-MW04-02	80-MW05-02
Laboratory Sample ID:	AH3924	AH3921	9511G321-001	AH3887	AH3922	AH3926
Date Sampled:	12/17/95	12/15/95	11/15/95	12/14/95	12/17/95	12/15/95
TOTAL ANALYTES (ug/L)						
Aluminum	672	4370	37.5	ND	696	17100
Arsenic	ND	ND	42	ND	ND	ND
Barium	55.6	135	12.1	11.7	181	405
Calcium	1630	13100	29100	78700	6780	53800
Copper	ND	ND	2.4	ND	ND	ND
Iron	ND	ND	13900	251	ND	ND
Lead	4.6	2.4	ND	ND	ND	ND
Magnesium	3680	11300	3580	2580	7860	39000
Manganese	ND	51.4	202	67	21.3	44.5
Mercury	ND	ND	ND	ND	ND	0.54
Nickel	ND	ND	ND	ND	ND	ND
Potassium	1130	14300	18300	1140	3430	10200
Silver	ND	ND	ND	ND	ND	3.8
Sodium	10100	8210	6250	9590	6760	26100
Thallium	ND	13.4	ND	ND	5.1	ND
Vanadium	ND	ND	3.3	ND	ND	ND
Zinc	ND	ND	45.1	21.5	ND	ND

ug/L = micrograms per liter
J = value is estimated
ND = not detected

TABLE 4-12A
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 11
SITE 80 - ROUND 2 - GROUNDWATER
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA
TAL INORGANICS

Client Sample ID:	80-MW06-02	80-MW07-02	80-MW08-02
Laboratory Sample ID:	AH3925	AH3888	AH3923
Date Sampled:	12/15/95	12/14/95	12/16/95
TOTAL ANALYTES (ug/L)			
Aluminum	898	1310	491
Arsenic	ND	ND	ND
Barium	94.9	80.9	63.1
Calcium	17500	4730	18700
Copper	ND	ND	ND
Iron	ND	ND	266
Lead	12.8	ND	ND
Magnesium	12800	3470	8220
Manganese	90.8	17.9 J	20.8
Mercury	ND	ND	ND
Nickel	10.1	ND	ND
Potassium	11200	1460	3290
Silver	ND	ND	ND
Sodium	8950	14700	12100
Thallium	ND	ND	ND
Vanadium	ND	ND	ND
Zinc	ND	26.4	ND

ug/L = micrograms per liter
J = value is estimated
ND = not detected

TABLE 4-13

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 11 (SITE 80)
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)[2]
80-MW01	26.48	1.8	1	130	21	4.78	22.2	41
11/21/94			2	127	22	4.49	22.2	8.5
			4	127	22	4.43	22.4	7.4
			5	127	22	4.43	22.5	4.25
			6	127	22	4.44	22.6	2.3
			7	127	22	4.38	22.6	1
			8	125	23	4.38	22.7	0.9
80-MW02	23.30	1	1	774	20	4.29	23	>100
11/21/94			2	790	19	4.34	23	>100
			3.75	790	19	4.08	18.8	>100
			6	790	19	4.16	20.1	>100
			7	23	19	4.09	19.8	>100
80-MW03	17.60	0.7	Well went dry, slow recharge. After recharge well was sampled.					
11/20/94								
80-MW04	29.72	2.65	1.9	183	25.5	5.16	23.2	22
11/19/94			2.6	160	25	5.38	22.7	3.35
			3.8	162	26	5.11	23.8	1.75
			5.7	113	26	5.15	24.3	1.3
80-MW05	29.52	2.18	2.8	240	19.5	4.98	21.1	76
11/20/94			3.9	241	20	5.22	20.2	35
			6	248	19	5.38	-	5.8
			7.8	221	20	5.26	-	3.1
			9.2	243	20	5.32	-	2.0
80-MW06	29.10	2	2.5	231	20.5	5.04	-	>100
1/20/94			4	347	21	4.69	21.3	905
			5.25	341	21	5.56	-	5.4
			6.5	344	21	4.55	-	3.6
			8	347	21	4.33	20.7	2.9

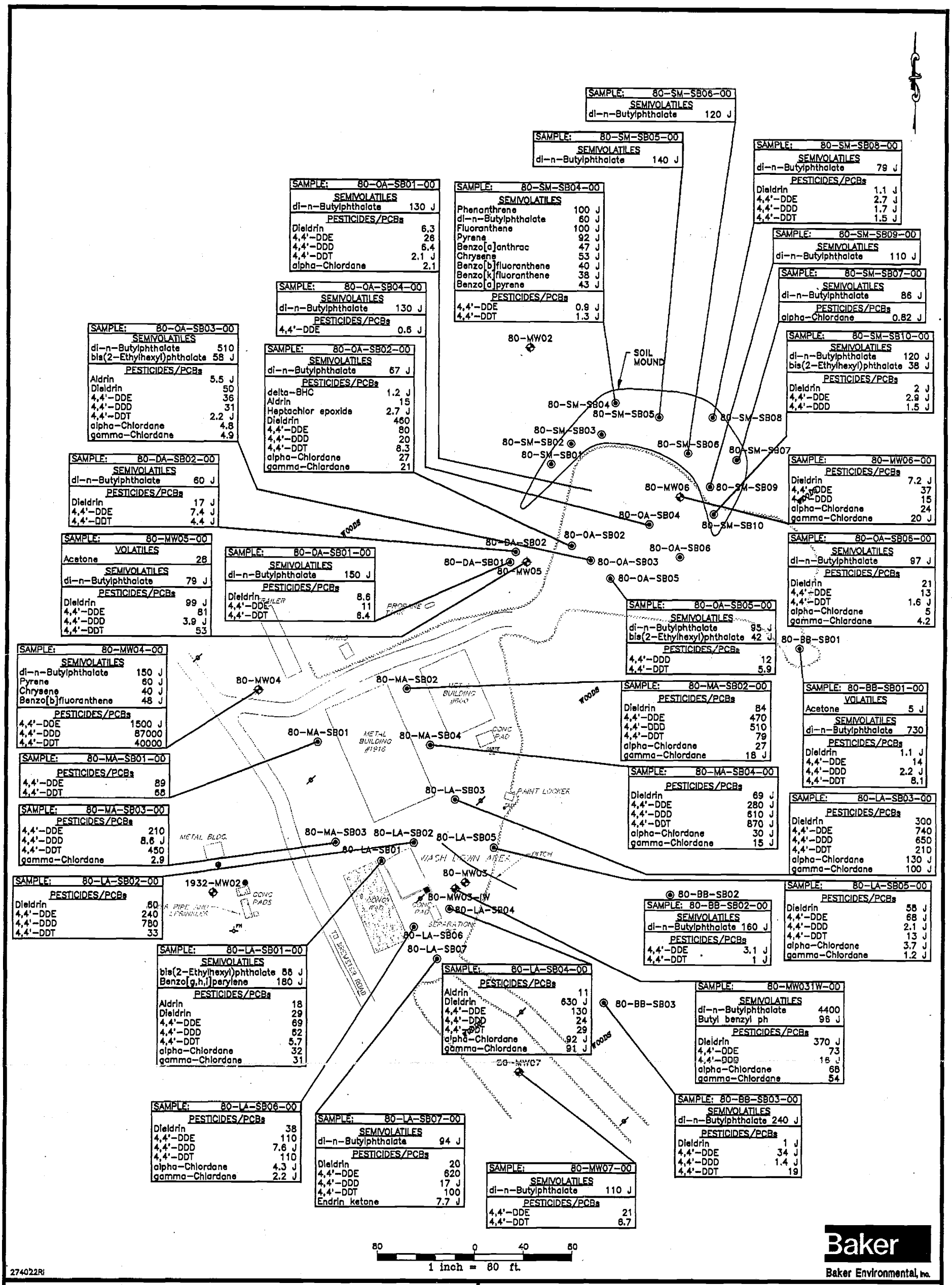
TABLE 4-13 (CONTINUED)

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 11 (SITE 80)
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)[2]
80-MW07	30.49	2.5	0.4	211	21	6.49	20.2	>100
11/19/94			1.8	221	20	5.69	20	>100
			2.6	211	21	5.46	-	23
			3.2	118	20.5	5.52	-	8.4
			4.2	210	20	5.30	-	4.1
			5.2	108	21	5.33	-	2.5
			6.2	108	21	5.26	-	1.3
80-MW08	26.75	2.1	0.5	383	19.3	5.52	19.0	69.0
7/14/95			1	377	19.2	45.66	19.1	34.0
			1.2	372	19.2	5.68	19.0	28.1
			1.4	372	19.4	5.63	19.2	21.4
			1.7	362	19.7	5.56	19.1	12.7
			1.9	373	19.5	5.56	18.7	7.3
			2.1	372	19.4	5.53	18.8	4.2
			2.4	362	19.6	5.56	19.2	5.3
			2.6	367	19.5	5.55	18.7	3.7
			2.9	375	19.2	5.55	18.7	2.3
			3.1	364	19.4	5.55	19.2	2.9
80-MW03IW	74.90	9.8	1.7	493	18	7.56	17.4	59
12/3/94			2	495	18.7	7.51	18.4	39
			3.1	488	22	8.24	19.9	19
			4.1	482	18.8	7.55	18.3	4.7
			5.1	469	19	7.5	18.6	2.6

(1) Measurements taken from top of PVC casing.
(2) NTU - nephelometric turbidity unit
" - " not measured

SECTION 4.0 FIGURES



274022RI

Baker Environmental, Inc.

LEGEND

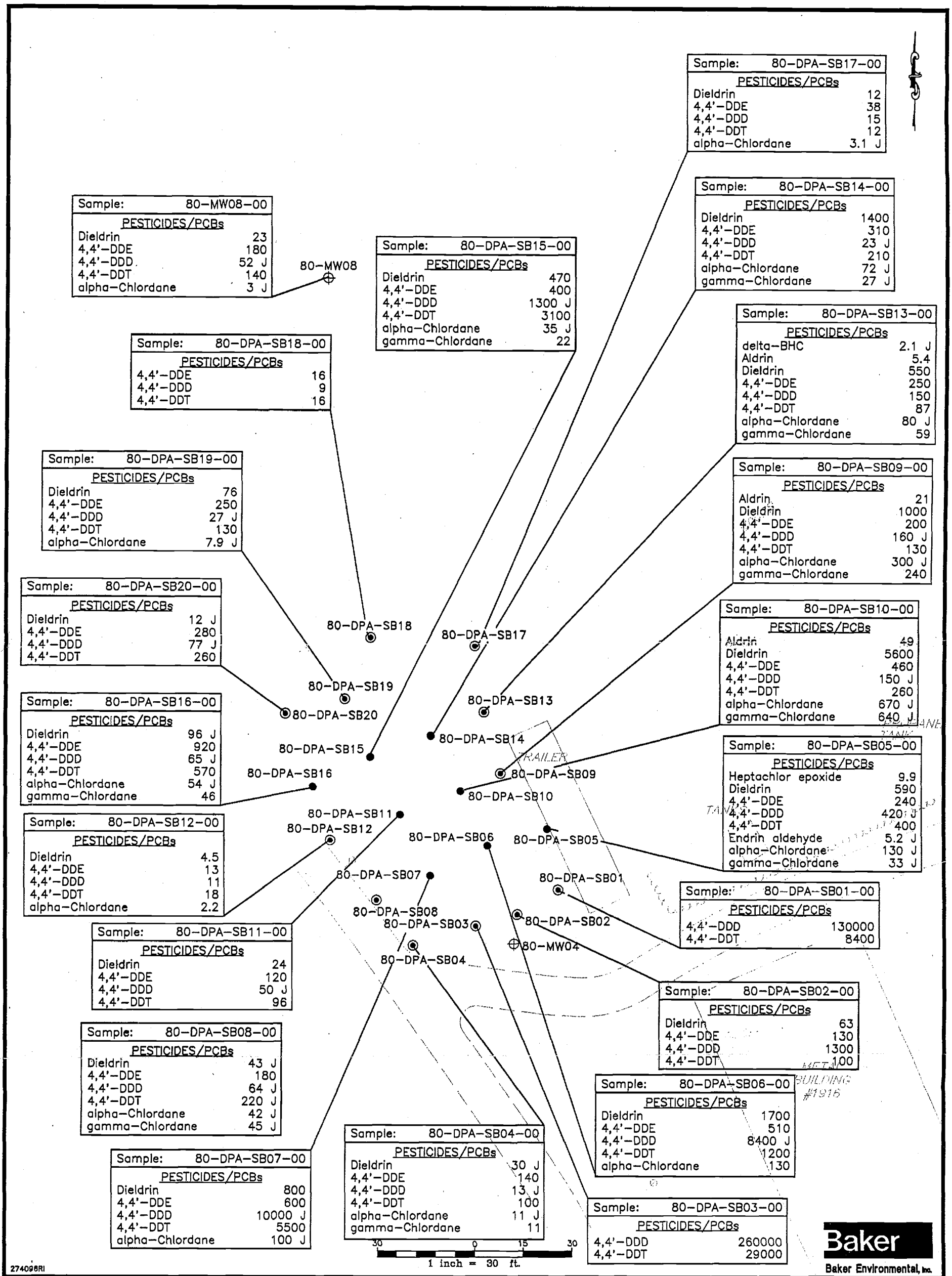
80-MW01 MONITORING WELL LOCATION

80-OA-SB01 SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS SHOWN 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 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE NORTH CAROLINA

01697XB3Z



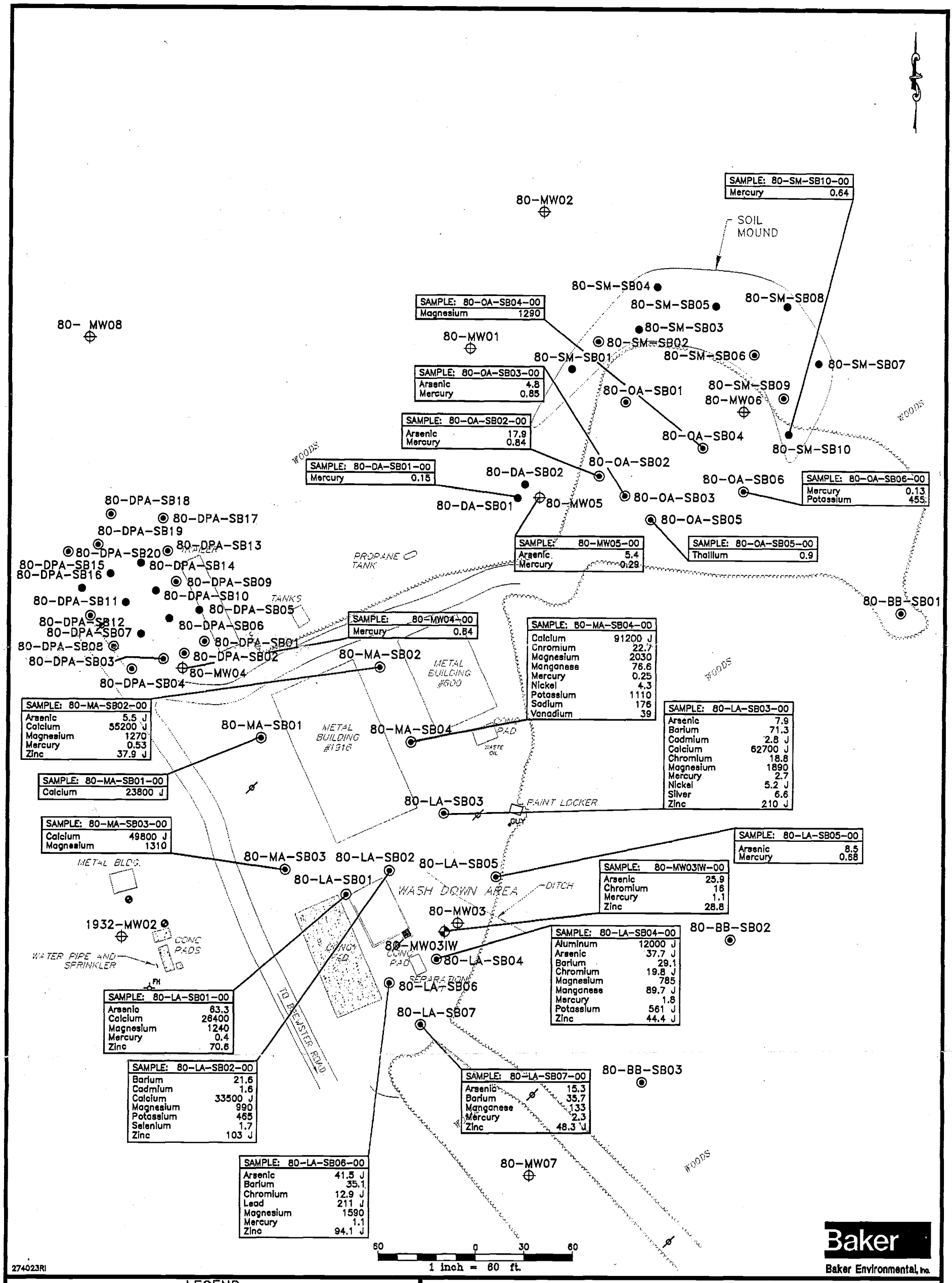
LEGEND

- 80-MW08 — SHALLOW MONITORING WELL LOCATION
- 80-DPA-SB01 — SOIL BORING LOCATION
- 80-DPA-SB05 — SURFACE SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MICROGRAMS PER KILOGRAM (ug/kg).
SOURCE: LANTDIV, OCT. 1991

FIGURE 4-2
POSITIVE DETECTIONS OF PESTICIDES IN SURFACE SOILS IN WEST/NORTHWEST SECTION AT SITE 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA REMEDIAL INVESTIGATION CTO-0274

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



274023RI

Baker

Baker Environmental, Inc.

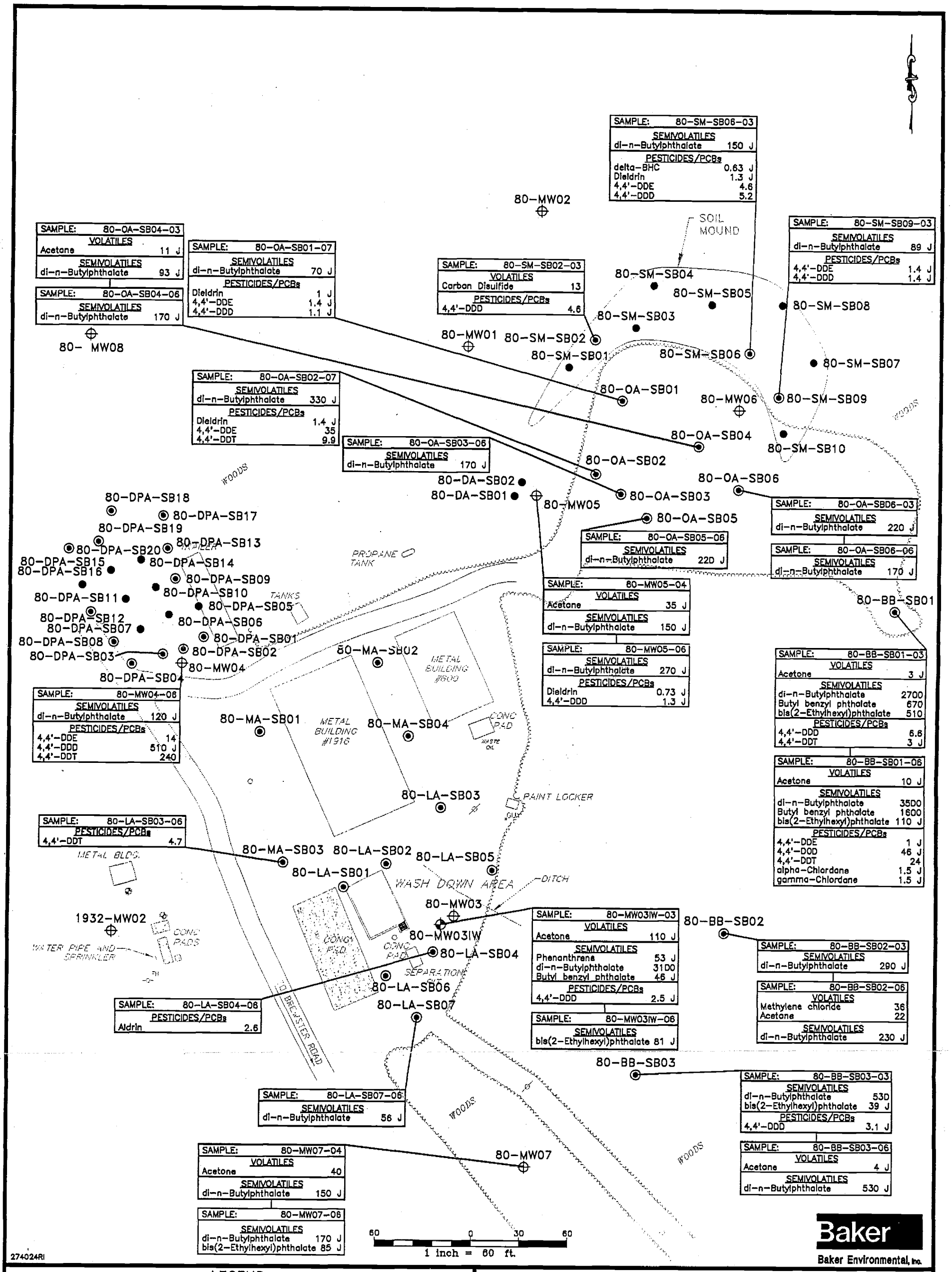
LEGEND

- 80-MW01 — SHALLOW MONITORING WELL LOCATION
- 80-MW03IW — INTERMEDIATE MONITORING WELL LOCATION
- 80-OA-SB01 — SOIL BORING LOCATION
- 80-SM-SB01 — SURFACE SOIL BORING LOCATION

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

FIGURE 4-3

POSITIVE DETECTIONS OF INORGANICS IN SURFACE SOILS ABOVE BASE BACKGROUND LEVELS AT SITE 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

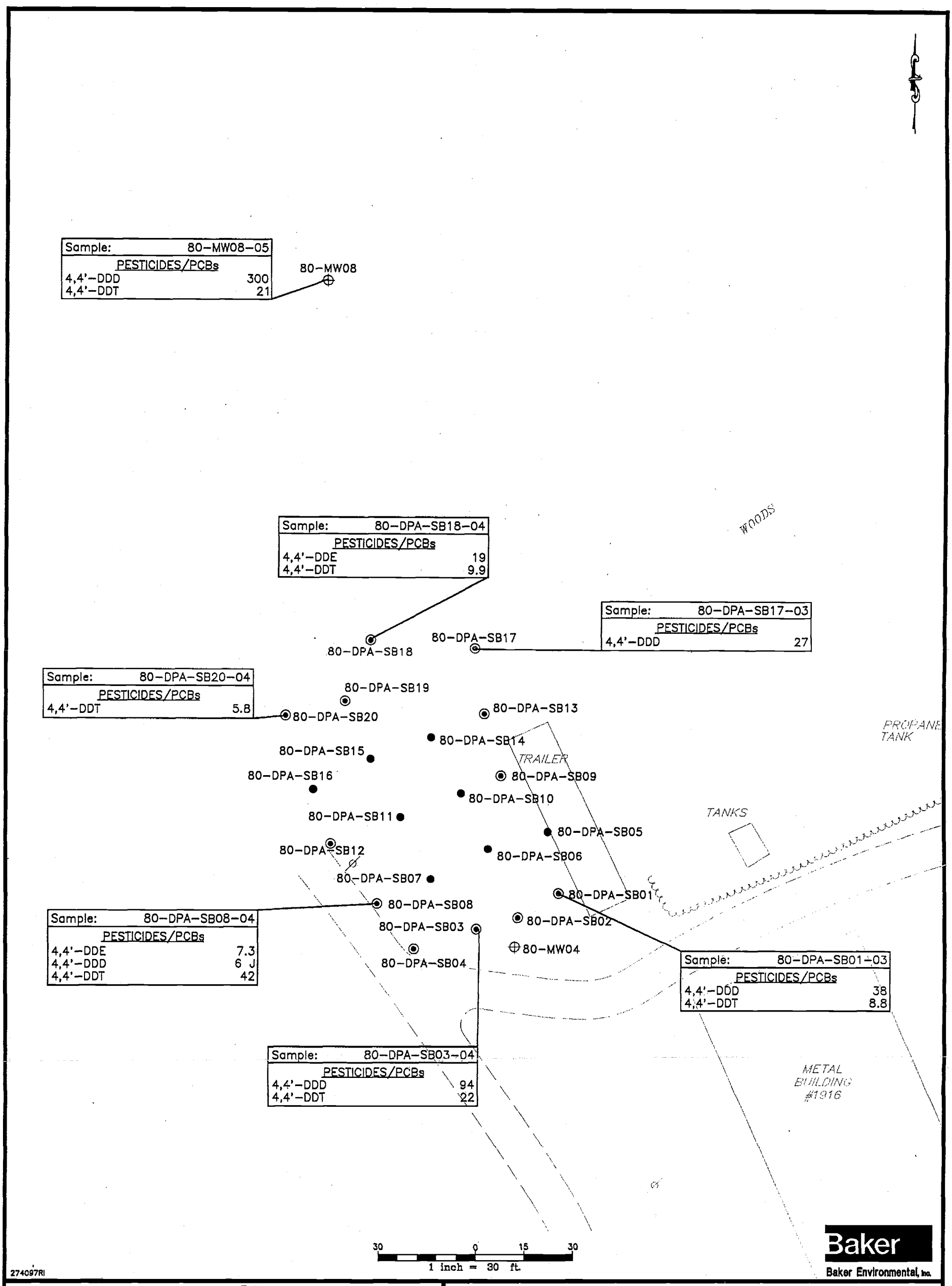


LEGEND

- 80-MW03 — SHALLOW MONITORING WELL LOCATION
- 80-MW03-IW — INTERMEDIATE MONITORING WELL LOCATION
- 80-OA-SB01 — SOIL BORING LOCATION
- 80-SM-SB01 — SURFACE SOIL BORING LOCATION

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

FIGURE 4-4
POSITIVE DETECTIONS OF ORGANICS IN SUBSURFACE SOILS AT SITE 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE NORTH CAROLINA



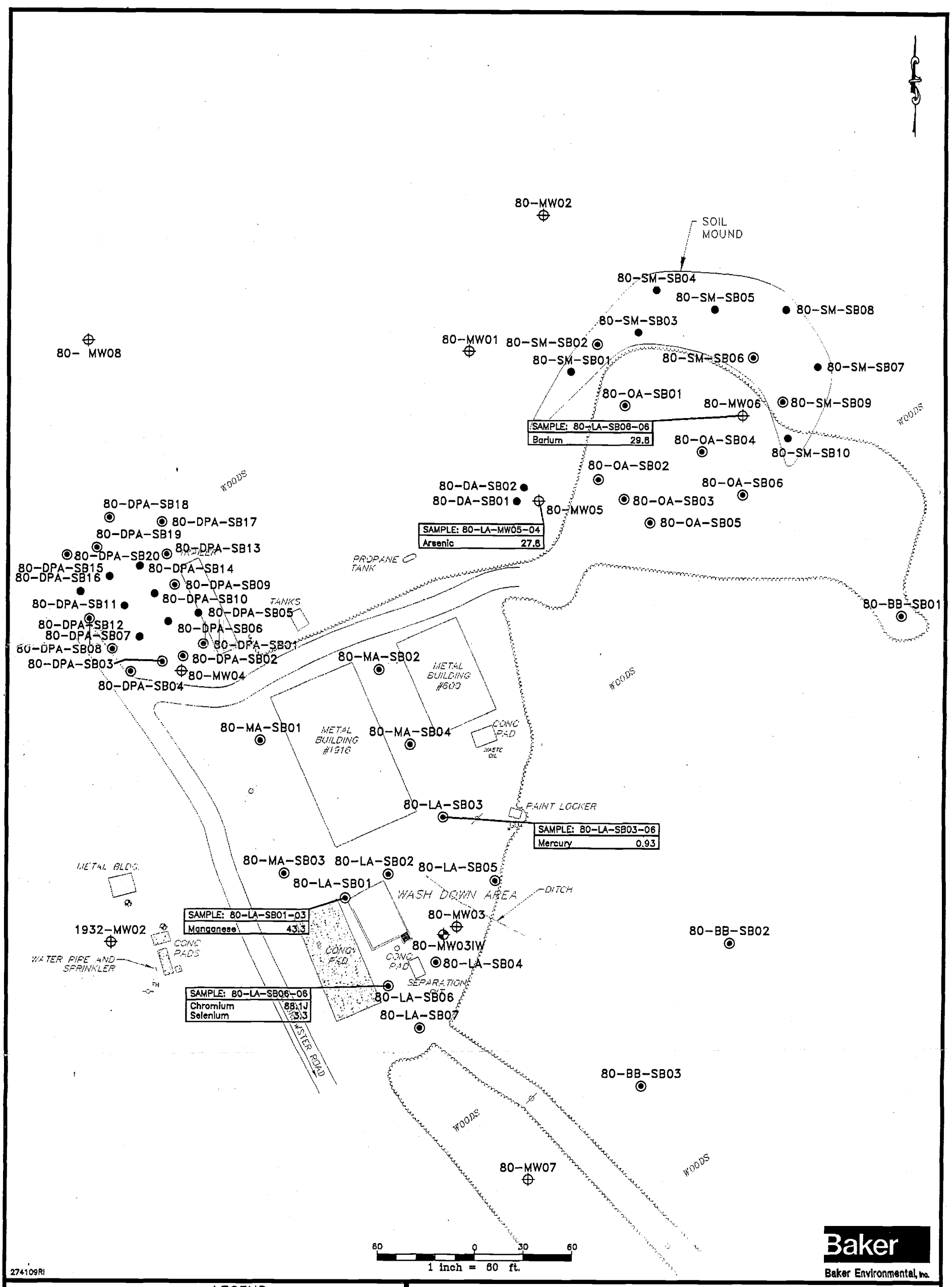
LEGEND

- 80-MW08 — SHALLOW MONITORING WELL LOCATION
- 80-DPA-SB01 — SOIL BORING LOCATION
- 80-DPA-SB05 — SURFACE SOIL BORING LOCATION

NOTE:
-SAMPLE CONCENTRATIONS SHOWN IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: LANTDIV, OCT. 1991

FIGURE 4-5
POSITIVE DETECTIONS OF PESTICIDES IN SUBSURFACE SOILS IN NORTH/NORTHWEST SECTION AT SITE 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

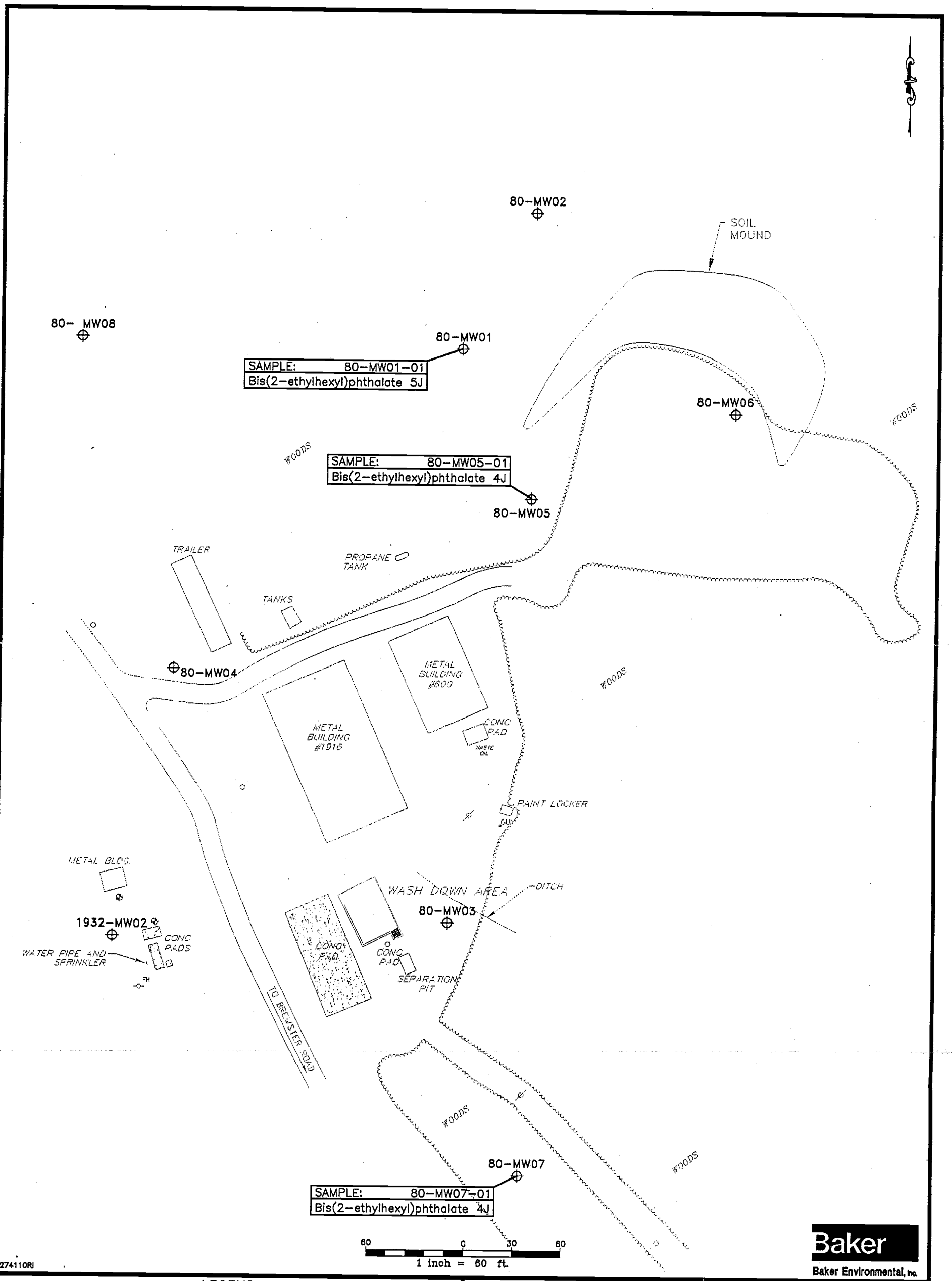


LEGEND

- 80-MW03 — SHALLOW MONITORING WELL LOCATION
- 80-MW03-IW — INTERMEDIATE MONITORING WELL LOCATION
- 80-OA-SB01 — SOIL BORING LOCATION
- 80-SM-SB01 — SURFACE SOIL BORING LOCATION

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

FIGURE 4-6
POSITIVE DETECTIONS OF INORGANICS IN SUBSURFACE SOILS ABOVE BASE BACKGROUND LEVELS AT SITE 80 - PARADISE POINT GOLF COURSE MAINTENANCE AREA REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

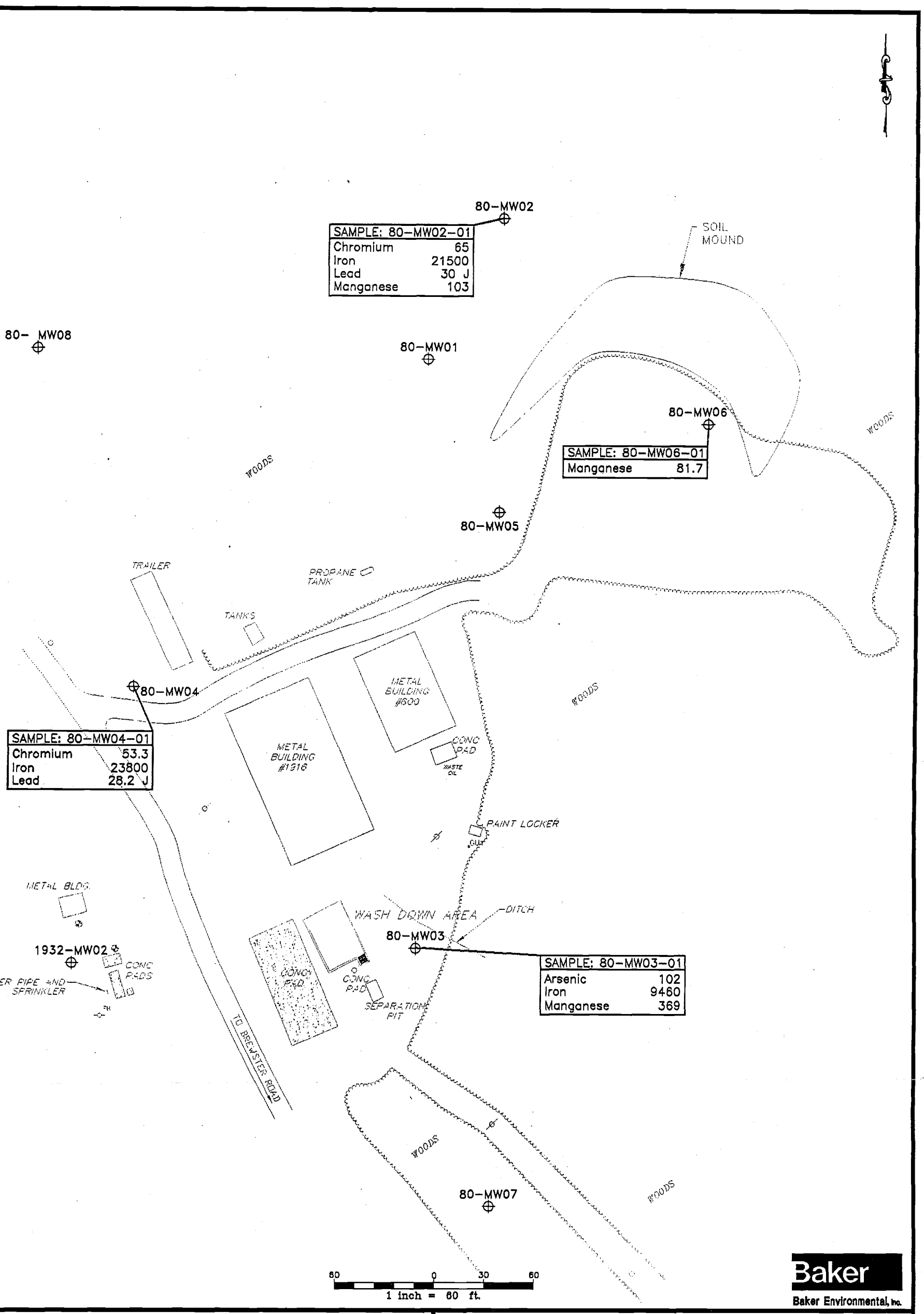


LEGEND

80–MW07 ⊕ SHALLOW MONITORING WELL LOCATION

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

FIGURE 4–7
POSITIVE DETECTIONS OF ORGANICS ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS AT SITE 80 – PARADISE POINT GOLF COURSE MAINTENANCE AREA REMEDIAL INVESTIGATION CTO–0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

80–MW07 ⊕ SHALLOW MONITORING WELL LOCATION

NOTE:
–SAMPLE CONCENTRATIONS SHOWN IN MICROGRAMS PER LITER (ug/L).

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

FIGURE 4–8
POSITIVE DETECTIONS OF TOTAL TAL METALS ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS AT SITE 80 – PARADISE POINT GOLF COURSE MAINTENANCE AREA
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 No. 11, Site 80, 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 80, the following potential contaminant transport pathways have been identified.

- On-site atmospheric deposition of windblown dust.
- Leaching of sediment contaminants to surface water.
- Leaching of soil contaminants to groundwater.
- Migration of groundwater contaminants off site.
- Migration of contaminants in surface water.
- Surface soil run-off from Site 80

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 On-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.

Site 80 is relatively flat with a slight slope to the northeast. The site is covered with grass and small pines. This vegetation reduces the likelihood of fugitive dust generation. Consequently, this transport pathway is not significant at the 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 the 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}).

At Site 80, there are no surface water bodies that traverse the site. However, there is a drainage ditch to the southeast of the wash area at Site 80. The drainage ditch enters the site from the machine shop road to the south of the site, curves around the back of the site, and leaves the site to the north. Surface water and sediment samples were not collected during this investigation, however, they were collected during a previous investigation performed by Halliburton NUS in 1991. Therefore, this pathway is not significant at this site.

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 and one intermediate monitoring wells at Site 80. 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.

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. There are no surface water bodies within the site boundaries of Site 80; therefore, this pathway is not 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 (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).

The study area is relatively flat, with a slight slope to the northeast. During the March 1994 site reconnaissance, surface water runoff was observed flowing in a southeast direction in the direction of the ditch. Surface water continues in a north-northeast direction away from the site. Groundwater flow direction across the site is to the northwest and discharges into Northeast Creek and its confluence with the New River.

Table 5-2 presents the general processes which influence the aquatic fate of contaminants at Site 80, 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 or aquatic processes for the fate of each compound, may aid in the elimination of unimportant processes.

5.2.5 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 particle into surface water and migrate in one of the aforementioned methods. There are no surface water bodies associated with this site; therefore, this is not considered to be a significant migration pathway.

5.2.6 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 site topography is variable with elevations ranging from 3 feet msl to 26 feet msl. The slope of the site is to the northeast. There are no surface water bodies within the site boundaries.

The following paragraphs summarize the site-specific fate and transport data for some contaminants detected at Site 80.

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 80.

5.3.1 Volatile Organic Compounds

VOCs (i.e., carbon disulfide) 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 Polycyclic Aromatic Hydrocarbons

Low water solubilities, high K_{ow} and K_{oc} indicate a strong tendency for PAHs to adsorb to soils. Of the PAHs, pyrene, 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. Other PAH are acenaphthene, fluorene, and pyrene. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint. An exceptionwould be 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 and 4,4'-DDD). As evidenced by the ubiquitous nature of 4,4'-DDT, 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. Soils at MCB Camp Lejeune are relatively neutral, 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. Department of Health Services. Toxicological Profile for p,p'-DDT, p,p'-DDE and p,p'-DDD. April 1989.

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.

Jones, et al., 1989.

Laskowski, D.A., C.A. Goring, P.S. MeCall and R.L. Swann. 1983."Terrestrial Environment Risk Analysis for Chemical." Environmental Risk Analysis for Chemical, R.A. Conways, ed. Van Noskrand Reinhold Co., New York, NY.

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, 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface Water-Part I. EPA/600-6-85/022a. September 1985.

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.

SECTION 5.0 TABLES

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES FOR ORGANIC CHEMICALS OF POTENTIAL CONCERN
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
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 ($atm\text{-}m^3/mole$)	Mobility Index
Volatiles:							
Carbon Disulfide	$3.6 \times 10^{+02}$[1]	$1.2 \times 10^{+03}$[1]	1.73[2]	2.0[2]	1.263[8]	3.0×10^{-02}[1]	3.9
Semivolatiles:							
Acenaphthene	1.5×10^{-03}[3]	3.47[3]	1.25[3]	3.97[3]	0.994[8]	1.5×10^{-04}[3]	2.5
Dibenzofuran	--	10[5]	3.9-4.10[5]	4.12-4.31[5]	1.0886[5]	--	--
Fluorene	1×10^{-02}[3]	1.69[3]	3.65[3]	4.18[3]	--	1.29×10^{-03}[3]	-5.4
Carbazole	7.0×10^{-04}[4]	1.2[4]	--	3.72[4]	1.1[4]	--	--
Pyrene	2.5×10^{-06}[3]	0.14[3]	4.64[3]	5.32[3]	--	4.75×10^{-06}[3]	-11.1
Bis(2-ethylhexyl)phthalate	9.8×10^{-06}[1]	0.34[1]	8.73[2]	5.1[1]	0.99[8]	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[8]	--	-14.3
Pesticides/PCBs:							
4,4'-DDD	1×10^{-06}[7]	0.16[6]	5.9[6]	6.2[6]	--	4×10^{-06}[1]	-12.7
4,4'-DDT	1.9×10^{-07}[7]	0.0034[6]	5.4[6]	6.19[6]	--	8.3×10^{-06}[1]	-14.6

Notes: -- = Value not available.
(1) SCDM, 1992
(2) SPHEM, 1986
(3) USEPA, 1985.
(4) USEPA, 1986.
(5) Montgomery, 1980.
(6) ATSDR, 1989.
(7) Clement, 1985.
(8)Verscheuran, 1983.

TABLE 5-2

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Volatiles: Carbon Disulfide	NA	NA	NA	NA	NA	NA
Semivolatiles: Acenaphthene(b)	+	--	+	+	--	--
Dibenzofuran	NA	NA	NA	NA	NA	NA
Fluorene(b)	+	--	+	+	--	--
Carbazole	NA	NA	NA	NA	NA	NA
Pyrene(b)	+	--	+	+	--	--
Bis(2-ethylhexyl)phthalate	+	--	+	--	--	+
Di-n-octylphthalate	+	--	+	--	--	+
Pesticides/PCBs: 4,4'-DDD	+	+	--	--	--	+
4,4'-DDT	+	+	--	--	+	+

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)
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Relative Mobility	Environmental Conditions			
	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. Additionally, a Time-Critical Removal Action (TCRA) has been proposed for the removal of pesticide and inorganic contaminated surface soil within the investigation area. Engineering design activities were completed in December 1995. Therefore, the BRA for this site was evaluated using contaminant concentrations before and after the TCRA. 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. 11, Site 80 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. Three environmental media were investigated during this RI: surface soil, subsurface soil and groundwater. 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 quantitation 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 variances in 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 this 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. 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. Health Advisories (HA) are relevant regulatory guidelines.

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 6-6 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.

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 80. 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. A TCRA has been designed for the removal of pesticide and inorganic (i.e., arsenic) contaminated surface soil. Therefore COPC selection will be discussed for soil contaminants prior to the TCRA and for soil contaminants remaining after the proposed TCRA.

6.2.2.1 Surface Soil

Thirty-four surface soil samples were analyzed for volatile organic contaminants (VOCs). Acetone was detected at a maximum concentration less than the residential soil RBC value. For this reason, it is not retained as a COPC.

Thirty-four surface soil samples were analyzed for SVOCs. The following contaminants were detected at concentrations less than respective residential soil RBC values: di-n-butylphthalate, fluoranthene, pyrene, butylbenzylphthalate, benzo(a)anthracene, chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene. For this reason, these SVOCs are not retained as COPCs. Phenanthrene and benzo(g,h,i)perylene were detected in 1 of 34 samples. These contaminants are not retained as COPCs, because the frequency of detection is less than 5 percent.

Fifty-five surface soil samples were analyzed for pesticide/PCBs. The following contaminants were detected at maximum concentrations less than respective residential soil RBC values: delta-BHC, heptachlor epoxide, 4,4'-DDE, endrin ketone and endrin aldehyde. For this reason, these contaminants are not retained as COPCs.

Aldrin, dieldrin, 4,4'-DDD, 4,4'-DDT, alpha-chlordane and gamma-chlordane were detected frequently (i.e., greater than 5 percent) in surface soil. In addition, these organics were detected at maximum concentrations exceeding respective residential RBC values. Consequently, these pesticides are retained as COPCs in surface soil.

Thirty-four surface soil samples were analyzed for inorganic contaminants. The following contaminants were detected at maximum concentrations less than respective residential soil RBCs: barium, cadmium, chromium, cobalt, copper, nickel, selenium, silver, vanadium and zinc. For this reason, these inorganics are not retained as COPCs. Consequently, these contaminants are not retained as COPCs. Thallium is not retained as a COPC, because the frequency of detection is less than 5 percent. Calcium, iron, magnesium, potassium, and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

Aluminum, arsenic, beryllium, manganese and mercury were detected frequently (i.e., greater than 5 percent) in surface soil samples. In addition, these inorganics were detected at maximum

concentrations exceeding respective background levels or residential soil RBCs. These inorganics are retained as COPCs in surface soil.

6.2.2.2 Surface Soil after TCRA

Twenty-two surface soil samples, that were analyzed for VOCs, will remain after the TCRA is completed. VOCs were not detected in the remaining soils. For this reason there are no VOCs retained as COPCs.

There were no SVOCs retained as COPC prior to the TCRA; therefore, no SVOCs are retained for evaluation after the TCRA.

After the TCRA, the maximum contaminant level for aldrin, dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, endrin ketone, alpha chlordane, and gamma-chlordane will be less than the respective residential soil RBC. For this reason, no pesticides are retained to estimate the risk after the TCRA.

Twenty-two surface soil samples that were analyzed for inorganics will remain after the TCRA. The following inorganics will remain at concentrations less than their respective residential soil RBC and will are not retained as COPCs: barium, cadmium, chromium, cobalt, copper, manganese, mercury, nickel, vanadium, and zinc. Contaminants that are essential nutrients (i.e., calcium and magnesium) are not retained as COPCs. Aluminum, arsenic, beryllium, and iron will remain at concentrations above their respective residential soil RBC. For this reason, these inorganics will be retained as COPCs after the TCRA.

6.2.2.3 Subsurface Soil

Thirty-two subsurface soil samples were analyzed for VOCs. Acetone and carbon disulfide were detected at maximum concentrations less than respective industrial soil RBC values. In addition, acetone was detected in soil samples at a maximum concentration less than the level detected in blanks. Consequently, these contaminants are not retained as COPCs.

Thirty-two subsurface soil samples were analyzed for SVOCs. Di-n-butylphthalate, butylbenzylphthalate and bis(2-ethylhexylphthalate) were detected at maximum concentrations less than respective industrial soil RBC values. For this reason, these contaminants are not retained at COPCs. Phenanthrene was detected in 1 of 32 samples. It is not retained as a COPC, because the frequency of detection is less than 5 percent.

Forty-five subsurface soil samples were analyzed for pesticide/PCBs. The following pesticides were detected at maximum concentrations less than respective industrial soil RBCs values: delta-BHC, aldrin, dieldrin, 4,4'-DDE, 4,4'-DDD and 4,4'-DDT. In addition, delta-BHC and aldrin were detected at frequencies less than 5 percent. Consequently, these contaminants are not retained as COPCs.

Thirty-two subsurface soil samples were analyzed for inorganic contaminants. The following inorganics were detected at maximum concentrations less than respective industrial soil RBCs: aluminum, antimony, barium, beryllium, chromium, cobalt, copper, manganese, mercury, nickel, selenium, vanadium and zinc. For this reason, these contaminants are not retained as COPCs. Calcium, iron, magnesium, potassium and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

Arsenic and lead were detected frequently in subsurface soil samples (i.e., greater than 5 percent). The maximum sample concentrations exceed respective background levels. In addition, arsenic is detected at a maximum concentration that exceeds the industrial soil RBC. Consequently, arsenic and lead are retained as COPCs in subsurface soil.

6.2.2.4 Groundwater Round One

Eight groundwater samples were analyzed for VOCs. Carbon disulfide was detected at a maximum concentration less than the tap water RBC value. For this reason, it is not retained as a COPC.

Eight groundwater samples were analyzed for SVOCs. The following contaminants were detected at maximum concentrations less than respective tap water RBCs: acenaphthene, dibenzofuran, fluorene, carbazole, pyrene and di-n-octylphthalate. For this reason, these contaminants are not retained as COPCs.

Bis(2-ethylhexyl)phthalate was detected frequently, at a maximum concentration exceeding the tap water RBC value. Consequently, it is retained as a COPC in groundwater.

Nine groundwater samples were analyzed for pesticide/PCB contaminants. 4,4'-DDD and 4,4'-DDT were detected at maximum concentrations exceeding respective tap water RBC values. For this reason, these contaminants are retained as COPCs.

Eight groundwater samples were analyzed for inorganic contaminants. Barium copper, mercury, nickel and zinc were detected at maximum concentrations less than respective tap water RBCs. For this reason, these contaminants are not retained as COPCs. Calcium, iron, magnesium, potassium and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

Aluminum, arsenic, beryllium, chromium, lead, manganese and vanadium were detected frequently, at maximum concentrations exceeding respective tap water RBC values. Consequently, these contaminants are retained as COPCs in groundwater.

6.2.2.5 Groundwater Round Two

Eight groundwater samples were analyzed for inorganic contaminants. The following inorganics were detected at maximum concentrations less than their respective tap water RBCs: copper, mercury, nickel, silver, vanadium, and zinc. For this reason, these inorganics are not retained as COPCs. Calcium, magnesium, potassium, and sodium are considered essential nutrients and are not retained as COPCs.

Aluminum, arsenic, barium, iron, and manganese were detected frequently at maximum concentrations exceeding tap water RBC values. Consequently, these contaminants are retained as COPCs.

6.2.2.6 Summary of COPCs

Table 6-7 presents a detailed summary of COPCs identified in each environmental medium sampled at Site 80. Worksheets used for COPC selection are presented in Appendix L.

6.3 Exposure Assessment

This section addresses potential human exposure pathways at Site 80 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 80. Figure 6-1 presents the Site 80 conceptual model. Inputs to the conceptual model include qualitative descriptions of current and future land use patterns in the vicinity of Site 80. 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 adult civilian base personnel
- Future construction worker

The investigation area is currently used to conduct maintenance on golf course equipment. The golf course encompasses the study area in all directions; consequently, it is unlikely that trespassers would come into this area. Additionally, there are no residential areas within a mile of the study area that would permit frequent exposures to the site.

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.
- 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 6-8 presents the matrix of human exposure at Site 80.

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 and for current adult civilian base personnel. Because surface soil represents the 0 to 6-inch depth construction workers are more likely to be exposed to subsurface soil (i.e., soil excavation typically occurs to depths beyond 6 inches). Consequently, surface soil exposure was not evaluated for future construction workers.

6.3.2.2 Subsurface Soil

Subsurface soil is available for contact only during excavation activities, so potential exposure to subsurface soil is limited to future construction workers. Exposure pathways involving ingestion and dermal contact are evaluated for future construction workers only.

6.3.2.3 Groundwater

Currently, shallow groundwater at Site 80 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. Groundwater exposure is evaluated for future residential children and adults. Potential exposure pathways are ingestion, dermal contact and inhalation of volatile contaminants while showering. No volatile organic contaminants, however, were retained as COPCs in groundwater. Consequently, the inhalation exposure pathway is not evaluated for Site 80.

6.3.2.4 Surface Water/Sediment

There is no surface water body in the proximity of Site 80. Therefore, surface water/sediment samples were not collected as part of the remedial investigation at Site 80. Consequently, exposure to surface water/sediment is not evaluated.

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 80. 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 L.

6.3.4 Calculation of Chronic Daily Intakes (CDI)

In order to numerically calculate risks for current and future human receptors at Site 80, a CDI must be computed for each COPC, in each relevant exposure pathway.

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 6-9 through 6-13.

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 25 years is used to estimate current civilian base personnel working at the site. 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).

Current Civilian Base Personnel

During the course of daily activities at Site 80, civilian base personnel may be exposed to COPCs by ingesting surface soil.

The IR for military personnel exposed to surficial soils is assumed to be 480 mg/day. An EF of 250 days per year is used in conjunction with a 25-year ED (USEPA, 1989a).

Carcinogenic compounds have an AT 25,550 days (70 years x 365 days/year), and the AT for noncarcinogenic compounds is 9,125 days (25 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, 1991). 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 6-9.

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, 1992c).

Civilian Base Personnel

During work-related activities, base personnel may be exposed to COPCs through dermal contact with surface soil.

It is assumed that civilian base 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.

Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1992c).

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 6-10.

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 6.78E08 m^3/kg for all receptors in this scenario (USEPA, 1995).

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.

A derived IR value for residential exposure scenarios, 20 m^3/day is used for adults (USEPA 1991), and 12 m^3/day is used for children (USEPA 1995).

ED, EF, BW and AT values are the same as those used the incidental soil ingestion scenario.

Civilian Base Personnel

During work-related activities, base personnel may inhale COPCs emitted as fugitive dust. An inhalation rate of 20 m^3/day is used in this scenario (USEPA 1991).

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 1991).

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 6-11.

6.3.4.4 Ingestion of Groundwater

Currently at Site 80, 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.

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

Future children and adult residents may be exposed to COPCs through groundwater ingestion.

A 6-year-old child weighing 15kg has an IR of 1.0 L/day (USEPA 1991). 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 (USEPA 1989a).

IR for adults is 2 L/day (USEPA 1989a). ED is 30 years, the national upper-bound (90th percentile) length of time spent at one residence (USEPA 1991). 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 (USEPA 1989a).

A summary of groundwater ingestion exposure assessment input parameters is presented in Table 6-12.

6.3.4.5 Dermal Contact with Groundwater

As stated previously, deep groundwater currently provides the potable water supply at Site 80. 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.

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with groundwater, is as follows:

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

Where:

C	=	Contaminant concentration is groundwater (mg/L)
SA	=	Surface area available for contact (cm^2)
PC	=	Dermal permeability constant (cm/hr)
ET	=	Exposure time (hour/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Conversion factor (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) (USEPA 1991). The SA available for dermal absorption is estimated at 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992a).

PC is used to evaluate 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 (USEPA 1992a).

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 6-13.

Appendix M contains CDI calculation spreadsheets for specific exposure scenarios.

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 6-14. 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:

$$ICR = \sum_{i=1}^{n} CDI_i \times CSF_i$$

where CDI_i is the chronic daily intake (mg/kg/day) for compound i, and CSF 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:

$$HI = HQ_1 + HQ_2 + ...HQ_n$$

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

$$\gamma \text{ where } HQ_i = CDI_i / RfD_i$$

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 80 (soil and groundwater) are presented in Tables 6-15 and 6-16, 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 80, presented in Tables 6-15 and 6-16.

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 and future construction workers fall within or below the USEPA acceptable risk range. In other words, carcinogens in Site 80 soil generate no risks beyond acceptable levels for these three receptors. The ICR value calculated for current civilian base personnel, however, exceeds the acceptable risk range (ICR = 1.6E-04). This indicates that base personnel currently working at Site 80 may be at risk from carcinogens in the soil. Incidental soil ingestion drives this carcinogenic risk. Dieldrin is the COPC making the primary contribution to this risk (60 percent), and arsenic is a secondary contributor (23 percent).

HI values calculated for future residential adults, current civilian base personnel and future construction workers are less than 1.0, below the acceptable risk level for these three receptors. In other words, noncarcinogens in Site 80 soil generate no risks beyond acceptable levels. The HI value calculated for future residential children, however, is greater than 1.0 (HI = 1.8). This indicates that future residential children may experience adverse systemic health effects from noncarcinogens in Site 80 soil. Incidental soil ingestion drives this noncarcinogenic risk. Dieldrin is the COPC making the primary contribution to this risk (34.68 percent), and arsenic is a secondary contributor (36 percent).

6.5.1.2 TCRA Soil

ICR values estimated for current civilian base personnel (1.7E-05) and future receptors (i.e., children 1.1E-05, adults 5.1E-06, and construction workers 1.5E-07) do not exceed the USEPAs acceptable risk range.

HI values for current civilian base personnel (0.22) and future receptors (i.e., children 0.67, adults 0.11, and construction workers 0.02) are less than 1.0. This indicates that current and future receptors will not experience systemic health effects from exposure to soil once the contaminated soil has been removed.

6.5.1.3 Groundwater

ICR values calculated for future residential children and adults exceed the USEPA acceptable risk range (Child ICR = 6.8E-04; Adult ICR = 1.5E-03). This indicates that future residents may be at risk from carcinogens in Site 80 groundwater. Groundwater ingestion drives these carcinogenic risks. Arsenic is the COPC making the primary contribution to these risks (96 percent).

HI values calculated for future residential children and adults are greater than 1.0 (Child HI = 21; Adult HI = 9). This indicates that future residents may experience adverse systemic health effects from noncarcinogens in Site 80 groundwater. Groundwater ingestion drives these noncarcinogenic risks. Arsenic is the COPC making the primary contribution to these risks (80 percent), and aluminum is a secondary contributor (13 percent).

6.5.1.4 Groundwater Round Two

ICR values for future residential children and adults exceed the USEPA acceptable risk range (Child ICR = 6.6E-04; Adult ICR = 1.4E-03). This indicates that future residents may be at risk from carcinogens in the shallow groundwater at Site 80. The groundwater risk is driven by the ingestion of groundwater with arsenic contributing almost 100 percent of the risk.

HI values for future residential children and adults, although less than Round 1, are greater than 1.0 (Children HI = 5.1; Adult HI = 2.2). This indicates that future residents may experience adverse systemic health effects from exposure to the shallow groundwater at Site 80. Ingestion of arsenic (76 percent) and aluminum (21 percent) account for a majority of the overall risk.

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 80 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 80 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 80 were not quantitatively evaluated in the BRA, as there is no toxicity information promulgated by the USEPA:

- lead

6.7 BRA Conclusions

The BRA evaluates environmental media at Site 80, in terms of human health risk. Potential receptors at the site include future residential children and adults, current civilian adult base 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

2. Current Civilian Adult Base 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. Incidental ingestion of COPCs subsurface soil + dermal contact with COPCs in subsurface soil + inhalation of airborne COPCs

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 (7.7E-04) exceeds the USEPA acceptable cancer risk range. Total HI (31) is greater than 1.0. The risk from groundwater exposure (ingestion) drives the total carcinogenic and noncarcinogenic risks for future residential children (88 percent and 93 percent

contribution to risks, respectively). The risk from soil exposure (ingestion) contributes 7 percent to the total HI.

6.7.1.2 Future Residential Children after the TCRA

The total ICR for future residential children (6.7E-04) exceeds the USEPAs acceptable risk range, and the total HI (5.8) is greater than 1.0. Exposure to groundwater, via ingestion, accounts for a majority of the total risk (98 percent of the carcinogenic and 88 percent of the noncarcinogenic).

6.7.1.3 Future Residential Adults

Total ICR for future residential adults (1.6E-03) exceeds the USEPA acceptable cancer risk range. Total HI, (9.3) is greater than 1.0. The risk from groundwater exposure (ingestion) drives the total carcinogenic and noncarcinogenic risks for future residential adults (94 percent and 97 percent contribution to risks, respectively).

6.7.1.4 Future Residential Adult after the TCRA

The total ICR for future residential adults (1.4E-03) exceeds the USEPA acceptable risk range, the total HI (2.3) exceeds 1.0. Exposure to groundwater, via ingestion, accounts for nearly 100 percent of the total carcinogenic and noncarcinogenic risk.

6.7.1.5 Current Civilian Adult Base Personnel

Total ICR for current civilian adult base personnel (1.6E-04) exceeds the USEPA acceptable risk range. Because base personnel are not exposed to groundwater, the risk from soil exposure (ingestion) contributes 100 percent to this carcinogenic risk. Total HI (0.65) is less than 1.0. It can then be concluded that noncarcinogens in environmental media at Site 80 generate no health risks in excess of acceptable levels.

6.7.1.6 Current Civilian Adult after the TCRA

The total ICR for current civilian adult base personnel (1.7E-05) is within the USEPAs acceptable risk range. Additionally the HI (0.22) is below 1.0. These values indicate that the removal of soils under the TCRA will reduce risks to an acceptable level.

6.7.1.7 Future Construction Workers

Total ICR for future construction workers (1.5E-07) is below the USEPA acceptable risk range. Total HI (0.02) is less than 1.0. It can then be concluded that COPCs in environmental media at Site 80 generate no health risks in excess of acceptable levels.

Total site ICR and HI values are presented in Table 6-18. Table 6-19 presents the ICR and HI values estimated for risks after the completion of the TCRA.

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
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
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/kg)
Volatiles				
Methylene Chloride	14	Soil	140	140
Acetone	13	Soil	130	130
1,2-Dichloroethane	2J	Soil	20	20
2-Butanone	10	Soil	100	100
Tetrachloroethene	3J	Soil	30	30
Inorganics				
Calcium	113	Soil	113	113
Iron	76.2	Soil	76.2	76.2
Lead	4.7	Soil	4.7	4.7
Manganese	0.45	Soil	0.45	0.45
Mercury	0.22	Soil	0.22	0.22
Sodium	42.2	Soil	42.2	42.2
Zinc	68.1	Soil	68.1	68.1
Volatiles				
Methylene Chloride	1J	Groundwater	10	NA
Acetone	12	Groundwater	120	NA
1,2-Dichloroethane	2J	Groundwater	20	NA
2-Butanone	8J	Groundwater	80	NA
Inorganics				
Aluminum	49.5	Groundwater	247.5	NA
Calcium	26.4	Groundwater	132	NA
Iron	31.1	Groundwater	155.5	NA
Manganese	2.5J	Groundwater	12.5	NA
Sodium	135	Groundwater	675	NA
Zinc	16.8J	Groundwater	84	NA

(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.

NA = Not applicable

TABLE 6-2

ORGANIC DATA SUMMARY
SURFACE SOIL
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Volatiles		
Acetone	28	1/34
Semivolatiles		
Phenanthrene	100J	1/34
Di-n-butylphthalate	60J - 4,400	20/34
Fluoranthene	100J	1/34
Pyrene	60J - 92J	2/34
Butyl benzyl phthalate	96J	1/34
Benzo(a)anthracene	47J	1/34
Chrysene	40J - 53J	2/34
Bis(2-ethylhexyl)phthalate	38J - 66J	4/34
Benzo(b)fluoranthene	40J - 48J	2/34
Benzo(k)fluoranthene	38J	1/34
Benzo(a)pyrene	43J	1/34
Benzo(g,h,i)perylene	180J	1/34
Pesticide/PCBs		
Delta-BHC	1.2J - 2.1J	2/55
Aldrin	5.4 - 49	7/55
Heptachlor Epoxide	2.7J - 9.9	2/55
Dieldrin	1.1J - 5,600	38/55
4,4'-DDE	0.6J - 1,500J	45/55
4,4'-DDD	1.5J - 260,000	41/55
4,4'-DDT	1.3J - 40,000	44/55
Endrin ketone	7.7J	1/55
Endrin aldehyde	5.2J	1/55
Alpha-Chlordane	0.82J - 670J	29/55
Gamma-Chlordane	1.2J - 640J	22/55

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-3

INORGANIC DATA SUMMARY
SURFACE SOIL
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil			
	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	5151.959	1,740 - 12,000J	34/34	7
Antimony	5.835	ND	0/34	0
Arsenic	1.302	0.84J - 63.3	28/34	22
Barium	15.229	5.1 - 71.3	34/34	8
Beryllium	0.222	0.03 - 0.25	20/34	4
Cadmium	0.706	0.39 - 2.8J	6/34	2
Calcium	957.712	29.8 - 91,200J	33/34	18
Chromium	5.857	1.5J - 22.7	34/34	13
Cobalt	2.233	0.4 - 1.4	6/34	0
Copper	7.291	0.44J - 30.2	27/34	4
Iron	3260.2	565 - 7,420J	34/34	8
Lead	21.798	3.1 - 211J	33/34	10
Magnesium	177.212	65.1 - 2,030	34/34	17
Manganese	17.642	2.7 - 133	34/34	13
Mercury	0.087	0.13 - 2.7	16/34	16
Nickel	3.377	1.1J - 5.2J	10/34	3
Potassium	186.724	90.7J - 1,110	24/34	12
Selenium	0.831	1.2 - 1.7	2/34	2
Silver	0.945	1.1 - 6.6	2/34	2
Sodium	67.556	21.6 - 176	28/34	10
Thallium	1.076	0.9	1/34	0
Vanadium	8.498	2.1 - 39	34/34	9
Zinc	12.124	4.4 - 210J	20/34	14

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
SUBSURFACE SOIL
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Volatiles		
Acetone	11J - 110J	4/32
Carbon Disulfide	13	1/32
Semivolatiles		
Phenanthrene	53J	1/32
Di-n-butylphthalate	56J - 3,100	17/32
Butylbenzylphthalate	46J	1/32
Bis(2-ethylhexyl)phthalate	81J - 85J	2/32
Pesticide/PCBs		
Delta-BHC	0.63J	1/45
Aldrin	2.6	1/45
Dieldrin	0.73J - 1.4J	4/45
4,4'-DDE	1.4J - 35	7/45
4,4'-DDD	1.1J - 510J	12/45
4,4'-DDT	4.7 - 240	9/45

Notes: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-5

INORGANIC DATA SUMMARY
SUBSURFACE SOIL
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil			
	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	7229.446	477 - 9,900	32/32	2
Antimony	7.315	3.1J	1/32	0
Arsenic	2.32	0.53 - 27.8	11/32	7
Barium	14.126	2 - 29.8	32/32	1
Beryllium	0.207	0.02 - 0.26	15/32	4
Cadmium	0.745	ND	0/32	0
Calcium	449.1	28.5J - 821J	28/32	2
Chromium	13.503	2J - 88.1J	32/32	3
Cobalt	1.761	0.47J - 2.4J	10/32	1
Copper	2.868	0.43J - 5.5	18/32	3
Iron	8202.497	255 - 56,100J	32/32	9
Lead	8.672	2.5 - 13.2	30/32	2
Magnesium	273.731	21 - 516	31/32	4
Manganese	8.673	2.2J - 43.3	32/32	7
Mercury	0.135	0.93	1/32	1
Nickel	2.875	1J - 1.6J	4/32	0
Potassium	394.894	82.4J - 696	22/32	7
Selenium	0.939	0.94 - 3.3	6/32	6
Silver	0.95	ND	0/32	0
Sodium	56.731	17.5 - 83.6	28/32	9
Thallium	1.176	ND	0/32	0
Vanadium	14.078	1.5 - 56.7J	32/32	9
Zinc	7.763	1.6 - 18.1J	9/32	4

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 6-6

GROUNDWATER DATA SUMMARY
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
	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										
Carbon Disulfide	700	NE	NE	NE	1/8	1J	0	NA	NA	NA
Semivolatiles										
Acenaphthene	800	NE	NE	NE	1/8	4J	0	NA	NA	NA
Dibenzofuran	NE	NE	NE	NE	1/8	2J	NA	NA	NA	NA
Fluorene	280	NE	NE	NE	1/8	3J	0	NA	NA	NA
Carbazole	NE	NE	NE	NE	1/8	3J	NA	NA	NA	NA
Pyrene	210	NE	NE	NE	1/8	1J	0	NA	NA	NA
Bis(2-ethylhexyl)phthalate	3	NE	NE	NE	4/8	2J - 5J	3	NA	NA	NA
Di-n-octylphthalate	140	NE	NE	NE	1/8	1J	0	NA	NA	NA
Pesticide/PCBs										
4,4'-DDD	NE	NE	NE	NE	1/8	2.2J	NA	NA	NA	NA
4,4'-DDT	NE	NE	NE	NE	1/8	0.58J	NA	NA	NA	NA
Metals										
Aluminum	NE	NE	NE	NE	7/8	274 - 43,000	NA	NA	NA	NA
Arsenic	50	50	NE	NE	2/8	13.6 - 102	1	1	NA	NA
Barium	NE	4	4	20	7/8	19.6J - 252	0	0	NA	NA
Beryllium	NE	4	4	20	2/8	1.2 - 1.5	NA	0	0	0
Calcium	NE	NE	NE	NE	7/8	2,360 - 64,900	NA	NA	NA	NA
Chromium	50	100	0.2	0.8	2/8	53.3 - 65	2	0	2	2
Copper	1,000	1,300	NE	NE	2/8	13.5 - 14.5	0	0	NA	NA

TABLE 6-6 (Continued)

GROUNDWATER DATA SUMMARY
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
			Federal Health Advisories[3]						No. of Detects Above Health Advisories	
Contaminant	NCWQS[1]	MCL[2]	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
Iron	300	NA	NE	NE	3/8	9,460 - 23,800	3	NA	NA	NA
Lead	15	15	NE	NE	3/8	5.7J - 30J	2	2	NA	NA
Magnesium	NA	NA	NE	NE	7/8	3,330 - 21,000	NA	NA	NA	NA
Manganese	50	NA	NE	NE	5/8	43.9-369	3	NA	NA	NA
Mercury	1.1	2	NE	0.002	1/8	0.42	0	0	NA	1
Nickel	100	100	0.5	1.7	1/8	24	0	0	1	1
Potassium	NA	NA	NE	NE	6/8	1,680 - 14,600	NA	NA	NA	NA
Sodium	NA	NA	NE	NE	7/8	6,260 - 23,100	NA	NA	NA	NA
Vanadium	NA	NA	NE	NE	2/8	40.7 - 44.9	NA	NA	NA	NA
Zinc	2,100	NA	3	10	2/8	76.5J - 106	0	NA	2	2

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

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	Subsurface Soil	TCRA Surface Soil	Groundwater Round 1		Groundwater Round 2	
Volatiles							
Carbon disulfide				●		●	
Semivolatiles							
Acenaphthene				●		●	
Dibenzofuran				●		●	
Fluorene				●		●	
Carbazole				●		●	
Pyrene				●		●	
Bis(2-ethylhexyl)phthalate				●	X	●	X
Di-n-octylphthalate				●		●	
Pesticide/PCBs							
Aldrin	X						
Dieldren	X						
4,4'-DDD	X			●	X	●	
4,4'-DDT	X			●	X	●	
Alpha-Chlordane	X						
Gamma-Chlordane	X						
Metals							
Aluminum	X		X	●	X	●	X
Arsenic	X	X	X	●	X	●	X
Barium	X			●		●	X
Beryllium	X		X	●	X		
Calcium				●			
Chromium				●	X		
Copper				●		●	
Iron			X	●		●	X
Lead		X		●	X	●	
Magnesium				●		●	
Manganese	X			●	X	●	X
Mercury	X			●		●	
Nickel				●		●	
Potassium				●		●	
Sodium				●		●	
Vanadium				●	X	●	
Zinc				●		●	

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 6-8

MATRIX OF POTENTIAL HUMAN EXPOSURE
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium/ Exposure Route	Current Military Personnel	Future Construction Worker	Future Residential Population	Current Civilian Base Personnel
Soil Incidental Ingestion	NE	W	A,C	A
Dermal Contact	NE	W	A,C	A
Groundwater Ingestion	NE	NE	A,C	NE
Dermal Contact	NE	NE	A,C	NE
Surface Water Ingestion	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA
Sediment Incidental Ingestion	NA	NA	NA	NA
Dermal Contact	NA	NA	NA	NA
Air Inhalation of Vapor Phase Chemicals Indoor	NE	NE	A,C	NE
Inhalation of Particulates Outdoor	NE	W	A,C	A

Note:

L = Lifetime exposure
C = Exposure in children may be significantly greater than in adults
M = Military lifetime exposure
W = Construction duration exposure
-- = Exposure to population not likely via this route
NE = Not Exposed
NA = Not Applicable

TABLE 6-9

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION OF SOIL CONTAMINANTS
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Civilian Base Personnel				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, May 1992d
IR	Ingestion Rate	Child Adult Current Civilian Base Personnel Construction Worker	200 mg/day 100 mg/day 480 mg/day 480 mg/day	USEPA, December 1989a USEPA, March 1991
CF	Conversion Factor	1E-6 kg/mg		USEPA, December 1989a
Fi	Fraction Ingested from Contaminated Source	100%		Conservative Professional Judgement
EF	Exposure Frequency	Child Adult Current Civilian Base Personnel Construction Worker	350 days/yr 350 days/yr 250 days/yr 90 days/yr	USEPA, December 1989a USEPA, March 1991
ED	Exposure Duration	Child Adult Current Civilian Base Personnel Construction Worker	6 years 24 years 25 years 1 year	USEPA, December 1989a USEPA, March 1991
BW	Body Weight	Child Adult Current Civilian Base Personnel Construction Worker	15 kg 70 kg 70 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult Current Civilian Base Personnel Construction Worker	2,190 days 8,760 days 9,125 days 365 days	USEPA, December 1989a

TABLE 6-10

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Civilian Base Personnel, Future Construction Worker			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, 1992d
CF	Conversion Factor	1E-6 kg/mg	USEPA, December 1989a
SA	Exposed Surface Area of Skin Available for Contact	Child 2,300 cm^2 Adult 5,800 cm^2 Current Civilian Base Personnel 4,300 cm^2 Construction Worker 4,300 cm^2	USEPA, January 1992a Reasonable worst case: individual skin area limited to head, hands, forearms, lower legs and feet
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2	USEPA, Region IV, 1992c
ABS	Fraction Absorped (unitless)	Organics 1.0% Inorganics 0.1%	USEPA, Region IV, 1992c
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Current Civilian Base Personnel 250 days/yr Construction Worker 90 days/yr	USEPA, December 1989a USEPA, March 1991
ED	Exposure Duration	Child 6 years Adult 24 years Current Civilian Base Personnel 25 years Construction Worker 1 year	USEPA, December 1989a USEPA, March 1991
BW	Body Weight	Child 15 kg Adult 70 kg Current Civilian Base Personnel 70 kg Construction Worker 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 8,760 days Current Civilian Base Personnel 9,125 days Construction Worker 365 days	USEPA, December 1989a

TABLE 6-11

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Civilian Base Personnel, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, May 1992d
EF	Exposure Frequency	Child Adult Current Civilian Base Personnel Construction Worker	350 days/yr 350 days/yr 250 days/yr 350 days/yr	USEPA, December 1989a
ED	Exposure Duration	Child Adult Current Civilian Base Personnel Construction Worker	6 years 24 years 25 years 1 year	USEPA, March 1991
IR	Inhalation Rate	Child Adult Current Civilian Base Personnel Construction Worker	12 m^3 20 m^3 20 m^3 20 m^3	USEPA, March 1991 USEPA, May 1989b USEPA, March 1995
BW	Body Weight	Child Adult Current Civilian Base Personnel Construction Worker	15 kg 70 kg 70 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child Adult Current Civilian Base Personnel Construction Worker	2,190 days 8,760 days 9,125 days 365 days	USEPA, December 1989a
PEF	Site-Specific Particulate Emission Factor	All	6.79E08 m^3/kg	USEPA, March 1995

TABLE 6-12

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF GROUNDWATER CONTAMINANTS
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
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, May 1992d
IR	Ingestion Rate	Child Adult	1 L/day 2 L/day	USEPA, March 1991 USEPA, December 1989a
EF	Exposure Frequency	Child Adult	350 days/yr 350 days/yr	USEPA, December 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, March 1991
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, December 1989a

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH GROUNDWATER CONTAMINANTS
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
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, May 1992d
SA	Exposed Surface Area of Skin Available for Contact	Child 10,000 cm^2 Adult 23,000 cm^2	USEPA, January 1992a
PC	Permeability Constant	Chemical Specific	USEPA, January 1992a
ET	Exposure Time	All 0.25 hr/day	USEPA, January 1992a
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, March 25, 1991
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, December 1989a
CF	Conversion Factor	1 L/1000 cm^3	USEPA, December 1989a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, December 1989a

TABLE 6-14

TOXICITY FACTORS
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD	RfC	CSF	CSFI	WOE	Reference
Semivolatiles						
Bis(2-ethylhexyl)phthalate	2.0E-02	ND	1.4E-02	ND	B2	IRIS, 1995
Pesticides/PCBs						
Aldrin	3.0E-05	ND	1.7E+01	1.71E+01	B2	IRIS, 1995
Dieldrin	5.0E-05	ND	1.6E+01	1.6E+01	B2	IRIS, 1995
4,4'-DDD	ND	ND	2.4E-01	ND	B2	IRIS, 1995
4,4'-DDT	5.0E-04	ND	3.4E-01	3.4E-01	B2	IRIS, 1995
Alpha-Chlordane	6.0E-05	ND	1.3E+00	1.29E+00	B2	IRIS, 1995
Gamma-Chlordane	6.0E-05	ND	1.3E+00	1.29e+00	B2	IRIS, 1995
Metals						
Aluminum	1.0E+00	ND	ND	ND	ND	EPA-ECAO
Arsenic	3.0E-04	ND	1.5E+00	1.51E+01	A	IRIS, 1995
Beryllium	5.0E-03	ND	4.3E+00	8.4E+00	B2	IRIS, 1995
Chromium	5.0E-03	ND	ND	4.2E+01	D	IRIS, 1995
Lead	ND	ND	ND	ND	B2	
Manganese	1.4E-01	1.43E-05	ND	ND	D	IRIS, 1995
Mercury	3,0E-04	8.57E-05	ND	ND	D	IRIS, 1995
Vanadium	7.0E-03	ND	ND	ND	D	HEAST, 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-ECAO	Environmental Protection Agency - Environmental Criterion Assessment Office
ND	Not Determined
A	Human Carcinogen
B2	Probable Human Carcinogen - Sufficient Evidence
D	Not Classifiable as to Human Carcinogenicity

TABLE 6-15

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH SOIL PARADISE POINT GOLF COURSE MAINTENANCE AREA OPERABLE UNIT NO. 11 (SITE 80) REMEDIAL INVESTIGATION, CTO-0274 MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Future Residential Child		Future Residential Adult		Current Civilian Adult Base Personnel		Future Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Soil	8.2E-05	1.7	3.5E-05	0.18	1.5E-04	0.62	1.5E-07	0.02
Dermal Contact with Soil	7.0E-06	0.12	1.5E-05	0.06	8.4E-06	0.03	1.5E-09	<0.01
Inhalation of Soil Particulates	2.5E-08	<0.01	3.5E-08	<0.01	3.7E-08	<0.01	1.2E-09	<0.01
Total	8.9E-05	1.8	5.0E-05	0.24	1.6E-04	0.65	1.5E-07	0.02

TABLE 6-16

**TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH SOIL AFTER THE TCRA
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Receptors	Future Residential Child		Future Residential Adult		Current Civilian Adult Base Personnel		Future Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion	1.1E-05	0.58	4.8E-06	0.06	1.7E-05	0.2	1.5E-07	0.02
Dermal Contact	1.3E-07	0.09	2.8E-07	0.05	1.6E-07	0.02	1.5E-09	<0.01
Inhalation	9.5E-09	<0.01	1.4E-08	<0.01	1E-08	<0.01A	1.2E-09	<0.01
Total	1.1E-05	0.67	5.1E-06	0.11	1.7E-05	0.22	1.5E-07	0.02

TABLE 6-17

**TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs)
AND HAZARD INDICES (HIs) ASSOCIATED WITH GROUNDWATER
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Receptors	Future Residential Child		Future Residential Adult		Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Groundwater	6.8E-04	21	1.5E-03	9	6.6E-04	5.1	1.4E-03	2.2
Dermal Contact with Groundwater	3.3E-06	0.08	8.1E-06	0.04	3.2E-06	0.04	8E-06	0.02
Inhalation - Shower	NA	NA	NA	NA	NA	NA	NA	NA
Total	6.8E-04	29	1.5E-03	9.04	6.6E-04	5.14	1.4E-03	2.22

NA - Not Applicable (no contaminants selected as COPCs).

TABLE 6-18

TOTAL SITE RISK
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Groundwater		Total	
	ICR	HI	ICR	HI	ICR	HI
Current Civilian Adult Base Personnel	1.6E-04 (100)	0.65 (100)	NA	NA	1.6E-04	0.65
Future Child Resident	8.9E-05 (12)	1.8 (7)	6.8E-04 (88)	29	7.7E-04	31
Future Adult Resident	5.0E-05 (3)	0.24 (3)	1.5E-03 (4)	9.04 (97)	1.6E-03	9.3
Future Construction Worker	1.5E-07 (100)	0.02 (100)	NA	NA	1.5E-07	0.02

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
( ) = Approximate percent contribution to the total ICR or HI values
Total = Soil + Groundwater
NA = Not Applicable

TABLE 6-19

TOTAL SITE RISK AFTER TCRA
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION, CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

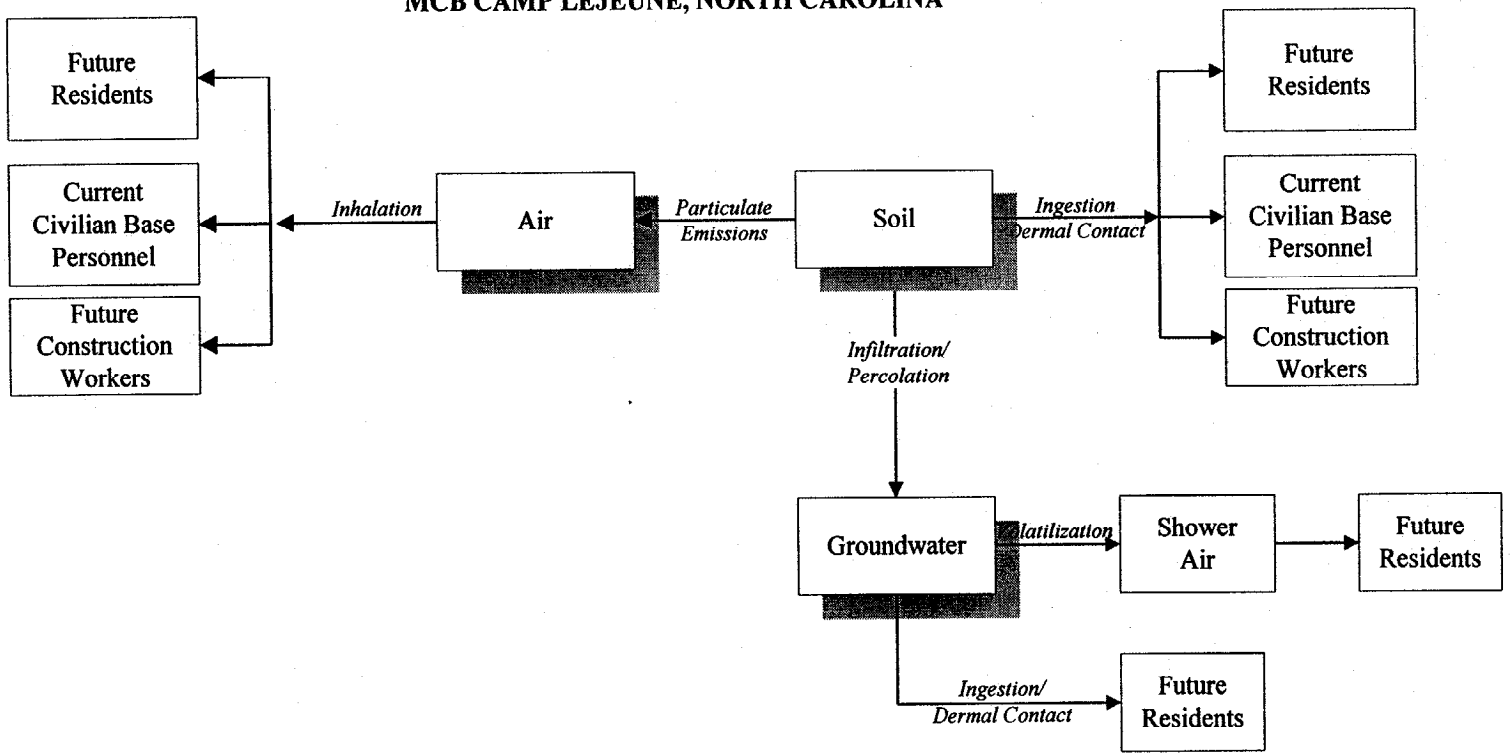
Receptors	Soil		Groundwater		Total	
	ICR	HI	ICR	HI	ICR	HI
Current Civilian Adult Base Personnel	1.7E-05 (100)	0.22 (100)	NA	NA	1.7E-05	0.22
Future Child Resident	1.1E-05 (1.6)	0.67 (12)	6.6E-04 (98.4)	5.14 (88)	6.7E-04	5.81
Future Adult Resident	5.1E-06 (0.4)	0.11 (5)	1.4E-03 (99.6)	2.22 (95)	1.4E-03	2.33
Future Construction Worker	1.5E-07 (100)	0.02 (100)	NA	NA	1.5E-07	0.02

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
( ) = Approximate percent contribution to the total ICR or HI values
Total = Soil + Groundwater
NA = Not Applicable

SECTION 6.0 FIGURES

FIGURE 6-1

CONCEPTUAL SITE MODEL
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
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. 11 (Site 80) that assesses the potential impacts to ecological receptors from contaminants detected at this 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 80 are potentially adversely impacting the terrestrial communities on, or adjacent to, the site. This assessment also evaluates the potential effects of contaminants at Site 80 on sensitive environments including wetlands and protected species. 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.

This ERA evaluates and analyzes the results from the Remedial Investigation (RI) including chemical analysis of the surface soil. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted. 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.

The risk assessment methodologies used in this evaluation are consistent with those outlined in the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1994), and Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information in the following documents was used to supplement the above-mentioned guidance documents:

- 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 receptors 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 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 are identified. Toxicological information for the contaminants detected in the media was obtained from available references and literature and used to evaluate the potential adverse 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 present 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 are evaluated include contaminants detected in the 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 contamination detected in the environmental media at Site 80 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 is 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 that are 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 detected in the surface soil that may not have been historically used at a site are retained as COPCs to evaluate risk, but may be 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 are detected infrequently are not retained as 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 80 are prevalent, however, their inherent toxicity to 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 are 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

There are no state or federal soil criteria, standards, or regulatory levels that can be used to evaluate potential ecological risks to terrestrial receptors (other than plants or invertebrates). Therefore, state or federal criteria or standards are not used to select COPCs for the surface soil.

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, 1989a). 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.

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 80. Once this task is completed, a final list of media-specific COPCs is 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 the surface soil during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria.

A comparison of the surface soil contaminant concentrations to base background concentrations is presented in Section 6.0 of this report. A summary of the COPCs in the surface soil is presented in Table 7-1. Of the fifty-five surface soil samples collected at Site 80, thirty-four were analyzed for

TCL volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), PCBs, and Target Analyte List (TAL) inorganics, while all fifty-five samples were analyzed for TCL pesticides.

7.3.2.1 Surface Soil

Twenty-two inorganics were detected in the Site 80 surface soil. Cobalt is not retained as a COPC because it was detected at a concentration of less than two times the base background concentration. Thallium is not retained as a COPC because it was detected infrequently (1/34). Calcium, magnesium, potassium, and sodium are not retained as COPCs 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 terrestrial life. The following sixteen inorganics are retained as COPCs because they were detected frequently at concentrations greater than two times the background concentration: aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc.

Eleven pesticides were detected in the surface soil. Delta-BHC, endrin aldehyde, endrin ketone, and heptachlor epoxide are not retained as COPCs because they were detected infrequently (1/55 or 2/55). The remaining seven pesticides (aldrin, alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin) are retained as COPCs because they were detected frequently.

Twelve SVOCs were detected in the surface soil. The following contaminants are not retained as COPCs because they were detected infrequently (1/34 or 2/34): benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, butylbenzyl phthalate, benzo(k)fluoranthene, fluoranthene, and phenanthrene. Benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, di-n-butylphthalate and pyrene are the only SVOCs retained as COPCs because they were detected frequently.

Acetone was the only VOC detected in the surface soil. Acetone is a common laboratory contaminant and it was detected at a concentration less than ten times the concentration in the blank sample. In addition, it was detected infrequently (1/34). Therefore, it was not retained as a COPC.

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 7-2 presents these values for the COPCs detected in the surface soil. Information from these tables is used to assess the fate and transport of the constituents and the potential risks to the environmental receptors at each site. The following paragraphs present the significance of each parameter included in the table.

Bioconcentration factors measure the tendency for a chemical to concentrate in biota. 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 organic carbon partition coefficient (Koc) measures the tendency for a chemical to partition between soil 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 organic portion in the soil.

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 and with adsorption to soil. The Kow is used to calculate the plant biotransfer factors that are used to estimate the COPC concentration in plants that potentially would 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 are obtained from Baes et.al., (1984), while the factors for organics are 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 is ingested by the red fox. The factors for inorganics are obtained from Baes et.al., (1984), while the factors for organics are 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 80 were identified during the field investigations and the habitat evaluation. Potential receptors of contaminants in soil include: deer, rabbits, foxes, birds and other terrestrial flora and fauna.

7.4.1 Regional Ecology

MCB 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, French 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, whitetail 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 - Develops on the lee side stable of 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 the 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 Site-Specific Ecology

During December 1994, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 80. Appendix N includes data sheets that provide more detailed information.

Four general habitats are present at Site 80 including deciduous forest, mixed forest, open area, and an ecotone or transition area between the open area and the forests (see Figure 7-1).

Deciduous forest is found to the north of the site. In this forest occasional loblolly pines (Pinus taeda) are mixed with three species of oaks: water oak (Quercus nigra), southern red oak (Q. falcata), and swamp chestnut oak (Q. michauxii). Sweetgum (Liquidambar styraciflua) and redbay (Persea borbonia) are also present. Portions of the understory of this forest are dominated by sweetbay (Magnolia virginiana). Dogwood (Cornus florida), holly (Ilex opaca), and sweet myrtle (Myrica cerifera) also are present in the understory. Japanese honeysuckle (Lonicera japonica) was noted during the habitat evaluation, particularly at the edges of the deciduous forest. Vegetation on the floor of this forest was limited to seedling trees and partridgeberry (Mitchella repens).

Mixed forest is present to the south and east of the site between the site itself and the golf course. Loblolly pine (Pinus taeda) is more prevelent in this forest than in the deciduous forest and occurs in stands of pine. Sweetgum (Liquidambar styraciflua), southern red oak (Quercus falcata), and water oak (Quercus nigra) also are present in this forest. The understory includes saplings of the canopy trees mixed with sweet myrtle (Myrica cerifera). Woody vines are not present, nor are herbaceous plants.

The open area occurs over the site itself and around the buildings of the maintenance area. Most of the open area is a grass lawn that is kept mowed, although part of the area is used for storage of woody debris from landscape maintenance and is essentially bare. Grass is dominant in most of the open area; however, small portions of the open area were dominated by an unidentified plant in the mint family. Herbaceous annuals and perennials growing with the grass include the following:

- Narrow-leaved Plantain- Plantago lanceolata
- Curly Dock- Rumex crispus
- Wild Onion- Allium vineale
- Chickweed- Stellaria media
- Dandelion- Taraxacum officinalis
- Cranesbill- Geranium sp.
- Buttercup- Ranunculus parviflorus
- Wood Sorrel- Oxalis acetosella
- Indian Strawberry- Duchesnea indica
- Fleabane- Erigeron sp.
- Water Pennywort- Hydrocotyl americana

An ecotone or transition zone is present between the forested and the open areas at Site 80. In addition to trees found in the forested areas, sycamore (Platanus occidentalis) is found in the

ecotone. Secondary sapling species include smooth sumac (Rhus glabra), juniper (Juniperus virginianus), and hercules club (Aralia spinosa).

Vines are the dominant class of plants in some areas of the ecotone, although the vine species were mixed. Vines present include the following:

- Trumpet Creeper- Campsis radicans
- Japanese honeysuckle- Lonicera japonica
- Jasmine- Gelsemium sempervierens
- Greenbriar- Smilax rotundifolia
- Bullbriar- Smilax bona-nox

Several species of herbaceous plants are found in the ecotone. They include:

- Dogfennel- Eupatorium capillifolium
- Goldenrod- Solidago sp.
- White clover- Trifolium sp.
- Hyssop-leaved Skullcap- Scutellaria integrifolia

Several species of birds were observed at Site 80, although the habitat evaluation was conducted in the late afternoon when birds are not active. Birds identified at the site include species commonly found in residential areas such as:

- Chickadee- Parus carolinensis
- Carolina Wren- Thyrothorus ludovicianus
- Flicker- Colaptes auratus
- Towhee- Pipilo erythrophthalmus
- Robin- Turdus migratorius
- Cardinal- Richmondena cardinalis
- Mourning Dove- Zenaida macroura

Signs of whitetail deer (Odocoileus virginianus) and raccoon (Procyon lotor) also were observed at Site 80. No reptiles or amphibians or signs of these animals were noted. There is no surface water on, or in the vicinity of Site 80.

7.4.3 Sensitive Environments

This section describes the sensitive environments that were evaluated at Site 80. These sensitive environments include wetlands, threatened and endangered species, and other potentially sensitive environments.

7.4.3.1 Wetlands

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992). 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). 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 where applicable (Figures 7-1).

Site-specific wetland delineations were not conducted at Site 80, however, no potential wetland areas were observed during the habitat evaluation.

7.4.3.2 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 MCB Camp Lejeune and several programs are underway to manage and protect them. Table 7-3 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 MCB Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Research on the bird at MCB 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 MCB 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 MCB 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 MCB 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 MCB Camp Lejeune. Peregrine falcons have been observed at the base.

In addition to the protected species that breed or forage at MCB 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 80 during the habitat evaluation nor would they be expected to occur. Protected species at MCB 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 80.

A natural heritage resources was conducted at MCB 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 base. In addition, several State endangered or threatened and Federal and State candidate species were found on the base. The results of this survey are included in Appendix O.

7.4.3.3 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 80 is discussed below.

- Marine Sanctuary - Site 80 is not located within a Marine Sanctuary (NCMFC, 1992).

- National Park - Site 80 is not located within a National Park (NPS, 1993).

- Designated Federal Wilderness Area - Site 80 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 80 is not located within a Sensitive Area identified under the NEP or NCWP (NC MFC, 1994).

- Critical Areas Identified under the Clean Lakes Program - Site 80 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1993).

- National Monument - Site 80 is not located near a National Monument (NPS, 1993).

- National Seashore Recreational Area - Site 80 is not located within a National Seashore Recreational Area (NPS, 1993).

- National Lakeshore Recreational Area - Site 80 is not located within a National Lakeshore Recreational Area (NPS, 1993).

- National Preserve - Site 80 is not located within a National Preserve (NPS, 1993).

- National or State Wildlife Refuge - Site 80 is not located within a National or State Wildlife Refuge (NC WRC, 1992).

- Unit of the Coastal Barrier Resource Program - Site 80 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 80 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 - There is no surface water present at Site 80.

- 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 - There is no surface water present at Site 80.

- National river reach designated as Recreational - There is no surface water present at Site 80.

- Federal designated Scenic or Wild River - There is no surface water present at Site 80.

- State land designated for wildlife or game management - Site 80 is not located within a State game land (NC WRC, 1992).

- State designated Scenic or Wild River - There is no surface water present at Site 80.

- State designated Natural Area - Site 80 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 - There is no surface water present at Site 80.

- Areas of Significant Value - Site 80 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 80 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.

The assessment endpoint for this ERA is the potential reduction of the terrestrial receptor population or subpopulation that is attributable to contaminants from Site 80. The measurement endpoints include exceedances of contaminant-specific soil effect concentrations (i.e., Surface Soil Screening Values (SSSVs)) and contaminant-specific effect doses (i.e., Terrestrial Reference Values (TRVs)).

7.6 Conceptional Model

This section of the ERA presents each potential exposure pathway via soil, groundwater, and air, 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 is present:

- A source and mechanism of chemical release
- An environmental transport medium

- A feasible receptor exposure route
- A receptor exposure point

7.6.1 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 in the areas of detected COPCs including: deer, fox, 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 contaminants from the soil. This exposure pathway is likely to occur at Site 80 and is retained for further analysis. Some terrestrial species burrow in the subsurface soil. However, this pathway is not evaluated because current guidance does not provide sufficient information to evaluate risk to these receptors.

7.6.2 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. However, no groundwater discharges were observed and no surface water is associated with Site 80. Therefore, this pathway is incomplete and it will not be evaluated in the ERA.

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 to these receptors.

7.6.3 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 and groundwater. The potential exposure points for receptors are areas at/or adjacent to the site. The air exposure pathway is not evaluated in this ERA because air sampling was not conducted, and current guidance does not provide sufficient information to evaluate risk to ecological receptors.

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 (i.e., COPCs) to the ecological receptors. The RI included

collecting samples for analytical analysis of soil and groundwater. The analytical results for the data used in ERA are presented in Section 4.0 of this report.

The regional ecology, site ecology, and habitat characterization in the areas surrounding Site 80 are presented in Section 7.4 of this ERA. Information on sensitive environments and endangered species also is included in this section.

Exposure of contaminants in the surface soil to terrestrial flora and fauna (invertebrates and microorganisms) are assumed to be equal to the contaminant concentration in the surface soil. However, 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 soil to other terrestrial fauna (mammals, birds) are estimated using the chronic daily intake models.

7.8 Ecological Effects Characterization

The ecological effects data used to assess potential risks to terrestrial receptors in this ERA are presented in the following sections.

7.8.1 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 (ORNL) (Will and Suter, 1994a, 1994b). The contaminant concentrations in the surface soils are compared to the SSSVs to determine if potential impacts to terrestrial flora and fauna (invertebrates) may be expected (see Table 7-4).

Several of the inorganics and pesticides exceeded the SSSVs in some of the samples. With the exception of one arsenic detection, the remaining arsenic, copper, lead, manganese, selenium, silver and zinc detections were located in the areas immediately surrounding the buildings and the concrete pads. These areas mostly are gravel covered. The remaining inorganics (aluminum, chromium, iron, mercury, and vanadium) exceeded the SSSVs in each sample that they were detected. However, the majority of these samples that had contaminants exceeding the basewide background concentrations were located in the areas immediately surrounding the buildings and the concrete pads.

Samples with highest pesticide concentrations that exceeded the SSSVs were located in the areas immediately surrounding the buildings and the concrete pads, and in the open grass area west of the site.

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 sections present the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 80 by both direct and indirect exposure to COPCs via surface soil and foodchain transfer. Because surface water was not present at Site 80, this portion of the model was deleted from the equations presented below.

Based on the regional ecology and potential habitat at the site, the indicator species used in this analysis are the whitetail deer, cottontail rabbit, red fox, and the bobwhite quail. The exposure points for these receptors are the surface soil. The routes for terrestrial exposure to the COPCs in the soil are incidental soil ingestion, and ingestion of vegetation and small mammals.

7.8.4.1 Derivation of Terrestrial Reference Value

Total exposure of the terrestrial receptors to the COPCs in the soil 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, 1995), 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 P 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 surface soil 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 surface soil and vegetation is determined using the following equation:

$$CDI = \frac{[(Cs)(Bv)(Iv)+(Cs)(Is)][H]}{BW}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg/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 range area, unitless
BW	=	Body weight, kg

To calculate the contaminant concentration in the small mammal, the resulting CDI dose 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 red fox is determined using the following equation:

$$CDI = \frac{[(Cs)(Bv)(Iv)+(Cs)(Is)+(Cm)(Im)][H]}{BW}$$

Where:

CDI	=	Chronic Daily Intake, mg/kg/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 range area, unitless
BW	=	Body weight, kg

Bioconcentration of the COPCs to plants is calculated using the soil to plant transfer coefficient (Bv) 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 7-5.

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 terrestrial populations at Site 80 from contaminants identified at the site.

A Quotient Index (QI) approach is used to characterize the risk to terrestrial receptors from exposure to contaminants in the surface soil. This approach characterizes the potential effects by comparing the CDI to the TRV. The QI is calculated as follows:

$$QI = \frac{CDI}{TRV}$$

Where:	QI	=	Quotient Index
	CDI	=	Chronic Daily Intake, mg/kg/day
	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. However, it is important to determine which contaminants are posing the highest risks, in order to evaluate the significance of those contaminants to the site. 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.

Table 7-6 presents the QIs for each contaminant for each species. The total QI for the cottontail rabbit was "2.8" with the highest individual contaminant QI of "1.67" for dieldrin. The QIs for the other species (whitetail deer, red fox, and bobwhite quail) were less than "1".

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 80 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 80 that are protective of public health and the environment.

7.10.1 Terrestrial Receptors

Several of the contaminants at Site 80 exceeded the SSSVs. As was presented in the Ecological Effects Section of this report, many of the exceedences were located in gravel covered areas. These areas are not likely to support an ecologically significant community of terrestrial soil flora or fauna and therefore the significance of the potential impacts is low.

The contaminants located in the grass covered area have the potential to decrease the population of terrestrial invertebrates and plants. Several of the samples contained pesticide concentrations several orders of magnitude above the SSSVs. The contamination appears to be limited to a small portion of the site, and is only expected to impact terrestrial invertebrates and plants in that area. However, it should be noted, that since the pesticides have high BCF values, they may accumulate in species ingesting these terrestrial invertebrates and plants.

Under current conditions, the contaminants located in the gravel covered areas have less of a potential to decrease the population of terrestrial invertebrates and plants. This area is very disturbed with vehicle traffic and therefore, most likely does not have a significant terrestrial invertebrate population. With the exception of a few patches of grass, no plants grow in these areas.

The rabbit was the only species that had a total QI value that exceeded "1". It had a QI of 2.8, and therefore has a relatively low potential for adversely impacting the rabbit population. Much of the site is gravel covered, thus reducing a rabbit's potential habitat. Therefore, the model overestimates the risk to the rabbit.

7.10.2 Threatened and Endangered Species

No threatened or endangered species are known to occur at Site 80, therefore no adverse impacts to these species from contaminants at Site 80 are expected.

7.10.3 Wetlands

No wetlands have been identified at Site 80, therefore no adverse impacts to wetlands from contaminants at Site 80 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 paragraphs present some of the uncertainty in this ERA.

There is uncertainty in the ecological endpoint comparison. Potential adverse impacts to terrestrial invertebrates and plants were evaluated by comparing the COPC concentration in the soil to SSSVs. Most of the studies used to develop the SSSVs 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 biotransfer factors. Biotransfer factors can vary widely from species to species. The species used in the calculation of the 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.

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 receptors from these contaminants

7.12 Conclusions

Several of the COPCs detected in the surface soils at Site 80 exceeded the SSSVs. Many of these exceedences are located in gravel covered areas and are not expected to cause a significant reduction in the soil flora or fauna population. However, some of the exceedences are located in the open grass area and may cause a significant reduction in the soil flora or invertebrate population in that area. Finally, the COPCs at Site 80 are not expected to cause a significant adverse risk to terrestrial mammals or birds.

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.

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.

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.

IRIS. 1995. Integrated Risk Information System. Accessed through Chemical Information Systems, Inc. Baltimore Maryland.

LeBlond, Richard. 1991. Critical Species List - Camp Lejeune Endangered Species and Special-Interest Communities Survey. Principal Investigator.

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, 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.

NC WRC, North Carolina Wildlife Resources Commission. June, 1992. 1992-1993 Hunting and Fishing Maps for North Carolina Game Lands.

NPS, National Park Service. 1993. National Park System Map and Guide. U.S. Department of the Interior, National Park Service, 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.

Suter, Glenn W. II. 1993 Ecological Risk Assessment. Lewis Publishers. Chelsea, Michigan.

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, U.S. Environmental Protection Agency. January 26, 1995a. "Toxic Substance Spreadsheet". Region IV, Atlanta, Georgia.

USEPA, U.S. Environmental Protection Agency. January 19, 1995. "Region III BTAG Screening Levels". Region III, Philadelphia, PA.

USEPA, U.S. Environmental Protection Agency. Spetember 26, 1994. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Environmental Response Team, Edison, NJ.

USEPA, U.S. Environmental Protection Agency. September 1993a. Sediment Quality Criteria for the Protection of Benthic Organisms- Dieldrin. Office of Science and Technology. Health and Ecological Criteria Section. Washington, D.C. EPA-822-R-93-015.

USEPA, U.S. Environmental Protection Agency. December 1993b. Wildlife Exposure Factors Handbook. Office of Research and Development. Washington, D.C. EPA/600/R-93/187a.

USEPA. U.S. Environmental Protection Agency. February 1992. Framework for Ecological Risk Assessment. United States Environmental Protection Agency. Risk Assessment Forum. EPA/630/R-92/001.

USEPA, U.S. Environmental Protection Agency. June 1991. National Functional Guidelines for Organic Data Review. Draft. USEPA Contract Laboratory Program.

USEPA. U.S. Environmental Protection Agency. December, 1989a. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Interim Final EPA/540/1-89/002.

USEPA. U.S. Environmental Protection Agency. March 1989b. 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.

USEPA. U.S. Environmental Protection Agency. March 1989c. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. Environmental Research Laboratory, Corvallis, OR. EPA/600/3-89/013.

USEPA. U.S. Environmental Protection Agency. October 1986. 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.

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. 1994a. 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. 1994b. 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

CONTAMINANTS OF POTENTIAL CONCERN IN THE SURFACE SOIL
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Surface Soil
Inorganics	
Aluminum	X
Arsenic	X
Barium	X
Beryllium	X
Cadmium	X
Chromium	X
Copper	X
Iron	X
Lead	X
Manganese	X
Mercury	X
Nickel	X
Selenium	X
Silver	X
Vanadium	X
Zinc	X
Semivolatiles	
Benzo(b)fluoranthene	X
Bis(2-ethylhexyl)phthalate	X
Chyrsene	X
Di-n-butylphthalate	X
Pyrene	X
Pesticides	
Aldrin	X
Alpha-chlordane	X
Gamma-chlordane	X
4,4'-DDE	X
4,4'-DDD	X
4,4'-DDT	X
Dieldrin	X

TABLE 7-2

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-274

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors[1][2]		
				Bv	Br	Bb
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
Nickel	47[3]	ND	ND	6.00e-02	6.00e-02	6.00e-03
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
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(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
Di-n-butylphthalate	89[3]	170,000[5]	5.2[6]	3.80e-02	3.80e-02	3.98e-03
Pyrene	30[3]	38,000[5]	5.3[6]	3.30e-02	3.30e-02	5.01e-03

TABLE 7-2 (Continued)

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-274

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors[1][2]		
				Bv	Br	Bb
Pesticides/PCBs						
Aldrin	4,670[3]	96,000[5]	3[6]	7.14e-01	7.14e-01	2.51e-05
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[8]	4.6[6]	8.50e-02	8.50e-02	1.00e-03

[1] Baes et.al., 1984 for the inorganics
[2] The organics were calculated using Travis and Arms, 1988
[3] USEPA, 1995a (Region IV)
[4] USEPA, 1995b (Region III)
[5] USEPA, 1986.
[6] SCDM, 1991.
[7] Montgomery, 1990.
[8] USEPA, 1993a (Sediment Quality Criteria for Dieldrin)
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

TABLE 7-3

PROTECTED SPECIES AT MCB CAMP LEJEUNE
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
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 7-4

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant of Potential Concern	Soil Flora and Fauna Screening Values[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest Screening Value
	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	34/34	1,740-12,000J	34
Arsenic	10	60	NE	100	28/34	0.84J-63.3	6
Barium	500	440[2]	440[2]	3,000	34/34	5.1-71.3	0
Beryllium	10	NE	NE	NE	20/34	0.03-0.25	0
Cadmium	3	20	3	20	6/34	0.39-2.8J	0
Chromium	1	0.4	0.0075[2]	10	34/34	1.5J-22.7	34
Copper	100	50	20	100	27/34	0.44J-30.2	1
Iron	100[2]	NE	3,515	200	34/34	565-7,420J	34
Lead	50	500	300	900	33/34	3.1-211J	3
Manganese	500	330[2]	330[2]	100	34/34	2.7-133	1
Mercury	0.3	0.1	300	30	16/34	0.13-2.7	16
Nickel	30	200	NE	90	10/34	1.1J-5.2J	0
Selenium	1	70	0.26[2]	100	2/34	1.2-1.7	2
Silver	2	NE	NE	50	2/34	1.1-6.6	1
Vanadium	2	58[2]	58[2]	20	34/34	2.1-39	34
Zinc	50	200	500	100	20/34	4.4-210J	4

TABLE 7-4 (Continued)

**FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA**

Contaminant of Potential Concern	Soil Flora and Fauna Screening Values[1]				Contaminant Frequency/Range		No. of Positive Detects Above Lowest Screening Value
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	
Semivolatiles (µg/kg)							
Benzo(b)fluoranthene	NE	100[2]	100[2]	NE	2/34	40J-48J	0
Bis(2-ethylhexyl)phthalate	NE	NE	NE	NE	4/34	38J-66J	NA
Chrysene	NE	100[2]	NE	100[2]	2/34	40J-53J	0
Di-n-butylphthalate	200,000	NE	NE	NE	20/34	60J-4,400	0
Pyrene	NE	100[2]	100[2]	NE	2/34	60J-92J	0
Pesticides/PCBs (µg/kg)							
Aldrin	NE	100[2]	100[2]	NE	7/55	5.4-49	0
4',4-DDD	NE	100[2]	100[2]	NE	41/55	1.5J-260,000	15
4',4-DDE	NE	100[2]	100[2]	NE	45/55	0.6J-1,500J	25
4',4-DDT	NE	4[2]	4[2]	NE	44/55	1.3J-40,000	38
Alpha-chlordane	NE	<100[2]	<100[2]	NE	29/55	0.82J-670J	6
Gamma-chlordane	NE	<100[2]	<100[2]	NE	22/55	1.2J-640J	2
Dieldrin	NE	<100[2]	<100[2]	NE	38/55	1.1J-5,600	12

(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, 1995b (Region III BTAG Soil Screening Values)

TABLE 7-5

EXPOSURE FACTORS FOR TERRESTRIAL CHRONIC DAILY INTAKE MODEL
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-274

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Small Mammal
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 100%
Feeding Rate	kg/d	1.6[2]	0.237[4]	0.0135[3]	0.601[3]	0.112[3]
Incident Soil Ingestion	kg/d	0.0185[1]	0.0057[5]	0.0011[5]	0.0168[5]	0.00269[5]
Rate of Drinking Water Ingestion	L/d	1.1[2]	0.119[3]	0.0191[3]	0.385[3]	0.0652[3]
Rate of Vegetation Ingestion	kg/d	1.6	0.237	0.0135	0.12	0.112
Body Weight	kg	45.4[2]	1.229[3]	0.174[3]	4.54[3]	0.3725[3]
Rate of Small Mammal Ingestion	kg/d	NA	NA	NA	0.48	NA
Home Range Size	acres	454[2]	9.30[3]	26.24[3]	1,245[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

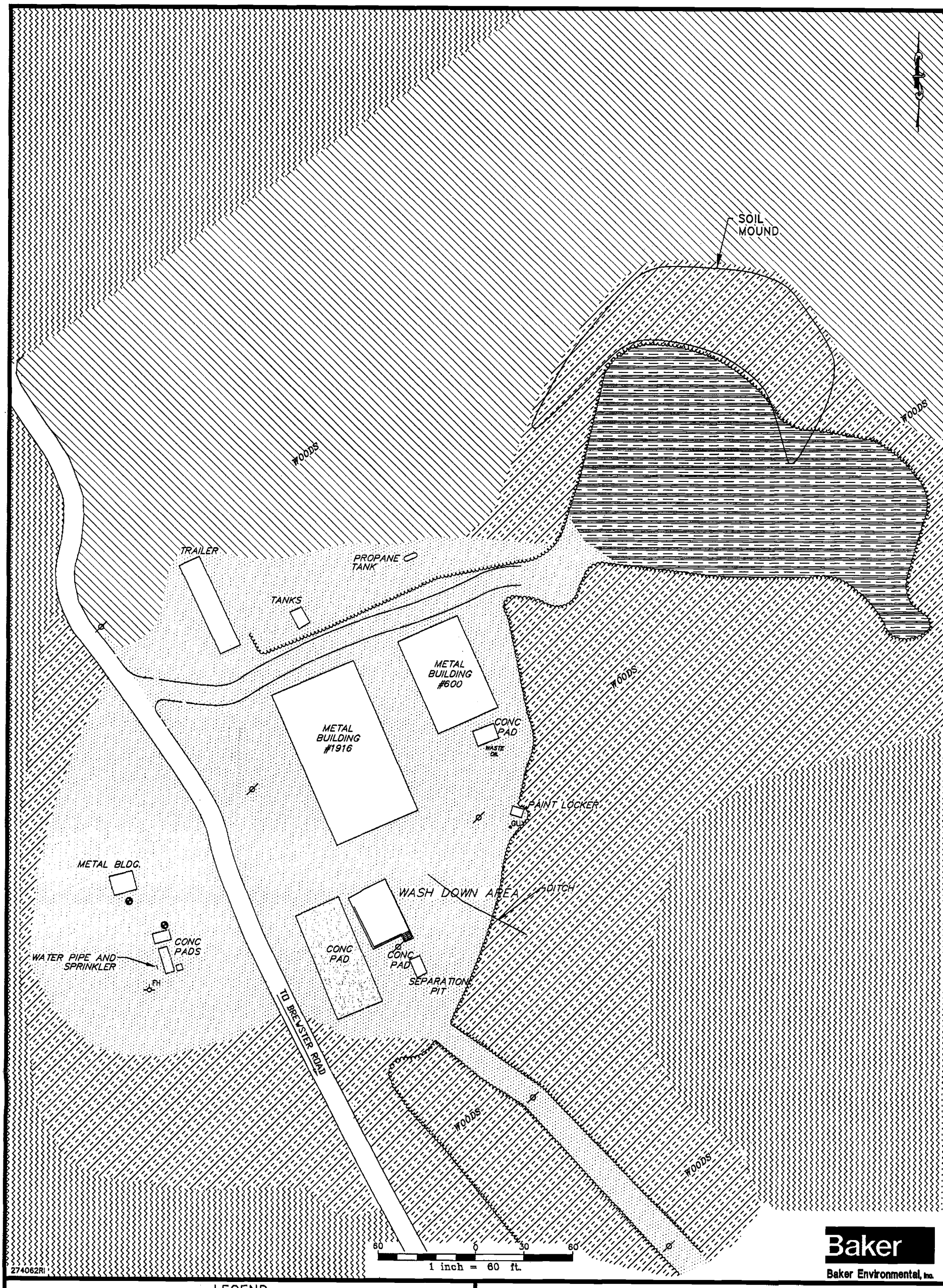
TABLE 7-6

TERRESTRIAL INTAKE MODEL QUOTIENT INDICES
PARADISE POINT GOLF COURSE MAINTENANCE AREA
OPERABLE UNIT NO. 11 (SITE 80)
REMEDIAL INVESTIGATION CTO-0274
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Red Fox	Bobwhite Quail	Cottontail Rabbit	Whitetail Deer
Aluminum	6.95e-04	3.69e-02	2.22e-01	8.22e-04
Arsenic	2.30e-03	2.59e-04	6.50e-03	1.75e-04
Barium	9.85e-04	3.82e-03	5.29e-02	1.64e-03
Beryllium	1.39e-06	1.86e-05	1.99e-04	1.57e-06
Cadmium	9.03e-05	2.01e-04	2.46e-01	8.04e-03
Chromium	3.00e-05	1.70e-05	1.10e-04	2.23e-06
Copper	8.48e-06	1.77e-04	4.32e-03	2.80e-04
Iron	5.10e-04	5.18e-03	6.23e-02	5.78e-04
Lead	4.13e-05	1.79e-03	2.95e-02	8.05e-04
Manganese	9.65e-05	1.40e-04	1.07e-02	6.80e-04
Mercury	1.85e-04	8.56e-03	1.44e-01	4.89e-03
Nickel	3.15e-07	2.20e-05	1.44e-03	4.10e-05
Selenium	1.04e-04	8.23e-05	4.24e-03	1.09e-04
Silver	2.03e-04	5.60e-05	1.01e-01	1.22e-03
Vanadium	1.10e-04	5.79e-05	1.03e-01	3.99e-05
Zinc	1.60e-03	1.64e-03	5.84e-02	1.93e-03
Aldrin	1.38e-05	8.57e-04	2.30e-02	2.14e-06
Alpha-chlordane	1.00e-05	2.67e-05	7.87e-03	6.14e-07
Gamma-chlordane	6.17e-06	1.64e-05	4.85e-03	3.78e-07
4,4'-DDD	4.20e-04	1.40e-01	6.39e-02	5.30e-04
4,4'-DDE	1.50e-05	5.13e-03	2.58e-03	2.30e-05
4,4'-DDT	9.16e-05	2.95e-02	1.22e-02	9.26e-05
Dieldrin	1.78e-03	1.04e-02	1.67e+00	2.79e-05
Benzo(b)fluoranthene	8.14e-07	1.04e-05	1.03e-04	7.48e-07
Bis(2-ethylhexyl)phthalate	2.45e-06	1.07e-05	5.69e-04	5.79e-06
Chrysene	9.63e-07	1.33e-05	1.65e-04	1.47e-06
Di-n-butylphthalate	3.76e-08	8.22e-04	8.26e-06	8.24e-08
Pyrene	2.42e-07	3.50e-06	5.04e-05	4.92e-07
Total Quotient Index	**9.30e-03**	**2.45e-01**	**2.83e+00**	**2.19e-02**

Note: Shaded samples are Quotient Indices that exceed "1"

SECTION 7.0 FIGURES



LEGEND

- DECIDUOUS FOREST
- MIXED FOREST
- OPEN AREA
- WOODY DEBRIS
- GOLF COURSE

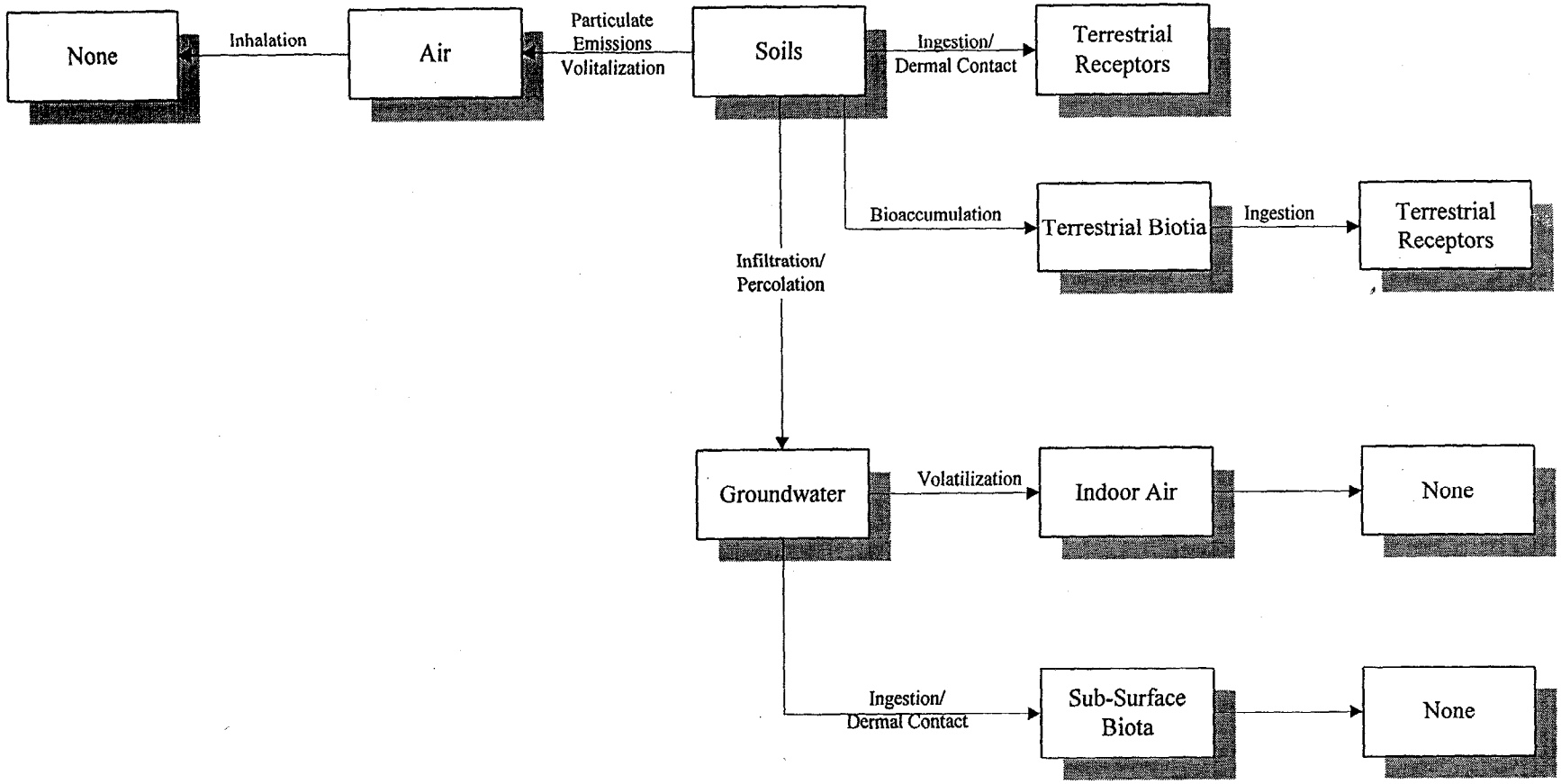
SOURCE: W.K. DICKSON & CO., INC., JANUARY 1995

FIGURE 7-1
BIOHABITAT MAP
SITE 80 - PARADISE POINT GOLF
COURSE MAINTENANCE AREA
REMEDIAL INVESTIGATION CTO-0274
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01697X032

FIGURE 7-2

FLOWCHART OF POTENTIAL ECOLOGICAL EXPOSURE PATHWAYS AND RECEPTORS
SITE 80: PARADISE POINT GOLF COURSE MAINTENANCE AREA



8.0 CONCLUSIONS

The following conclusions for Operable Unit (OU) No. 11 (Site 80) are based on the results of the Remedial Investigation, and the human and ecological risk assessment.

1. Pesticides are the most frequently detected contaminants in the surface soil at Site 80. They exhibited the highest concentration ranges of all soil contaminants. Pesticides were detected in 20 of 55 surface soil samples. Pesticides detected in the surface soil are dieldrin, 4,4'-DDE, 4,4'-DDD, 4,4'-DDT, alpha-chlordane and gamma-chlordane. Concentrations of pesticides range from 0.6J µg/kg for 4,4'-DDE in sample 80-OA-SB04-00 to 260,000 µg/kg for 4,4'-DDD in sample 80-DPA-SB03-00. The highest pesticide levels are in the in the Detected Pesticide Area (DPA) in the west/northwest section of the site. Additionally, elevated levels of pesticides were detected in the lawn area (LA). Pesticide levels in this area are one to three orders of magnitude lower than in the DPA area. Pesticides at other locations of the site are four orders of magnitude lower than the DPA. Pesticide concentrations at this site are higher than what is normally attributed to past historical applications at Camp Lejeune.

2. Pesticides are the predominant contaminants in the subsurface soil at Site 80. However, concentrations are one to two orders of magnitude less than concentrations in the surface soil. The highest subsurface pesticide contaminant levels are in the west/northwest portion of the site. 4,4'-DDD is the most frequently detected pesticide (12 of 45 samples) and exhibits the highest concentration (510J µg/kg) at a depth of 11 to 13 feet at soil boring location 80-MW04. The maximum concentration of 4,4'-DDT (240 µg/kg) is at 11 to 13 feet in soil boring location 80-MW04.

3. Polynuclear aromatic hydrocarbons (PAHs) are infrequently detected in the surface soil at concentrations levels less than 100 µg/kg. The location of most of the PAH detections and the highest PAH concentrations is in the soil mound in the northeast area of the site. This is near the open area where burning operations of wood and leaves occur and may be the source of the PAH contamination. Phenanthrene was the only PAH detected in the subsurface soil (53J µg/kg) at a depth of 5 to 7 feet.

4. Levels of volatile organics, acetone and carbon disulfide, detected in the surface and subsurface soil samples are less than 10 times the concentration detected in QA/QC blanks. Therefore, it is believed that the presence of these contaminants is not due to past activities at the site.

5. Inorganic contaminant levels detected in the surface soil were within one order of magnitude (or less) of base background concentrations. Inorganics arsenic, barium, chromium, manganese, mercury, and selenium exhibited concentrations above base background levels for inorganics in the subsurface soil.

6. The pesticides 4,4'-DDD (2.2J µg/L) and 4,4'-DDT (0.58 µg/L) were detected in monitoring well 80-MW04. Federal and/or State groundwater criteria have not been adopted for these pesticides.

7. Semivolatiles were detected at low levels in a limited number of shallow monitoring wells. The semivolatiles included acenaphthene, fluorene, carbazole, and pyrene. The maximum concentration of acenaphthene (4J µg/L) and pyrene (1 µg/L) did not exceed the intermin NCWQS maximum allowable concentration 80 µg/L and 210 µg/L, respectively. Fluorene was detected at a concentration (3J µg/L) well below the NCWQS (280 µg/L).

8. Carbon disulfide (1J µg/L) was the only volatile organic detected in the groundwater. This concentration is well below the NCWQS interim maximum allowable concentration (700 µg/L).

9. Concentrations of total metals in the groundwater are within an order of magnitude or less of the dissolved metal concentrations. Aluminum, arsenic, chromium, iron, lead, and manganese were detected at concentrations greater than their respective Federal and/or State standard. Total metal concentrations in the shallow groundwater are within the range of concentration of metals typically detected at MCB Camp Lejeune.

10. Inorganic contaminants that were detected in groundwater samples collected during Round Two at concentrations above respective Federal or State criteria include iron, manganese, and thallium.

11. ICR soil values estimated for future residential children and adults and future construction workers fall within or below the acceptable risk range. However, the ICR value estimated for current civilian base personnel exposure to soil (ICR = 1.8E-04) exceeds the acceptable risk range. This indicates that base personnel currently working at the Site 80 may be at risk. The majority of the risk to this receptor is driven by the ingestion of soils with the ingestion of dieldrin (60 percent), arsenic (23 percent), 4,4'-DDD (12 percent), and 4,4'-DDT (4 percent) accounting for a majority of the risk.

    HI values estimated for future residential adults, current civilian base personnel and future construction workers exposure to soil are less than 1.0. This indicates that there is a potential for systemic effects to future residential children from contact with soil. The HI value estimated for future residential children exposure to soil (1.8) is greater than 1.0. Incidental ingestion of soil drives the risk, and dieldrin contributes approximately 35 percent of the risk. A majority of the risk is associated with the ingestion of dieldrin (37 percent), arsenic (36 percent), 4,4'-DDT (15 percent), alpha (4 percent) and gamma (2 percent) chlordane.

12. Groundwater ICR values estimated for future residential children and adults exceed the acceptable risk range (children 6.8E-04 and adults 1.5E-03). These values indicate that potential future residents may be at risk from use of the groundwater. The majority of the risk (96 percent) is driven by the ingestion of arsenic.

13. Groundwater HI values for future residential children and adults are greater than 1.0 (children 21 and adults 9). This indicates that potential systemic risks may occur from the future use of the groundwater. The ingestion of arsenic and aluminum account for the greatest contribution of risk 80 percent and 13 percent, respectively.

14. Remediation of the soil should be considered under a Time Critical Removal Action (TCRA) to eliminate the potential risks to current civilian base personnel working at the site and future residential children.

15. Removal of soil under a TCRA will reduce risks from exposure to soil to as acceptable level for current civilian base personnel (ICR = 1.7E-05, HI = 0.22) and future receptors including children (ICR = 1.1E-05, HI = 0.67), adults (ICR = 5.1E-06, HI = 0.11), and construction worker (ICR = 1.5E-07, HI = 0.02).