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FINAL

REMEDIAL INVESTIGATION AT OPERABLE UNIT NO. 10 (SITE 35, CAMP GEIGER AREA FUEL FARM)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0232

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LIST OF ACRONYMS AND ABBREVIATIONS

ABS	adsorption factor
AF	soil to skin adherence factor
AQTESOLV	Aquifer Test Solver Program
AQUIRE	Aquatic Information Retrieval Database
ARARs	Applicable or Relevant and Appropriate Requirements
ARL	Aquatic Reference Level
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
AT	averaging time
ATc	averaging time carcinogen
ATnc	averaging time noncarcinogen
ATEC	ATEC Associates, Inc.
AWQC	Federal Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
BCF	bioconcentration factor
bgs	below ground surface
BI	biotoxic index
BOD	biological oxygen demand
BRA	baseline risk assessment
BTEX	benzene, toluene, ethylbenzene, xylenes
BW	body weight
CAMA	Coastal Area Management Act
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COPC	contaminant of potential concern
COD	chemical oxygen demand
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRQL	Contract Required Quantitation Limit
CSA	Comprehensive Site Assessment
CSF	Cancer Slope Factor
DoN	Department of the Navy
1,2-DCE	1,2-dichloroethene
DEM	Division of Environmental Management
DDE	dichlorodiphenyldichloroethylene
DDT	diphenyltrichloroethane

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

ECD	electron capture detector
ED	exposure duration
EF	exposure frequency
EL	exposure level
ERA	ecological risk assessment
ER-L	Effects Range-Low
ER-M	Effects Range-Median
ESE	Environmental Science and Engineering, Inc.
ET	exposure time
FAWQC	Federal Ambient Water Quality Criteria
FFA	Federal Facilities Agreement
FFS	Focused Feasibility Study
F_i	fraction ingested from source
FID	flame ionization detector
f_{oc}	sediment particle grain size
FSAP	Field Sampling and Analysis Plan
FWS	Fish and Wildlife Service
FWQSV	Freshwater Water Quality Screening Values
gpd/ft	gallons per day per foot
gpm	gallons per minute
H	mean species diversity
HA	health advisory
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
HQW	high quality water
i	hydraulic gradient
IAS	Initial Assessment Study
ICR	incremental cancer risk
ID	inside diameter
IDW	investigative derived wastes
IR	ingestion rate
IRA	interim remedial action
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)

LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LAW	Law Engineering
LOAEL	lowest observed adverse effect level
LUST	leaking underground storage tank
MBI	Macroinvertebrate Biotic Index
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
mg/kg	milligram per kilogram
mg/L	milligram per liter
MF	modifying factor
MI	mobility index
ml	milliliter
mL/g	milliliters per gram
msl	mean sea level
MTBE	methyl-tertiary-butyl-ether
MW	monitoring well
NACIP	Navy Assessment and Control of Installation Pollutants
NC DEHNR	North Carolina Department of Environment, Health and Natural Resources
NC DOT	North Carolina Department of Transportation
NCMFC	North Carolina Marine Fisheries Commission
NCSPCS	North Carolina State Plane Coordinate System
NCP	National Oil and Hazardous Substances Contingency Plan
NCWP	Near Coastal Waters Program
NCWQC	North Carolina Water Quality criteria
NCWQS	North Carolina Water Quality Standards
NCWRC	North Carolina Wildlife Resources Commission
N_e	effective porosity
NEESA	Naval Energy and Environmental Support Activity
NEP	National Estuary Program
NOAA	National Oceanic and Atmospheric Administration
NOAEL or NOEL	No observed adverse effect level
NPL	National Priorities List
NPS	National Park Service
NSW	nutrient sensitive waters
NUS	NUS Corporation
NWI	national wetlands inventory
O&G	oil and grease
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PC	permeability constant
PCBs	polychlorinated biphenyls

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PCE	tetrachloroethene
PEF	particulate emissions factor
PHA	public health assessment
PID	photoionization detector
POL	petroleum, oil, lubricants
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
PVC	polyvinyl chloride
pw	pumping well
QA/QC	quality assurance/quality control
QI	quotient index
RA	risk assessment
RBC	risk based concentrations
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RMC	RMC Environmental Services, Inc.
S	storativity, water solubility
SA	site assessment or surface area
SAP	Sample and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SCS	Soil Conservation Service
SD	sediment
SMCL	Secondary Drinking Water Regulations
SQC	sediment quality criteria
SOPs	standard operating procedures
SSV	sediment screening value
SU	standard units
SVOCs	semivolatile organic compounds
SW	surface water
SWQSVs	surface water quality screening values
T	transmissivity
TAL	target analyte list
TBC	to be considered
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TEF	toxicity equivalency factor

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TICs	tentatively identified compounds
TOC	total organic carbon
TPH	total petroleum hydrocarbons
Tracer	Tracer Research Corporation
trans-1,2-DCE	trans-1,2-dichloroethene
TRVs	terrestrial reference values
TSS	total suspended solids
UCL	upper confidence limit
UF	uncertainty factor
µg/g	micrograms per gram
µg/L	micrograms per liter
USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USCS	Unified Soil Classification System
USGS	United States Geological Survey
USMC	United States Marine Corps
UST	underground storage tank
VOCs	volatile organic compounds
VP	vapor pressure
V_x	average seepage velocity
WAR	Water and Air Research, Inc.
WOE	weight of evidence
WQS	water quality standards
WQSV	water quality screening values
WS	Wilderness Society

EXECUTIVE SUMMARY

Introduction

This document was prepared by Baker Environmental, Inc. (Baker) to serve as a report on the Remedial Investigation (RI) conducted at Operable Unit (OU) No. 10, Site 35 - Camp Geiger Area Fuel Farm in the spring and summer of 1994.

The purpose of this RI was to evaluate the nature and extent of the threat to public health and the environment caused by the release of hazardous substances, pollutants or contaminants. This was accomplished by sampling several media (soil, groundwater, sediment, surface water, fish, crabs, and benthic macroinvertebrates) at OU No. 10, evaluating the analytical data and performing a human health risk assessment (RA) and ecological RA. This RI Report contains the results of all field investigations, a technical memorandum summarizing groundwater data and aquifer characteristics at MCB, Camp Lejeune, the human health RA, and the ecological RA. Previous investigations were conducted by Water and Air Research, Inc., (WAR), Environmental Science and Engineering, Inc. (ESE), NUS Corporation (NUS), Law Engineering (LAW), and Baker Environmental, Inc. (Baker).

Site Location and Description

Camp Geiger is located at the extreme northwest corner of MCB, Camp Lejeune. The main entrance to Camp Geiger is off U.S. Route 17, approximately 3.5 miles southeast of the City of Jacksonville, North Carolina. Site 35, the Camp Geiger Area Fuel Farm refers primarily to five, 15,000-gallon aboveground storage tanks (ASTs), a pump house, and a fuel unloading pad situated within Camp Geiger just north of the intersection of Fourth and "G" Streets.

Site History

Construction of Camp Geiger was completed in 1945, four years after construction of MCB, Camp Lejeune was initiated. Originally, the Fuel Farm ASTs were used for the storage of No. 6 fuel oil, but, were later converted for storage of other petroleum products including unleaded gasoline, diesel fuel, and kerosene. The date of their conversion is not known.

Routinely, the ASTs at Site 35 supply fuel to an adjacent dispensing pump. A leak in an underground line at the station was reportedly responsible for the loss of roughly 30 gallons per day of gasoline over an unspecified period (Law, 1992). The leaking line was subsequently sealed and replaced.

The ASTs at Site 35 are currently used to dispense gasoline, diesel and kerosene to government vehicles and to supply USTs in use at Camp Geiger and the nearby New River Marine Corps Air Station. The ASTs are supplied by commercial carrier trucks which deliver product to fill ports located on the fuel unloading pad at the southern end of the facility. Six, short-run (120 feet maximum), underground fuel lines are currently utilized to distribute the product from the unloading pad to the ASTs. Product is dispensed from the ASTs via trucks and underground piping.

Reports of a release from an underground distribution line near one of the ASTs date back to 1957-58 (ESE, 1990). Apparently, the leak occurred as the result of damage to a dispensing pump. At that time, the Camp Lejeune Fire Department estimated that thousands of gallons of fuel were released although records which document this incident do not exist. The fuel reportedly migrated to the east and northeast toward Brinson Creek. Interceptor trenches were excavated, and the captured fuel was ignited and burned.

Another abandoned underground distribution line extended from the ASTs to the former Mess Hall Heating Plant, located adjacent to "D" Street, between Third and Fourth Streets. The underground line dispensed No. 6 fuel oil to a UST which fueled the Mess Hall boiler. The Mess Hall, located across "D" Street to the west, was demolished along with its Heating Plant in the 1960s.

In April 1990, an undetermined amount of fuel had been discovered by Camp Geiger personnel along the unnamed drainage channels north of the Fuel Farm. Apparently, the source of the fuel, believed to be diesel or jet fuel, was an unauthorized discharge from a tanker truck that was never identified. The Activity reportedly initiated an emergency clean-up which included the removal of approximately 20 cubic yards of soil.

The Fuel Farm is scheduled to be decommissioned in April 1995. Plans are currently being prepared to empty, clean, dismantle, and remove the ASTs along with all concrete foundations, slabs on grade, berms and associated underground piping. The Fuel Farm is being removed to make way for a six lane divided highway proposed by the North Carolina Department of Transportation (NCDOT). Construction of the highway is scheduled to commence in August 1995.

Previous Investigations

The following is a summary of the previous investigations performed at Site 35.

Initial Assessment Study

MCB, Camp Lejeune was placed on the National Priority List (NPL) on October 4, 1989 after the Initial Assessment Study of 1983 identified 76 potentially contaminated sites at the base (Water and Air Resources, 1983). Site 35 was identified as one of 22 sites warranting further investigation. Sampling and analysis of environmental media was not conducted during the Initial Assessment Study.

Confirmation Study

ESE performed Confirmation Studies of the 22 sites requiring further investigation and investigated Site 35 between 1984 and 1987 (ESE, 1990). In 1984, ESE advanced three hand-auger borings and collected groundwater and soil samples from each location. Soils were analyzed for lead and oil and grease. Lead was detected in soil samples obtained from hand auger borings at concentrations ranging from 6 to 8 mg/kg. Oil and grease was also detected at concentrations ranging from 40 to 2,200 mg/kg.

Shallow groundwater samples were obtained from the open boreholes and analyzed for lead, oil and grease, and volatile organic compounds (VOCs) including benzene, trans-1,2-dichloroethene (T-1,2-DCE), trichloroethene (TCE), and methylene chloride. Lead was detected in each sample ranging from 3,659 μg/L to 1,063 μg/L. Oil and grease was detected in only one sample at 46,000 μg/L. The only detected VOC was methylene chloride in one sample at 4 μg/L.

In 1986, ESE collected two sediment and two surface water samples from Brinson Creek and installed three permanent monitoring wells: two east of and one west of the Fuel Farm. Surface water and sediment samples were analyzed for lead, oil and grease and ethylene dibromide. Groundwater samples were obtained in December 1986 and again in March 1987 and were analyzed for lead, oil and grease, and VOCs.

No target analytes were detected in either surface water sample. Both sediment samples were reported to contain lead and oil and grease although no data indicating actual levels of detection were provided in ESE's report. Levels were reported to be higher in the upstream sample, prompting ESE to suggest that the discharge of contaminated groundwater to the creek is occurring at the far northern section of the fuel farm ASTs or that the source of oil and grease and lead may be upstream.

Lead was detected in only one of six samples (33 μg/L) obtained from the three permanent monitoring wells. Oil and grease was detected in all six samples ranging from 200 μg/L to 12,000 μg/L. Detected VOCs included benzene (1.3 μg/L to 30 μg/L), trans-1,2-DCE (3.2 μg/L to 29 μg/L), and TCE (detected at 11 μg/L on both sample dates).

Focused Feasibility Study

A Focused Feasibility Study (FFS) was conducted in 1990 in the area north of the Fuel Farm by NUS Corporation. The investigation included the installation of four groundwater monitoring wells. Results of laboratory analysis revealed that groundwater in one well and soil cuttings from two borings were contaminated with petroleum hydrocarbons. No nonaqueous product was observed.

A geophysical investigation was conducted by NUS as part of the FFS in an attempt to identify underground storage tanks (USTs) at the site of the former gas station. The results indicated the presence of a geophysical anomaly to the north of the former gas station.

Comprehensive Site Assessment

Law Engineering, Inc. (Law) conducted a Comprehensive Site Assessment (CSA) during the fall of 1991 (Law, 1992). The CSA involved the drilling of 18 soil borings to depths ranging from 15 to 44.5 feet. These soil borings were ultimately converted to nested wells that monitor the water table aquifer along two zones. The shallow zone, or water table zone, generally extends from 2.5 to 17.5 feet, below ground surface (bgs). The deeper zone monitored by the nested wells generally ranges from 17.5 to 35 feet bgs. Five additional soil borings were drilled and nine soil borings were hand-augered to provide data regarding soil contamination in the vadose zone. Additional groundwater data was provided via 21 drive-point groundwater or "Hydropunch" samples. A "Tracer" study was also performed to investigate the integrity of the ASTs and underground distribution piping.

Soil and groundwater samples obtained under the CSA were analyzed for both organic and inorganic compounds. Groundwater analyses included purgeable hydrocarbons (EPA 601), purgeable aromatics and methyl-tertiary butyl ether (MTBE) (EPA 602), polynuclear aromatic hydrocarbons (EPA 610), and unfiltered lead (EPA 239.2). Soil analyses were limited to total petroleum hydrocarbons (TPH) (SW846 3rd Edition, 5030/3550: gasoline/diesel fractions) and lead (SW846 3rd Edition, 6010). Ten soil samples were analyzed for ignitability by SW846 3rd Edition, 1010.

The results of the CSA identified areas of impacted soil and groundwater. The nature of the contamination included both halogenated (i.e., chlorinated) organic compounds (e.g., TCE, trans-1,2-DCE, and vinyl chloride) and nonhalogenated, petroleum-based constituents (e.g., TPH, MTBE, benzene, toluene, ethylbenzene, and xylene). The contamination encountered was typically identified in both shallow (2.5 to 17.5 feet bgs) and deep (17.5 to 35 feet bgs) wells.

Law also identified several plumes of shallow groundwater contamination including two plumes comprised primarily of petroleum-based constituents (e.g., BTEX) and two plumes comprised of halogenated organic compounds (e.g., TCE). The plumes are all located north of Fourth Street and east of E Street except for a portion of a TCE plume. This plume extends southwest beyond the corner of Fourth and E Streets.

In general, contaminant concentrations in soil were greatest in those samples taken at or below the water table. Law concluded that soil contamination at Site 35 was likely due to the presence of a dissolved phase groundwater plume and seasonal fluctuations of the water table.

A follow-up to the CSA was conducted by Law in 1992. Reported as an Addendum to the CSA (Law, 1993), it was designed to provide further characterization of the southern extent of the petroleum contamination resulting from historical releases. Three monitoring wells were installed including MW-26, -27, and PW-28. Soil samples were obtained from each of these locations and analyzed for TPH (gasoline and diesel fractions). As part of the follow-up, a pump test was performed to estimate the hydraulic characteristics of the surficial aquifer. This test was designed to determine performance characteristics of a designated pumping well and to estimate hydraulic parameters of the aquifer. An approximate hydraulic conductivity of 100 feet/day was determined for the surficial aquifer.

Interim Remedial Action RI/FS by Baker

Baker conducted an Interim Remedial Action RI in December 1993. An additional seven soil borings were located within and around groundwater contaminant plume areas identified during the CSA. In addition to the soil borings, thirteen shallow soil samples were taken adjacent to Brinson Creek to determine the extent of contamination emanating from Site 35. Two of these shallow soil samples were situated upstream along Brinson Creek to provide background information on TPH and oil and grease.

In addition to soil sampling, a second round of groundwater level measurements were obtained for comparison to those presented in the CSA.

The most prevalent contaminants detected in soil samples taken during the Interim Remedial Action RI were benzene, toluene, ethylbenzene xylenes, naphthalene, and 2-methylnaphthalene. These constituents are commonly associated with fuel contamination. TPH (gasoline and diesel) and oil and grease were also observed, in addition to sporadic occurrences of lead, chromium, vanadium, and arsenic.

Analytical results, in general, confirm the previous findings that contamination in the majority of the identified soil is associated with a dissolved petroleum hydrocarbon contaminant plume in shallow groundwater. Oil and grease results observed in shallow soil samples obtained from the Brinson Creek area are likely influenced by the presence of naturally occurring organics in soils or an upgradient contamination source. This is supported by elevated background concentrations of oil and grease in surface soil samples obtained along the banks of Brinson Creek approximately 1/2-mile upstream of the site.

The Interim Remedial Action RI/FS culminated with an executed Interim Record of Decision (ROD) signed on September 15, 1994, for the remediation of contaminated soil along and adjacent to the proposed highway right-of-way at Site 35. Three areas of soil contamination requiring remediation have been identified. The first area is located in the vicinity of the Fuel Farms ASTs, and the two other areas are located north of the Fuel Farm. The larger of these two areas is located along "F" Street in the vicinity of monitoring well MW-11; the smaller area is in the area of monitoring well MW-25. Baker has estimated that approximately 3,600 cubic yards (4,900 tons) of contaminated soil is present in these three areas.

A fourth area of soil contamination, located immediately north of Building G480, was also identified in the Interim ROD. Additional data pertaining to this fourth area became available subsequent to the execution of the Interim ROD. This data indicated that contaminated soil was encountered in this area during the removal of a UST there in January 1994. The contaminated soil was excavated and reportedly disposed off site; however, no documentation is available regarding how or where the soil was disposed. An additional soil investigation will be conducted in this area to confirm that the contaminated soil was not returned to the excavation and that follow-up soil remediation in this area is not necessary.

Other Investigations

Two USTs located near the Fuel Farm have been the subject of previous investigations conducted under an Activity-wide UST program. The two USTs include a No. 6 fuel oil UST situated adjacent to the former Mess Hall Heating Plant and a No. 2 fuel oil UST situated adjacent to the Explosive Ordnance and Disposal Armory, Office, and Supply Building. The former UST was abandoned in place years ago (date unknown) and has been the subject of previous environmental investigations performed by ATEC Associates, Inc. and Law. The latter UST was removed in January 1994. Contaminated soils adjacent to the UST were reportedly removed with the tank. However, samples were not collected to confirm the limits of the contaminated soils. Sampling is expected to be conducted to corroborate the limits of soil contamination.

Comprehensive Remedial Investigation/Feasibility Study

A comprehensive RI was conducted by Baker in 1994 to evaluate the nature and extent of the threat to public health and the environment caused by the release of hazardous substances, pollutants, or contaminants, and to support a Feasibility Study evaluation of potential remedial alternatives.

Remedial Investigation Field Activities

The RI field program was initiated on April 11, 1994. Data gathering activities were derived from: a soil gas survey and groundwater screening investigation; a soil investigation; a groundwater investigation; a surface water and sediment investigation; and an ecological investigation.

Soil Gas Survey and Groundwater Screening Investigation

Baker monitored the collection of 67 soil gas samples and 72 groundwater screening samples from sample locations established across the Site 35 study area. This investigation focused on obtaining additional information to assess the source(s) of halogenated compounds in shallow groundwater. The majority of the sample locations were located south of the Fuel Farm and south of Fourth Street, and were based on the results of previous investigations, which revealed TCE in groundwater. The purpose of this activity was to assist in the placement of soil borings/monitoring wells.

Soil Investigation

The soil investigation involved the drilling of 26 soil borings at locations primarily determined by the results of the soil gas survey and groundwater screening investigation. Borings were advanced to three depths and included 10 shallow borings (14 to 17 feet bgs), 11 intermediate borings (41 to 47 feet bgs), and five deep borings drilled to a depth equivalent to 5 to 10 feet below the semi-confining layer separating the surficial aquifer from the Castle Hayne Aquifer (51.0 to 66.0 feet bgs).

Soil samples (surface and subsurface) obtained from the borings were analyzed for a few of the following parameters; TCL volatiles, semivolatiles, pesticides/PCBs, TAL metals, as well as a variety of engineering parameters that will be used in the FS. A summary of each sample, the depth it was collected and parameters analyzed is provided in Appendix I.

Groundwater Investigation

The groundwater investigation included the installation of shallow, intermediate, and deep groundwater monitoring wells. The shallow monitoring wells were installed to intercept the upper portion of the surficial aquifer. The intermediate wells were constructed to monitor the lower portion of the surficial aquifer with screens set just above what appeared to be a semi-confining layer separating the surficial aquifer from the underlying Castle Hayne Aquifer (see Appendix H for boring logs/well construction records). A total of 21 shallow and intermediate wells were installed under this RI. In addition, five deep groundwater wells were installed to monitor the upper portion of the Castle Hayne Aquifer immediately below the suspected semi-confining layer.

Groundwater samples were obtained from each of the 26 newly installed wells and 29 existing wells. The samples were analyzed for TCL volatiles, semivolatiles, pesticides/PCBs, and TAL metals as well as a variety of engineering parameters.

Surface Water/Sediment Investigation

Surface water and sediment samples were obtained along Brinson Creek which flows roughly north to south immediately east of the Fuel Farm. Samples were obtained from ten stations including three upstream and seven adjacent/downstream locations. Surface water and sediment samples were also collected from an off-base reference station. The reference station included the White Oak River watershed.

The surface water and sediment samples were analyzed for TCL volatiles, semivolatiles, pesticides/PCBs, TAL metals, and particle size distribution.

Ecological Investigation

The ecological investigation included biological sampling (i.e., fish, shellfish, and benthic macroinvertebrates) along Brinson Creek and along three streams in the nearby White Oak River watershed including Webb Creek, Hadnot Creek, and Holland Mill Creek. The work performed in the White Oak River watershed was part of an overall ecological background investigation conducted as part of this RI.

Nature and Extent of Contamination

The nature and extent of contamination at Site 35 was determined based on the analytical results of the various media considered under the RI including soil, groundwater, sediment, surface water, and fish tissue. The RI results were also compared to the results from previous environmental investigations performed at Site 35, when applicable.

Surface and Subsurface Soil

Relatively few detections of VOCs and SVOCs were observed in surface and subsurface soil samples obtained under the RI. The most significant contamination detected involved tetrachloroethane in subsurface soil at boring 35MW-30B located near the barracks southwest of the Fuel Farm. Pesticides were detected in surface soil samples only, but, are not deemed to be site related. No PCBs were detected in surface soil samples. Detected inorganics were generally similar to background surface and subsurface soil concentrations at Camp Lejeune.

Groundwater

The nature and extent of groundwater contamination was considered based on the interval of groundwater monitored and included the upper portion of the surficial aquifer; the lower portion of the surficial aquifer; and the upper portion of the Castle Hayne Aquifer.

The results of the RI confirm the results of previous environmental investigations conducted at Site 35 and expand the existing database. Additional groundwater monitoring wells were installed in the surficial aquifer south of the Fuel Farm, and Fourth Street and in the upper portion of the Castle Hayne Aquifer.

No substantial contamination was detected in the upper portion of the Castle Hayne Aquifer. This indicates that, to date, the suspected semi-confining layer that separates the surficial aquifer from the Castle Hayne Aquifer has served effectively as an aquitard (see Figure 3-4).

Extensive groundwater contamination was observed in the surficial aquifer along both the upper and lower monitored intervals. Fuel-related organic contaminants, when encountered, appear more prevalent in the upper portion of the surficial aquifer. Conversely, solvent-related organic contaminants, when encountered, appear more prevalent in the lower portion of the surficial aquifer. This is likely due to the fact that the latter are the more dense compounds having a specific gravity greater than groundwater.

The extent of fuel-related contamination appears to be adequately defined based on the data obtained to date. It is limited to the area north of Fourth Street in the vicinity of obvious suspected sources such as the Fuel Farm and nearby former UST sites.

The extent of solvent-related contamination has not been completely defined to date nor have all of its sources been identified. A plume appears to extend from north of Fourth Street south to Fifth Street beyond which the RI did not extend in the southerly direction (see Figures 4-4 and 4-7). The source of this plume has not been determined. A second smaller plume is present in the vicinity of the Former Vehicle Maintenance Garage (Building TC474). The smaller plume appears to be adequately defined with Building TC474 and the immediate vicinity as the likely source of contamination.

Elevated levels of inorganic contaminants (total and dissolved) were detected in groundwater samples obtained from within the surficial aquifer. It is questionable whether this contamination is due to past site activities because the results are similar to those obtained by Baker at other Camp Lejeune sites. The elevated total metals are believed to be caused by suspended particulates in the samples.

Surface Water and Sediment

Significant levels of organic and inorganic contaminants were detected in sediment samples obtained from locations adjacent to and downstream of Site 35. The results of VOC analyses were "masked" by the presence of high levels of Tentatively Identified Compounds (TICs), and consequently, few VOC detections were reported. Nevertheless, the Baker field team commented during sampling that the sediment samples appeared to contain elevated levels of fuel-related contaminants which could also explain the presence of TICs. Lead at elevated levels was also detected in these sediment samples, and like the organic contaminants, could be related to Site 35.

Surface water contamination was limited to a single detection of lead and zinc downstream of Site 35 at levels in excess of the WQSVs and the NCWQS. No organic contaminants were detected in surface water samples.

Fish

A variety of organic and inorganic contaminants were detected in fillet and whole body samples analyzed under this RI. The most significant contaminants detected were the pesticides dieldrin, and 4,4'-DDD with a single detection of inorganic mercury. These contaminants were primarily responsible for the calculated risk to human health in excess of EPA guidelines.

Baseline Human Health Risk Assessment

The BRA highlights the media of interest from the human health standpoint at OU No. 10 by identifying areas with elevated ICR and HI values. Current and future potential receptors at the site include current military personnel, current recreational adults and children, future residents (i.e., children and adults), and future construction workers. Contaminants of Potential Concern (COPCs) are identified by media and the total site risk for each of these receptors is estimated by logically summing the multiple pathways likely to affect the receptor during a given activity (see Table ES-1). The following algorithms defined the total site risk for the current and future potential receptor groups assessed in a quantitative manner. The risk associated with each site is derived using the estimated risk from multiple areas of interest.

1. Current Military Personnel
    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs

TABLE ES-1

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Ground-water		Surface Water		Sediment		Fish	
VOCs												
Acetone				X						X	●	X
1,1,2,2-Tetrachloroethane						X						
Chloroform						X						
Methylene Chloride				X								X
1,1,2-Trichloroethane						X						
1,1-Dichloroethane						X						
1,1-Dichloroethene					●	X						
2-butanone												X
Benzene					●	X						
Carbon disulfide		X										X
cis-1,2-Dichloroethene					●	X						
Ethylbenzene					●	X						
Methyl Tertiary Butyl Ether					●	X						
Tetrachloroethene				X		X						
Toluene		X			●	X				X		X
trans-1,2-Dichloroethene					●	X						
Trichloroethene					●	X						
Xylenes (Total)		X			●	X						
SVOCs												
Benzo(a) pyrene		X										
Indeno(1,2,3-cd) pyrene		X										
Dibenz(a,h) anthracene		X										
Benzo(g.h,i) perylene	●	X										
4-Methylphenol						X						
2,4-Dimethylphenol						X						
Naphthalene					●	X						
Dibenzofuran					●	X						
Fluorene						X						
Anthracene						X						
Carbazole						X						
Diethylphthalate									●	X		
Di-n-butylphthalate										X		

TABLE ES-1 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Ground-water		Surface Water		Sediment		Fish	
Bis(2-ethylhexyl)phthalate		X								X		
Phenol		X				X						
2-Methylnaphthalene					●	X						
2-Methylphenol						X						
Acenaphthene		X										
Phenanthene	●	X			●	X						
Carbazole		X										
Fluoranthene		X										
Pyrene		X		X								
Butylbenzlphthalate		X										
Benzo(a)anthracene		X										
Chrysene		X										
Benzo(b) fluoranthene	●	X	●	X								
Pesticides												
Aldrin						X						X
gamma-BHC												X
alpha-Chlordane		X							●	X	●	X
beta-BHC		X				X				X	●	X
Dieldrin	●	X							●	X	●	X
Endosulfan II	●	X							●	X	●	X
Endrin Ketone	●	X							●	X	●	X
Endrin Aldehyde	●	X							●	X	●	X
Endrin		X							●	X	●	X
delta-BHC					●	X				X		X
gamma-Chlordane		X							●	X		
Heptachlor					●	X				X	●	X
Heptachlor Epoxide									●	X		X
Methoxychlor									●	X		
4,4'-DDE		X							●	X	●	X
4,4'-DDT		X				X			●	X	●	X
4,4'-DDD	●	X				X			●	X	●	X
Inorganics												
Aluminum		X		X		X		X		X	●	X
Antimony		X			●	X	●	X				
Arsenic	●	X	●	X	●	X	●	X	●	X		

TABLE ES-1 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Ground-water		Surface Water		Sediment		Fish	
Barium		X		X	●	X		X	●	X	●	X
Beryllium		X			●	X			●	X		
Cadmium		X		X	●	X						X
Calcium		X		X		X		X		X		
Chromium		X		X	●	X	●	X	●	X		
Cobalt		X		X	●	X	●	X	●	X		
Copper		X		X		X			●	X	●	X
Lead	●	X	●	X	●	X	●	X	●	X	●	X
Magnesium		X		X		X		X		X		
Manganese	●	X		X	●	X	●	X	●	X	●	X
Mercury						X	●	X		X	●	X
Nickel		X		X	●	X			●	X		
Potassium				X		X		X		X		
Selenium		X		X		X		X	●	X	●	X
Silver				X	●	X						
Sodium						X		X		X		
Thallium		X	●	X	●	X	●	X	●	X		
Vanadium		X		X	●	X	●	X	●	X		
Zinc		X		X	●	X	●	X	●	X	●	X
Iron		X		X		X		X		X		

● Selected as COPC..
X Positively detected in media.

2. Future Residents (Children and Adults)

    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation airborne of COPCs

    b. Ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater + inhalation of volatile COPCs

3. Future Construction Worker

    a. Incidental ingestion of COPCs in on-site subsurface soil + dermal contact with COPCs in subsurface soil + inhalation of airborne COPCs

4. Current Recreational Children and Adults

    a. Ingestion of COPCs in surface water and sediment + dermal contact with COPCs in surface water and sediment

    b. Ingestion of fish tissue (adults only)

The total site ICR and HI values associated with current and future receptors at this site are presented in Table ES-2. The total site ICR for the current recreational child (4.4×10^{-7}) current recreational adult (1.9×10^{-5}), and current military personnel (3.1×10^{6}) are below the USEPA's upper bound risk range (1×10^{-4} to 1×10^{-6}), therefore adverse effects are considered unlikely. The total site HI for the current recreational child (0.01) and current military personnel (0.09) did not exceed unity. Therefore, adverse effects are considered unlikely. The total site HI for the current recreational adult (1.8) is slightly above unity. The total site risk is due to potential exposure from fish fillet ingestion which is driven by the presence of mercury. However, the exposure parameters used to calculate risk from fish ingestion are very conservative; mercury was not found to be causing a risk in any other media at Site 35; and the fish collected at Site 35 are considered migratory and move along Brinson Creek, therefore this risk may not be due to contamination at the site. Therefore, the risk from ingestion of fish may not be site related.

The total site ICR and HI for the future construction worker (1.2×10^{-7} and 0.02, respectively) are below the USEPA's risk range, therefore, risk to this receptor is considered unlikely. The total site ICR for future adult residents (4.3×10^{-3}) and future child residents (2.1×10^{-3}) exceed the USEPA's upper bound risk range (1×10^{-4} to 1×10^{-6}). The total site risk is driven by future potential exposure to groundwater. The ICR values are driven by the presence of arsenic and beryllium. The total site HI for the future adult resident (44) and the future child resident (104) exceed unity. The total site risk is driven by future potential exposure to groundwater. The HI values are driven by the presence of cis-1,2-dichlorothene, trichloroethene, benzene, antimony, arsenic, barium, chromium, cadmium, manganese, and vanadium.

Ecological Risk Assessment

Overall, metals and pesticides appear to be the most significant site related COPCs that have the potential to affect the integrity of the aquatic and terrestrial receptors at Site 35. Although the

American alligator has been observed at Site 35, potential adverse impacts to this species could not be quantitatively evaluated.

Aquatic Ecosystem

Surface water quality showed exceedances of aquatic reference values for lead, mercury, and zinc. In addition, iron, cobalt and manganese were above the concentration that caused adverse impacts to aquatic species in a few studies. However, most of the studies did not meet the criteria for reliability, and other studies indicated that potential impacts to aquatic organisms did not occur at the concentrations detected in the surface water at Brinson Creek. For sediments, concentrations of lead and the organics dieldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endrin, alpha-chlordane, and gamma-chlordane exceeded the aquatic reference values. In the surface water, mercury exceeded aquatic reference values in the upstream stations. Although these levels were indicative of a high potential for risk (QI > 100), mercury is not believed to be site related. Zinc only exceeded unity slightly and was only found at a single station. Lead has a single exceedance of the aquatic reference value by slightly greater than 10 indicating a moderate potential for risk to aquatic receptors. Lead also was found in the groundwater samples at similar levels and is site related.

In the sediments, lead exceeded the lower sediment aquatic reference value throughout Brinson Creek. The only exceedances of the higher sediment aquatic reference value occurred downstream of Site 35 with the highest QI of 137 representing a high potential for risk to aquatic receptors. The lead detected in the sediments is likely site related, the result of past reported surface spills/runoff and past and ongoing groundwater discharges to surface water.

Pesticides exceeded the sediment aquatic reference values throughout Brinson Creek. The highest QI, 2,600 for dieldrin, represents a high potential for risk to aquatic receptors. There is no documented pesticide disposal or storage/preparation activities at Site 35. The pesticide levels detected in the sediments probably are a result of routine application in the general vicinity of Site 35.

Although, the pesticides in the sediments were found at levels indicating contamination throughout the watershed, the highest levels were observed in the lower reaches of Brinson Creek. This deposition trend may be related to the higher organics in the sediments in the lower reach, which would accumulate more of these types of contaminants.

The fish community sampled in Brinson Creek was representative of an estuarine ecosystem with both freshwater and marine species present. In addition, the presence of blue crabs, grass shrimp, and crayfish support the active use of Brinson Creek by aquatic species.

The absence of pathologies observed in the fish collected from Brinson Creek indicates that the surface water and sediment quality may not adversely impact the fish community.

The benthic macroinvertebrate community demonstrated the typical tidal/freshwater species trend of primarily chironmids and oligochaetes in the upper reaches and polychaetes and amphipods in the lower reaches. Species representative of both tolerant and intolerant taxa were present. Species richness and densities were representative of an estuarine ecosystem.

In summary, the aquatic community in Brinson Creek is representative of an estuarine community and does not appear to be significantly impacted by surface water and sediment quality.

Terrestrial Ecosystem

Surface soil quality indicated a potential for adversely impacting the terrestrial receptors that have direct contact with the surface soils. This adverse impact is primarily due to cadmium in the surface soils. Cadmium was detected at a relatively high concentration in only out of ten surface soil samples, therefore any estimation of adverse effects on terrestrial receptors using this cadmium concentration is conservative.

There also appears to be impacts to the terrestrial receptors due to copper in the fish tissue. Copper was not detected in the surface water but was detected in sediment samples collected downstream of Site 35 at concentrations lower than the sediment samples taken upstream of Site 35. As such, the copper in the fish tissue does not appear to be site related.

Conclusions

- Site 35 is an active petroleum product Fuel Farm scheduled for decommissioning and dismantlement in early 1995. The Fuel Farm dates back to 1945 and has a poorly documented history of various spills and leaks associated with aboveground and underground storage tanks and associated piping.

- Site 35 is situated within Camp Geiger in the northwest corner of Camp Lejeune. It is located along Brinson Creek which is a boundary line between Camp Lejeune and adjacent private property.

- Several environmental studies have been conducted at Site 35 dating back to 1983. The data obtained to date indicate the presence of significant elevated levels of organic and inorganic contaminants in surficial groundwater, Brinson Creek sediments, and fish tissue. Contaminated soil (fuel-related) in the vicinity of a proposed highway through Site 35 has been addressed through an Interim Record of Decision executed on September 15, 1994. One potentially significant area of subsurface soil contamination was identified during the RI in the vicinity of the Barracks located southwest of the Fuel Farm based on detections of PCE subsurface soil samples obtained from borings 35MW-30B and -37B. In addition, the Baker field team commented that during the drilling of boring 35MW-29B a strong odor was encountered although no VOCs or SVOCs were detected in subsurface soil samples obtained at this location.

- Organic contamination in groundwater is presently limited to the surficial aquifer which is monitored at two levels including the groundwater surface (upper portion) and atop an underlying suspected semi-confining layer (lower portion). The suspected semi-confining layer appears to be adequately serving as an effective aquitard separating the surficial aquifer from the underlying Castle Hayne Aquifer as no significant levels of contamination were detected in the underlying Castle Hayne Aquifer. Relative to organic contaminants, both fuel- and solvent-related contaminants were detected in groundwater samples obtained from the upper and lower portions of the surficial aquifer. In general, fuel-related contamination was detected most prevalently in samples obtained from wells monitoring the upper portion of the surficial aquifer. Conversely, solvent-related contaminants were more prevalent in groundwater samples obtained from wells monitoring the lower portion of the surficial aquifer.

TABLE ES-2

TOTAL SITE RISK
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Groundwater		Surface Water		Sediment		Fish		TOTALS	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Future Child Resident	4.5E-05 (<1)	0.93 (1)	2.1E-03 (99)	103 (99)	NA	NA	NA	NA	NA	NA	2.1E-03	104
Future Adult Resident	2.7E-05 (<1)	0.10 (<1)	4.3E-03 (99)	44 (99)	NA	NA	NA	NA	NA	NA	4.3E-03	44
Future Construction Worker	1.2E-07 (100)	0.02 (100)	NA	NA	NA	NA	NA	NA	NA	NA	1.2E-07	0.02
Current Military Personnel	3.1E-06 (100)	0.09 (100)	NA	NA	NA	NA	NA	NA	NA	NA	3.1E-06	0.09
Current Recreational Child	NA	NA	NA	NA	1.1E-07 (27)	<0.01 (<1)	3.3E-07 (73)	0.01 (99)	NA	NA	4.4E-07	0.01
Current Recreational Adult	NA	NA	NA	NA	1.2E-07 (<1)	<0.01 (<1)	4.5E-07 (<1)	<0.01 (<1)	1.8E-05 (99)	1.8 (99)	1.9E-05	1.8

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
ND = Not Determined
NA = Not Applicable
( ) = Percent Contribution to Total Risk

The source of the fuel-related groundwater contamination appears to be the Fuel Farm, underground piping, and nearby USTs. It appears to be adequately defined and somewhat limited to the area north of Fourth Street.

Solvent-related contamination appears to be separated into two plumes. The smaller plume is located in the vicinity of Building TC474, a former Vehicle Maintenance Garage, which is its most likely source. The larger plume is located west of the Fuel Farm and extends from north of Fourth Street south to Fifth Street and possibly beyond. Based on data obtained to date the horizontal limits of the second solvent-related plume has not been defined and its source is not known.

- Elevated levels of inorganic contaminants (total and dissolved) were detected in groundwater samples obtained from within the surficial aquifer. It is questionable whether this contamination is due to past site activities because the results are similar to those obtained by Baker at other Camp Lejeune sites.

- Organic and inorganic contaminants were detected in sediment samples obtained at locations adjacent to and downstream of Site 35. The results of VOC analyses were "masked" by the presence of Tentatively Identified Compounds (TICs) at high levels. The TICs may be indicative of accumulated higher molecular weight hydrocarbons which are the remnants of past contamination.

  Inorganic contamination, primarily in the form of lead, was also detected at elevated concentrations and is likely related to Site 35.

- Baker calculated that the human health risk associated with Site 35 is in excess of the acceptable range. The total risk was driven by future potential exposure to groundwater and current potential exposure to fish. However, only non-carcinogenic risks were likely with exposure to fish.

- The ecological risk assessment indicated that the aquatic community within Brinson Creek was representative of an estuarine community and does not appear to be adversely impacted by surface water and sediment quality. Additionally, there are no significant adverse impacts to terrestrial receptors from site-related contaminants.

Recommendations

Based on the data obtained it is recommended that:

- The remedial investigation at Site 35 be extended south of Fifth Street as needed to define the extent and locate the source(s) of solvent-related groundwater contamination in the surficial aquifer.

- The monitoring wells screened within the surficial aquifer that were sampled under the RI for inorganic contaminants (total phase only) be resampled using low-flow pumping techniques. This technique uses a peristaltic pump that limits the pumping rate to between 0.20 - 0.30 gallons per minute (gpm). These pumping rates are set to produce no net head loss in the well being sampled. Sediments (the likely source of the high inorganic concentrations in total phase samples) in the bottom of the well are also left mostly undisturbed. Samples are collected only after 3 to 5 well volumes have been removed, water quality has stabilized, and turbidity levels are less than 10 Nephelometric Turbidity Units (NTUs).

- Surface soils and sediments be resampled for mercury and zinc in order to replace that data which was rejected during validation. The data generated from the additional sampling of soils and sediments combined with the results of the low-flow groundwater sampling for metals should enable Baker to determine whether or not Site 35 is the source of elevated zinc and/or mercury concentrations in Brinson Creek surface water and fish. In addition, new information regarding metals concentrations in Site 35 media will be used to further evaluate the human health and environmental risks associated with the site. The soils and sediment data and any associated analyses will be incorporated into an addendum to the RI Report.

- Sediment samples along Brinson Creek be obtained at locations adjacent to and downstream of Site 35 and analyze for TPH (EPA Methods 5030 and 3550) so as to provide data regarding the extent of organic contamination that was "masked" by TICs in results obtained under the RI.

- An Interim Remedial Action Feasibility Study be prepared that focuses on groundwater in the vicinity of the Fuel Farm and north of Fourth Street. The purpose of this Interim FS will be to address groundwater contamination in this area which may be a continuing source of contamination to Brinson Creek.

- The northeastern edge of the halogenated organic plume has not been delineated. Therefore, soil and groundwater samples should be collected on the northern side of Brinson Creek in order to determine if the creek is acting as a barrier to groundwater contamination that may be migrating off-site.

- Special precautions be taken when soil excavation is performed during the construction of the new highway. Specifically, it is recommended that the written construction workplans reference the need for monitoring of volatile organic contaminant concentrations in the breathing zone of the workers, and that institutional and engineering controls be established to minimize human exposure to both VOCs and fugitive dust particulates. Although the calculated risk to human health for future construction workers on Site 35 is well below the EPA acceptable range, adverse exposure to a volatilized fraction of contaminants in the subsurface soil or inhalation of airborne contaminants is possible.

1.0 INTRODUCTION

This document is a report on the Remedial Investigation (RI) activities performed at Operable Unit (OU) No. 10, Site 35 - Camp Geiger Area Fuel Farm. It has been prepared by Baker Environmental, Inc. (Baker) for presentation to the Department of the Navy (DoN), Naval Facilities Engineering Command, Atlantic Division (LANTDIV) under Navy CLEAN Contract Number N62470-89-D-4814. The RI has been conducted in accordance with guidelines and procedures presented in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP)(40 CFR 300.430). USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA 1988) was used as a guide for preparing this document.

The purpose of this RI was to evaluate the nature and extent of the threat to public health and the environment caused by the release of hazardous substances, pollutants or contaminants. This was accomplished by sampling several media (soil, groundwater, sediment, surface water, fish, crabs, and benthic macroinvertibrates) at OU No. 10, evaluating the analytical data and performing a human health risk assessment (RA) and ecological RA. This RI report contains the results of all field investigations, a technical memorandum summarizing groundwater data and aquifer characteristics at MCB, Camp Lejeune, the human health RA, and the ecological RA. Previous investigations were conducted by Water and Air Research, Inc., (WAR) Environmental Science and Engineering, Inc. (ESE), NUS Corporation (NUS), Law Engineering (LAW) and Baker Environmental, Inc. (Baker).

Marine Corps Base (MCB) Camp Lejeune, North Carolina has been actively involved in various environmental investigation and remediation programs since 1983, beginning with the Navy Assessment and Control of Installation Pollutants (NACIP) Program. The first study conducted under the NACIP to investigate potentially hazardous site at MCB Camp Lejeune was an Initial Assessment Study (IAS). It was conducted in 1983 and identified areas of concern that may potentially cause threats to human health and the environment as a result of past storage, handling, and/or disposal of hazardous material. Based on a review of historical records, field inspections and personal interviews, 76 areas of concern (AOCs) were identified. The IAS concluded that none of the sites pose an immediate threat to human health or the environment, however, 22 sites warrant further investigation to assess long-term impacts. During preliminary investigation of the AOCs, an additional AOC (Site 78, Hadnot Point Industrial Area) was identified.

The Department of Navy's Installation Restoration Program (IRP) was initiated in 1986 following the legislation of the Superfund Amendments and Reauthorization Act (SARA). The IRP was implemented to follow the requirements of SARA and replaced the NACIP.

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

The FFA covers 23 sites at MCB Camp Lejeune that require investigation in accordance with the NCP, CERCLA and SARA under the terms and conditions outlined in the FFA. These sites have been divided into 13 operable units to simplify proceeding with Remedial Investigation/Feasibility Studies (RI/FS) activities.

1.1 Background

This section presents an overview of Site 35 and is divided into two subsections, Site Description and Site History.

1.1.1 Site Description

MCB, Camp Lejeune (also referred to as the "Activity") is located in Onslow County, North Carolina (Figure 1-1). The Activity currently covers approximately 234 square miles and is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The borders of the Activity are defined by the U.S. Route 17 and State Route 24 to the west and northwest, respectively. The eastern border is defined by the Atlantic Ocean shoreline and the City of Jacksonville, North Carolina, borders the Activity to the north.

Camp Geiger is located at the extreme northwest corner of MCB Camp Lejeune and contains a mixture of troop housing, personnel support and training facilities. The main entrance is located along U.S. Route 17, approximately 3.5 miles southeast of the City of Jacksonville, North Carolina. Site 35, Camp Geiger Area Fuel Farm refers primarily to five, 15,000-gallon aboveground storage tanks (ASTs), a pump house, a fuel loading/unloading pad, an oil water separator, and a distribution island situated just north of the intersection of Fourth and "G" Streets. Results of previous investigations have expanded the study area beyond the confines of the Fuel Farm. To date, the study area is bounded on the west by D Street, on the north by Second Street, on the east by Brinson Creek and on the south by Fifth Street and Building No. TC572 (Figure 1-2).

Brinson Creek begins north of US Route 17 and forms the eastern boundary of the site and Camp Geiger, as it flows to the New River. East of Brinson Creek is private property. It appears, based on rough field measurements and observations, that Brinson Creek is tidally influenced to some point north of Site 35.

The 40-acre study area surrounding Site 35 is primarily covered with vegetation. Although the majority of the area is maintained, the portion adjacent to Brinson Creek is heavily wooded and overgrown. Roadways, buildings, former building foundations and several large parking areas are located throughout the study area. Eight large warehouses (TC572, TC470, TC473, TC474, TC462, TC560, TC341, and TC342), five barracks (G530 through G534) for temporary housing troops and an armory (G480) presently exist within the boundaries of the study area.

A pair of abandoned railroad tracks are located near warehouses TC462 and TC560 oriented in the north/south direction which appear to have been used to supply the series of three warehouses (two existing and one former), the ice house and the fuel farm. Chemicals are currently being stored within a fenced portion of the study area located between warehouses TC470 and TC572. The foundations of previously existing structures are scattered throughout the study area marking the former existence of a warehouse (TC460), a mess hall, a mess hall heating plant, a gas station and an ice house.

Two large fields exist in the central and western central portions of the study area. Both of the fields are used for recreation and training exercises. The "COMMARFORLANT Nuclear Biological Chemical Defense School Training Range" is located southeast of the site. Training exercises and lectures on nuclear, chemical and biological warfare are administered at this facility. This facility stores and employs the chemical warfare training agent CS (0-chlorobenzylidene malonitrile) on a regular basis.

1.1.2 Site History

Construction of MCB, Camp Lejeune began in 1941 with the objective of developing the "Worlds Most Complete Amphibious Training Base." Construction started at Hadnot Point, where the major functions of the Activity are centered. Development at the Activity is primarily in five geographical locations under the jurisdiction of the Base Command. These areas include Camp Geiger, Montford Point, Courthouse Bay, Mainside, and the Rifle Range Area.

Construction of Camp Geiger was completed in 1945, four years after construction of MCB, Camp Lejeune was initiated. Originally, the Fuel Farm ASTs were used for the storage of No. 6 fuel oil, but were later converted for storage of other petroleum products including unleaded gasoline, diesel fuel, and kerosene. The date of their conversion is not known.

Routinely, the ASTs at Site 35 supply fuel to an adjacent dispensing pump. A leak in an underground line at the station was reportedly responsible for the loss of roughly 30 gallons per day of gasoline over an unspecified period (Law, 1992). The leaking line was subsequently sealed and replaced.

The ASTs at Site 35 are currently used to dispense gasoline, diesel and kerosene to government vehicles and to supply underground storage tanks (USTs) in use at Camp Geiger and the nearby New River Marine Corps Air Station. The ASTs are supplied by commercial carrier trucks which deliver product to fill ports located on the fuel loading/unloading pad located south of the ASTs. Six, short-run (120 feet maximum), underground fuel lines are currently utilized to distribute the product from the unloading pad to the ASTs. Product is dispensed from the ASTs via trucks and underground piping.

Previously abandoned underground distribution line extended from the ASTs to the former Mess Hall Heating Plant, located adjacent to "D" Street, between Third and Fourth Streets. The underground line dispensed No. 6 fuel oil to a UST which fueled the Mess Hall boiler. The Mess Hall, located across "D" Street to the west, is believed to have been demolished along with its Heating Plant in the 1960s.

Reports of a release from an underground distribution line near one of the ASTs date back to 1957-58 (ESE, 1990). Apparently, the leak occurred as the result of damage to a dispensing pump. At that time the Camp Lejeune Fire Department estimated that thousands of gallons of fuel were released although records of the incident have since been destroyed. The fuel reportedly migrated to the east and northeast toward Brinson Creek. Interceptor trenches were excavated and the captured fuel was ignited and burned.

In April 1990, an undetermined amount of fuel was discovered by Camp Geiger personnel along two unnamed drainage channels north of the Fuel Farm. Apparently, the source of the fuel, believed to diesel or jet fuel, was an unauthorized discharge from a tanker truck that was never identified. The

Activity reportedly initiated an emergency clean-up which included the removal of approximately 20 cubic yards of soil.

The Fuel Farm is scheduled to be demolished by April 1995. Plans are currently being prepared to empty, clean, dismantle, and remove the ASTs along with all concrete foundations, slabs on grade, berms and associated underground piping. The Fuel Farm is being removed to make way for a six lane divided highway proposed by the North Carolina Department of Transportation (NCDOT) (Figure 1-3).

In addition to the Fuel Farm dismantling, soil remediation activities will be executed along the highway right-of-way as per an Interim Record of Decision executed on September 15, 1994. The soil remediation work is scheduled to commence in May 1995.

1.2 Summary of Previous Investigations

The purpose of this section is to summarize existing information pertaining to previous environmental studies involving Site 35. Information presented herein can be found in the Initial Assessment Study of Marine Corps Base, Camp Lejeune, North Carolina (WAR, 1983), Final Site Summary Report, MCB Camp Lejeune (ESE, 1990) Draft Field Investigation/Focused Feasibility Study, Camp Geiger Fuel Spill Site (NUS, 1990), Underground Fuel Investigation and Comprehensive Site Assessment (Law, 1992) and the Addendum Report of Underground Fuel Investigation and Comprehensive Site Assessment (Law, 1993) and the Interim Remedial Action Remedial Investigation/Feasibility Study (Baker, 1994). Sample locations associated with each of these studies are depicted on Figure 1-4.

1.2.1 Initial Assessment Study

MCB, Camp Lejeune was placed on the National Priority List (NPL) in 1983 after the Initial Assessment Study (IAS) identified 76 potentially contaminated sites at the Activity (WAR, 1983). Site 35 was identified as one of 23 sites warranting further investigation. Sampling and analysis of environmental media was not conducted during the IAS.

1.2.2 Confirmation Study

ESE performed Confirmation Studies of the 22 sites requiring further investigation which included a study of the Fuel Farm between 1984 and 1987 (ESE, 1990). In 1984, ESE advanced three hand-auger borings (35GW-1, -2, and -3) downgradient of the site, and collected groundwater and soil samples from each location. Soils were analyzed for lead and oil and grease. Lead was detected in soil samples obtained from hand auger borings at concentrations ranging from 6 to 8 mg/kg. Oil and grease was also detected at concentrations ranging from 40 to 2,200 mg/kg.

Shallow groundwater samples were obtained from the open boreholes and analyzed for lead, oil and grease, and volatile organic compounds (VOCs) including benzene, trans-1,2,-dichloroethene (trans-1,2,-DCE), trichloroethene (TCE), and methylene chloride. Lead was detected in each sample ranging from 1,063 μg/L (35GW-3) to 3,659 μg/L (35GW-1). Oil and grease was detected in sample 35GW-2 at 46,000 μg/L. The only detected VOC was methylene chloride in sample 35GW-1 at 4 μg/L.

In 1986, ESE collected two sediment (35SE1 and 35SE2) and two surface water (35SW1 and 35SW2) samples from Brinson Creek and installed three permanent monitoring wells (35GW-4, -5, and -6 which were later renamed EMW-5, -6, and -7), two east of and one west of the Fuel Farm. Table 1-1 details well construction. Surface water and sediment samples were analyzed for lead, oil and grease and ethylene dibromide. Groundwater samples were obtained in December 1986 and again in March 1987 and were analyzed for lead, oil and grease (O&G), and volatile organic compounds (VOCs).

No target analytes were detected in either surface water sample. Both sediment samples were reported to contain lead and oil and grease although no data indicating actual levels of detection were provided in ESE's report. Levels were reported to be higher in the upstream sample, prompting ESE to suggest that the discharge of contaminated groundwater to the creek is occurring at the far northern section of the Fuel Farm ASTs or that the source of O&G and lead may be upstream.

Lead was detected in only one of six samples (33 µg/L: EMW-6) obtained from the three permanent monitoring wells. Oil and grease was detected in all six samples in a range from 200 µg/L (EMW-5: December 1986) to 12,000 µg/L (EMW-5: March 1987). Detected VOCs included benzene (range: 1.3 µg/L at EMW-7 to 30 µg/L at EMU-6), trans-1,2,-DCE (range: 3.2 µg/L at EMW-5 to 29 µg/L at EMW-7), and TCE (detected at 11 µg/L at EMW-7 on both sample dates).

ESE recommended further investigations designed to determine the horizontal and vertical extent of contamination residing within the soils and groundwater beneath the site and sediments in Brinson Creek. In addition, ESE recommended investigation of the adjacent automotive maintenance/hobby shop to determine if it is a source of VOC contamination. In conjunction with the investigations, ESE recommended a risk assessment for portions of the ESE report that pertain to Site 35 (Appendix A).

1.2.3 Focused Feasibility Study

A Focused Feasibility Study (FFS) was conducted in 1990 in the area north of the Fuel Farm by NUS. Although the FFS was conducted, a Record of Decision was not signed as a result. The FFS included the installation of four groundwater monitoring wells numbered EMW-1, -2,-3, and -4. Table 1-1 summarizes well construction details. Baker was not able to obtain a copy of the NUS report. It was, however, discussed in the Comprehensive Site Assessment Report (Law, 1992). Law indicated that the results of laboratory analysis revealed groundwater in one well and soil cuttings from two borings were contaminated with petroleum hydrocarbons although non-aqueous product was not observed. No quantifiable data was provided in the Law report.

A geophysical investigation was also conducted by NUS as part of the FFS in an attempt to identify USTs at the site of the former gas station. The results indicated the presence of a geophysical anomaly in the vicinity of the former gas station.

1.2.4 Comprehensive Site Assessment

Law conducted a Comprehensive Site Assessment (CSA) during the fall of 1991 (Law, 1992). The CSA involved the drilling of 18 soil borings to depths ranging from 15 to 44.5 feet. These soil borings were ultimately converted to nested wells (MW-8 through 25) that monitor the water table aquifer along two zones. The shallow wells were constructed to monitor the water table and generally screened from 2.5 to 17.5 feet below ground surface (bgs). The deeper wells monitored the lower portion of the surficial aquifer and are generally screened from 17.5 to 35 feet bgs. Table 1-2 summarizes well construction details. Well MW-20 was the only well installed that is not a double nested well. It is screened from 3 to 12.5 feet bgs. Five additional soil borings were drilled and nine soil borings were hand-augered to provide data regarding vadose zone soil contamination. Three soil borings (SB-1, SB-2, SB-3) were drilled specifically to provide subsurface stratigraphic data. Additional groundwater data was provided via 21 drive-point groundwater or "Hydropunch" samples. A "Tracer" study was also performed to investigate the integrity of the ASTs and underground distribution piping.

Soil and groundwater samples obtained under the CSA were analyzed for both organic and inorganic compounds. Groundwater analyses included purgeable hydrocarbons (EPA 601), purgeable aromatics and methyl-tertiary-butyl-ether (MTBE) (EPA 602), polynuclear aromatic hydrocarbons (PAHs) (EPA 610), and unfiltered lead (EPA 239.2). Soil analyses were limited to total petroleum hydrocarbons (TPH) (SW846 3rd Edition, 5030/3550: gasoline/diesel fractions) and lead (SW846 3rd Edition, 6010). In addition, ten soil samples were analyzed for ignitability by SW846 3rd Edition, 1010.

The results of the CSA identified areas of impacted soil and groundwater. The nature of the contamination included both halogenated (i.e., chlorinated) organic compounds (e.g., TCE, trans-1,2-DCE, and vinyl chloride) and nonhalogenated, petroleum-based constituents (e.g., TPH, MTBE, benzene, toluene, ethylbenzene, and xylene). The contamination encountered was typically identified in both shallow (2.5 to 17.5 feet bgs) and deep (17.5 to 35 feet bgs) wells.

Law also identified several plumes of shallow groundwater contamination including two plumes comprised primarily of petroleum-based constituents (e.g., BTEX) and two plumes comprised of halogenated organic compounds (e.g., TCE). The plumes are all located north of Fourth Street and east of E Street except for a portion of a TCE plume that extends southwest beyond the corner of Fourth and E Streets.

In general, contaminant concentrations in soil were greatest in those samples taken at or below the water table. Law concluded that soil contamination at Site 35 was likely due to the presence of a dissolved phase groundwater plume and seasonal fluctuations of the water table. For portions of this report, refer to Appendix B.

A follow-up to the CSA was conducted by Law in 1992. Reported as an Addendum to the CSA (Law, 1993), it was designed to provide further characterization of the southern extent of the previously identified petroleum contamination. Three monitoring wells were installed including MW-26, -27, and PW-28. Monitoring well construction details are summarized in Table 1-2. Soil samples were obtained from each of these locations and analyzed for TPH (gasoline and diesel fractions). As part of the follow-up, a pump test was performed to estimate the hydraulic characteristics of the surficial aquifer. This test was designed to determine performance characteristics of the pumping well (PW-28) and to estimate hydraulic parameters of the aquifer. An approximate hydraulic conductivity of 100 feet/day was determined for the surficial aquifer. Portions of the Addendum to the CSA is provided in Appendix C.

1.2.5 Interim Remedial Action RI/FS

An Interim Remedial Action field investigation was initiated by Baker in December 1993. Its purpose was to provide additional soil data to augment the existing Site 35 database, to determine the presence of non-fuel related chemical contaminants, to provide additional information regarding the extent of soil contamination, and to support an Interim Remedial Action FS.

Seven soil borings (SB-29 through SB-35) were advanced to depths 6 to 12 feet for the purpose of collecting samples for chemical analysis. Samples were screened with an HNu photoionization detector (PID) to detect potential volatile organic hydrocarbons and to help select which sample would be submitted for laboratory analysis. Samples submitted to the laboratory were analyzed for USEPA Contract Laboratory Program (CLP) Target Compound List (TCL) volatiles and semivolatiles, Target Analyte List (TAL) inorganics, TPH by SW846 3rd Edition, Modified Method 8015 and oil and grease by SW846 3rd Edition Method 9071. Samples analyzed for TPH were extracted in accordance with SW 846 3rd Edition, Methods 5030 (gasoline range organics) and 3550 (diesel range organics). A composite sample was analyzed for the TCLP and RCRA Hazardous Waste Characteristics.

In addition, 13 shallow surface soil samples (BCSB-01 through BCSB-13) were collected at a depth of 0" to 12" from topographically low areas of Brinson Creek and the drainage channel located north of the Fuel Farm. Soil samples BCSB-01 through BCSB-10 were analyzed for CLP TCL volatiles and semivolatiles, TAL inorganics, TPH by SW 846 3rd Edition, Modified Method 8015 and oil and grease by SW 846 3rd Edition, Method 9071. Soil samples BCSB-11, 12, and 13 were analyzed for TPH and oil and grease only. A composite sample was analyzed for full TCLP and RCRA characteristics.

In general, analytical data gathered during the Interim RI suggests that the petroleum hydrocarbon contamination is primarily located near the surface of the shallow groundwater. The results indicate that the highest TPH related contamination occurs at or below the water table and groundwater fluctuations likely account for the subsurface soil contamination detected immediately above the top of the groundwater.

The Interim Remedial Action RI/FS culminated with an executed Interim Record of Decision (ROD), signed on September 15, 1994, for the remediation of contaminated soil along and adjacent to the proposed highway right-of-way at Site 35. Three areas of contaminated soil have been identified. The first area is located in the vicinity of the Fuel Farm ASTs, and the two other areas are located north of the Fuel Farm. The larger of these two areas is located along "F" Street in the vicinity of monitoring well MW-25. Baker has estimated that approximately 3,600 cubic yards (4,900 tons) of contaminated soil is present in these areas. Contaminated soil located in these areas is scheduled for removal and disposal at an off-site soil recycling facility beginning in 1995.

A fourth area of soil contamination, located immediately north of Building G480, was also identified in the Interim ROD. Additional data pertaining to this fourth area became available subsequent to the execution of the Interim ROD. This data indicated that contaminated soil was encountered in this area during the removal of a UST there in January 1994. The contaminated soil was excavated and reportedly disposed off site; however, no documentation is available regarding how or where the soil was disposed. An additional soil investigation will be conducted in this area to confirm that the contaminated soil was not returned to the excavation and that follow-up soil remediation in this area is not necessary.

1.2.6 Other Investigations

Two USTs located near the Fuel Farm have been the subject of previous investigations conducted under the Activity's UST program. The two USTs include a No. 6 fuel oil UST situated adjacent to the former Mess Hall Heating Plant and a No. 2 fuel oil UST situated adjacent to Building G480 (Explosive Ordnance and Disposal Armory, Office, and Supply Building). The former was abandoned in place years ago (date unknown) and has been the subject of previous environmental investigations performed by ATEC Associates, Inc. (ATEC) and Law. The latter was removed in January 1994. Contaminated soils adjacent to the UST were reportedly removed with the tank. However, samples were not collected to confirm the limits of contamination.

As part of the Interim Remedial Action for soil to be executed in 1995 by OHM Corporation, four soil borings will be advanced in the immediate vicinity of the former No. 2 fuel oil UST. Soil samples will be collected from each location immediately above the water table and analyzed for TPH (5030 and 3550). The sampling is expected to verify the remaining soils do not contain hydrocarbon contamination associated with the former UST.

ATEC conducted a site assessment in the vicinity of Building TC341 to investigate contamination associated with the UST previously used to supply fuel to the Mess Hall Heating Plant. During the investigation, ATEC installed three shallow monitoring wells and analyzed the soils and groundwater for TPH (EPA Method 8015) and BTEX (EPA Method 8020) (ATEC, 1992). The details of well construction are summarized on Table 1-1.

Results of TPH in soils ranged from 110 mg/kg (MW-3) to 2,000 mg/kg (MW-2). Total BTEX was detected in soils ranging from non-detected concentrations to 5,530 µg/kg in MW-2. TPH in groundwater was detected in MW-1 at a concentration of 5 mg/L and in MW-2 at 3 mg/L. Total BTEX was detected in the groundwater sample collected from MW-2 at a concentration of 34 µg/L. Based on these results, ATEC had recommended removal of the UST and associated piping. For details of the ATEC report please refer to Appendix E.

Law submitted a report for a leaking underground storage tank (LUST) site assessment for Building TC341 on April 13, 1994, to LANTDIV summarizing the activities conducted in March 1994. The assessment was conducted in order to delineate the extent of contamination identified by ATEC.

The assessment involved the installation of 12 Type II and two Type III groundwater monitoring wells and analysis of soils and groundwater (Figure 1-4). Well construction details are provided on Table 1-3. The soils were analyzed for TPH according to EPA Methods 5030/8015 (volatile fractions), 3550/8015 (semivolatile fraction), and 9071 (oil and grease), TCLP metals, ignitability, and pH. Groundwater samples were analyzed for purgeable aromatic hydrocarbons (EPA Method 602), polynuclear aromatic hydrocarbons (EPA Method 610), and the eight RCRA metals.

Results of TPH (5030/8015) in soils ranged from nondetectable concentrations to 4,100 mg/kg in MW-14 (3.5 to 5 feet). TPH (3550/8015) was detected in soil samples at MW-11, MW-17, MW-14, and MW-15 at concentrations of 11 mg/kg, 11 mg/kg, 800 mg/kg, and 490 mg/kg, respectively. In addition, TCLP metals (barium, chromium, and cadmium) were detected in samples at concentrations below TCLP limits. Results for pH in soils range between 5.53 to 7.48 and ignitability was not detected.

RCRA metals, volatile organic compounds, and semivolatile organic compounds were detected in groundwater samples from monitoring wells MW-1 through MW-17. RCRA metals were detected in both of the samples submitted for metals analyses. Volatile organic compounds were detected in four of the five samples submitted for analyses. Seventeen samples were submitted for analyses of semivolatile organic compounds and five possessed detectable concentrations. For complete details and results of the investigation, refer to Appendix F.

Law concluded that the majority of the soil and groundwater contamination originating from the tank system at Building TC341 had been adequately defined. Preparation of a Corrective Action Plan is in progress and was scheduled to be completed in January 1995.

1.3 Report Organization

The RI Report is a compilation of nine sections. Section 1.0, Introduction, presents the purpose of the RI, site description, site history, and results of previous investigations. The field investigation activities conducted under the RI are summarized in Section 2.0 and the physical characteristics of the study are summarized in Section 3.0. Section 4.0 presents a discussion of the nature and extent of contamination. Contaminant fate and transport and the baseline risk assessment are presented in Sections 5.0 and 6.0, respectively. Section 7.0 presents details of the ecological risk assessment. Conclusions and recommendations are discussed in Section 8.0. Tables, figures, and references pertinent to each section are presented at the end of each section.

SECTION 1.0 REFERENCES

SECTION 1.0 REFERENCES

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SECTION 1.0 TABLES

TABLE 1-1

SUMMARY OF EXISTING WELL CONSTRUCTION DETAILS
1992 UNDERGROUND STORAGE TANK ASSESSMENT NEAR THE FORMER MESS HALL HEATING PLANT
1990 FIELD INVESTIGATION OF CAMP GEIGER FUEL SPILL SITE
1986 SITE ASSESSMENT OF CAMP GEIGER FUEL FARM
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Date Installed	Consultant Supervising Well Installation	Top of PVC Casing Elevation (feet, above MSL)(1)	Ground Surface Elevation (feet, above MSL)	Stick-Up (feet, above ground surface)	Boring Depth (feet, bgs)(2)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)
1992 Underground Storage Tank Assessment Near Former Mess Hall Heating Plant										
MW-1(3)	6-1-92	ATEC and Associates	20.59(6)	--	--	20.0	20.0	5.0 - 20.0	3.0 - 20.0	2.0 - 3.0
MW-2(3)	6-2-92	ATEC and Associates	21.13(6)	--	--	20.0	20.0	5.0 - 20.0	3.0 - 20.0	2.0 - 3.0
MW-3(3)	6-2-92	ATEC and Associates	20.49(6)	--	--	20.0	20.0	5.0 - 20.0	3.0 - 20.0	2.0 - 3.0
1990 Field Investigation of Camp Geiger Fuel Spill Site										
EMW-1	1990(4)	NUS	19.16(7)	17.4(7)	1.8(7)	--	23.0	8.5 - 17.5(4)	--	--
EMW-2	1990(4)	NUS	--	--	--	--		1.87 - 10.89(4)	--	--
EMW-3	1990(4)	NUS	7.00(7)	4.7(7)	2.3(7)	--	14.85	3.06 - 12.06(4)	--	--
EMW-4	1990(4)	NUS	--	--	--	--		2.61 - 11.61(4)	--	--
1986 Site Assessment of Camp Geiger Fuel Farm										
EMW-5	1986(5)	ESE	17.98(7)	16.1(7)	1.9(7)	--	26.30	10.5 - 24.5(4)	--	--
EMW-6	1986(5)	ESE	15.97(7)	14.2(7)	1.8(7)	--	28.67	10.5 - 24.5(4)	--	--
EMW-7	1986(5)	ESE	18.49(7)	16.4(7)	2.1(7)	--	27.80	10.5 - 24.5(4)	--	--

Notes:
(1) MSL = mean sea level
(2) bgs = below ground surface
(3) Calculated values based on elevations recorded in Law's report, "Final Report Underground Fuel Investigation Comprehensive Site Assessment," dated February 7, 1992.
(4) Data/information was found in Law's report, "Final Report Underground Fuel Investigation Comprehensive Site Assessment," dated February 7, 1992.
(5) Data/information found in ESE's "Site Summary Report," dated September 1990.
(6) Elevations as recorded in Law's report, "Leaking Underground Storage Tank, Site Assessment Report," dated April 13, 1994.
(7) Data was gathered by Baker during 1994 Remedial Investigation.
(8) -- Indicates that the data is not known.

TABLE 1-2

SUMMARY OF EXISTING WELL CONSTRUCTION DETAILS
1991 ASSESSMENT OF A SUSPECTED FUEL LEAK ORIGINATING FROM THE CAMP GEIGER FUEL FARM (1991)
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Date Installed	Consultant Supervising Well Installation	Top of PVC Casing Elevation (feet, above MSL)(1)	Ground Surface Elevation (feet, above MSL)	Stick-Up (feet, above ground surface)	Boring Depth (feet, bgs)(2)	Well Depth (feet, bgs)	Screen Interval Depth(3) (feet, bgs)	Depth to Sand Pack(3) (feet, bgs)	Depth to Bentonite(3) (feet, bgs)
MW-8S/D	8-15-91	Law Engineering	19.17(4)	16.8(5)	2.4(4)	30.0	30.0	4.5 - 13.5 20.5 - 29.5	2.0 - 15.0 18.0 - 30.0	1.0 - 2.0 15.0 - 18.0
MW-9S/D	8-16-91	Law Engineering	18.88	16.9	2.0	30.0	30.0	3.5 - 12.5 25.5 - 29.5	2.0 - 13.0 16.0 - 30.0	1.0 - 2.0 13.0 - 16.0
MW-10S/D	8-19-91	Law Engineering	19.01	16.6	2.4	30.0	30.0	4.5 - 13.5 25.5 - 29.5	2.0 - 14.0 19.0 - 30.0	1.0 - 2.0 16.0 - 19.0
MW-11S/D	8-19-91	Law Engineering	18.39(4)	15.9(5)	2.5(4)	30.0	30.0	4.5 - 13.5 25.5 - 29.5	2.0 - 19.5 22.5 - 30.0	1.0 - 2.0 19.5 - 22.5
MW-12S/D	8-19-91	Law Engineering	19.94	17.3	2.6	28.5	28.5	5.0 - 14.0 24.0 - 28.0	3.0 - 14.5 19.0 - 28.5	2.0 - 3.0 15.5 - 19.0
MW-13S/D	8-19-91	Law Engineering	17.02	14.6	2.4	30.0	30.0	5.5 - 14.5 25.5 - 29.5	3.0 - 18.5 22.5 - 30.0	2.0 - 3.0 18.5 - 22.5
MW-14S/D	8-20-91	Law Engineering	17.73	15.3	2.4	30.0	30.0	3.5 - 12.5 24.5 - 28.5	2.0 - 13.0 21.0 - 29.0	1.0 - 2.0 18.0 - 21.0
MW-15S/D	8-20-91	Law Engineering	18.05(4)	15.5(5)	2.6(4)	30.0	30.0	4.5 - 13.5 25.5 - 29.5	2.5 - 17.5 25.0 - 30.0	1.5 - 2.5 17.5 - 23.0
MW-16S/D	8-21-91	Law Engineering	20.06	17.6	2.5	29.0	29.0	5.0 - 14.0 24.0 - 28.5	2.0 - 17.5 20.0 - 24.5	1.0 - 2.0 17.5 - 20.5
MW-17S/D	8-21-91	Law Engineering	16.77	14.1	2.7	29.5	29.5	7.5 - 16.5 25.0 - 29.0	4.5 - 19.5 22.5 - 30.0	3.5 - 4.5 19.5 - 22.5
MW-18S/D	8-21-91	Law Engineering	13.40(4)	10.8(5)	2.6(4)	25.0	25.0	3.0 - 12.0 20.5 - 24.5	1.5 - 14.0 17.0 - 25.0	0.5 - 1.5 14.0 - 17.0
MW-19S/D	8-22-91	Law Engineering	8.72	6.0	2.7	25.0	25.0	4.5 - 13.5 22.5 - 24.5	2.0 - 15.0 20.0 - 25.0	1.0 - 2.0 17.0 - 20.0

TABLE 1-2 (Continued)

SUMMARY OF EXISTING WELL CONSTRUCTION DETAILS
1991 ASSESSMENT OF A SUSPECTED FUEL LEAK ORIGINATING FROM THE CAMP GEIGER FUEL FARM (1991)
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Date Installed	Consultant Supervising Well Installation	Top of PVC Casing Elevation (feet, above MSL)(1)	Ground Surface Elevation (feet, above MSL)	Stick-Up (feet, above ground surface)	Boring Depth (feet, bgs)(2)	Well Depth (feet, bgs)	Screen Interval Depth(3) (feet, bgs)	Depth to Sand Pack(3) (feet, bgs)	Depth to Bentonite(3) (feet, bgs)
MW-20S/D	8-23-91	Law Engineering	15.97(4)	13.6(5)	2.4(4)	12.5	12.5	3.0 - 12.0	1.5 - 12.5	0.5 - 1.5
MW-21S/D	8-23-91	Law Engineering	17.57	15.1	2.5	27.5	27.5	4.5 - 13.5 25.5 - 27.0	2.0 - 14.0 22.0 - 28.5	1.0 - 2.0 19.0 - 22.0
MW-22S/D	8-28-91	Law Engineering	19.18(4)	16.3(5)	2.9(4)	35.0	35.0	5.5 - 14.5 32.5 - 35.0	3.0 - 25.5 29.0 - 35.0	2.0 - 3.0 25.5 - 29.0
MW-23S/D	8-27-91	Law Engineering	8.74	6.4	2.3	20.0	20.0	2.5 - 9.5 17.5 - 20.0	1.0 - 10.0 13.0 - 21.0	0.5 - 1.0 10.0 - 13.0
MW-24S/D	8-28-91	Law Engineering	18.72(4)	16.5(5)	2.2(4)	29.0	29.0	8.5 - 17.5 26.5 - 29.0	4.0 - 20.0 23.0 - 29.0	0.8 - 3.0 20.0 - 23.0
MW-25S/D	8-29-91	Law Engineering	13.32	11.3	2.0	30.0	30.0	4.5 - 13.5 27.5 - 30.0	2.0 - 22.0 25.0 - 30.0	1.0 - 2.0 22.0 - 25.0

Notes: (1) MSL = mean sea level

(2) bgs = below ground surface

(3) Two wells were installed within the same borehole, therefore, the two ranges of depth correspond to depths at which the screen, sand pack, and bentonite seal can be located with respect to each well.

(4) Elevations as recorded in Law's report, "Final Report Underground Fuel Investigation Comprehensive Site Assessment, dated February 7, 1992.

(5) Calculated values based on elevations recorded in Law's report, "Final Report Underground Fuel Investigation Comprehensive Site Assessment, dated February 7, 1992.

* A shallow and an intermediate well were installed in the same borehole at locations with an S/D designation. Law Engineering installed two separate sets of wells on two occasions (August 1991 and March 1994) and duplicated designations MW-8 through MW-17. Baker added the S/D designation for clarity. The designation indicates a shallow well screened across the water table. The D designation indicates an intermediate well screen in the 20 to 30-foot interval.

TABLE 1-3

SUMMARY OF EXISTING WELL CONSTRUCTION DETAILS
1994 UNDERGROUND STORAGE TANK ASSESSMENT NEAR BUILDING TC341
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Date Installed	Consultant Supervising Well Installation	Top of PVC Casing Elevation (feet, above MSL)(1)	Ground Surface Elevation (feet, above MSL)	Stick-Up (feet, above ground surface)	Boring Depth (feet, bgs)(2)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite(3) (feet, bgs)
MW-4	3-1-94	Law Engineering	20.52	18.4	2.1	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-5	3-1-94	Law Engineering	19.79(4)	17.9(5)	1.9(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-6	3-1-94	Law Engineering	19.16(4)	17.3(5)	1.9(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-7	3-1-94	Law Engineering	19.12(4)	17.2(5)	1.9(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-8	3-1-94	Law Engineering	16.56(4)	16.56(5)	Flush(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-9	3-3-94	Law Engineering	19.36(4)	17.4(5)	2.0(4)	33.0	32.0	27.0-32.0	24.5-33.0	0.0-22.0
MW-10	3-3-94	Law Engineering	19.31(4)	17.4(5)	1.95(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-11	3-4-94	Law Engineering	19.21(4)	17.3(5)	1.95(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-12	3-7-94	Law Engineering	19.75(4)	17.8(5)	2.0(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-13	3-7-94	Law Engineering	17.79(4)	15.8(5)	2.0(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-14	3-8-94	Law Engineering	16.31(4)	16.3(5)	Flush(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-15	3-8-94	Law Engineering	16.20(4)	16.2(5)	Flush(4)	30.0	30.0	25.0-30.0	23.0-30.0	0.0-22.0
MW-16	3-8-94	Law Engineering	16.53(4)	16.5(5)	Flush(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0
MW-17	3-8-94	Law Engineering	16.14(4)	16.1(5)	Flush(4)	14.0	13.0	3.0-13.0	2.0-14.0	0.0-2.0

Notes:
(1) MSL = mean sea level
(2) bgs = below ground surface
(3) Indicates that interval is recorded as cement in well construction records submitted to the State of North Carolina, however, some bentonite usually exists as a barrier within this interval to prevent cement intrusion into sand pack.
(4) Elevations as recorded in Law's report, "Leaking Underground Storage Tank, Site Assessment Report," dated April 13, 1994.
(5) Calculated values based on elevations recorded in Law's report, "Leaking Underground Storage Tank, Site Assessment Report," dated April 13, 1994.

* Law Engineering installed two separate sets of wells at this site on two occasions (August 1991 and March 1994) and duplicated designations MW-8 through MW-17. Additional designations (S [shallow]/D [deep]) were added to these nested wells installed in 1991 for clarity.

SECTION 1.0 FIGURES

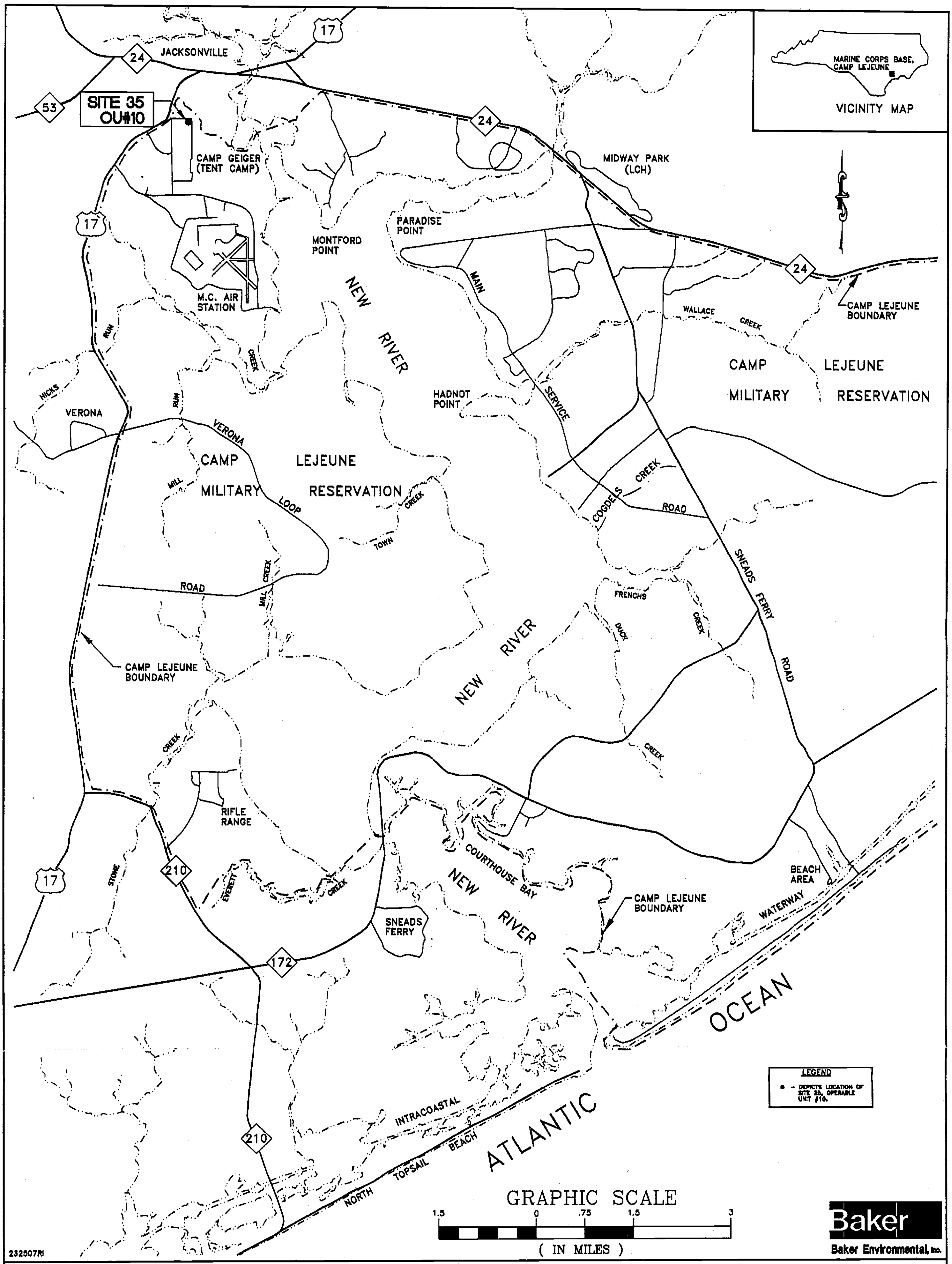
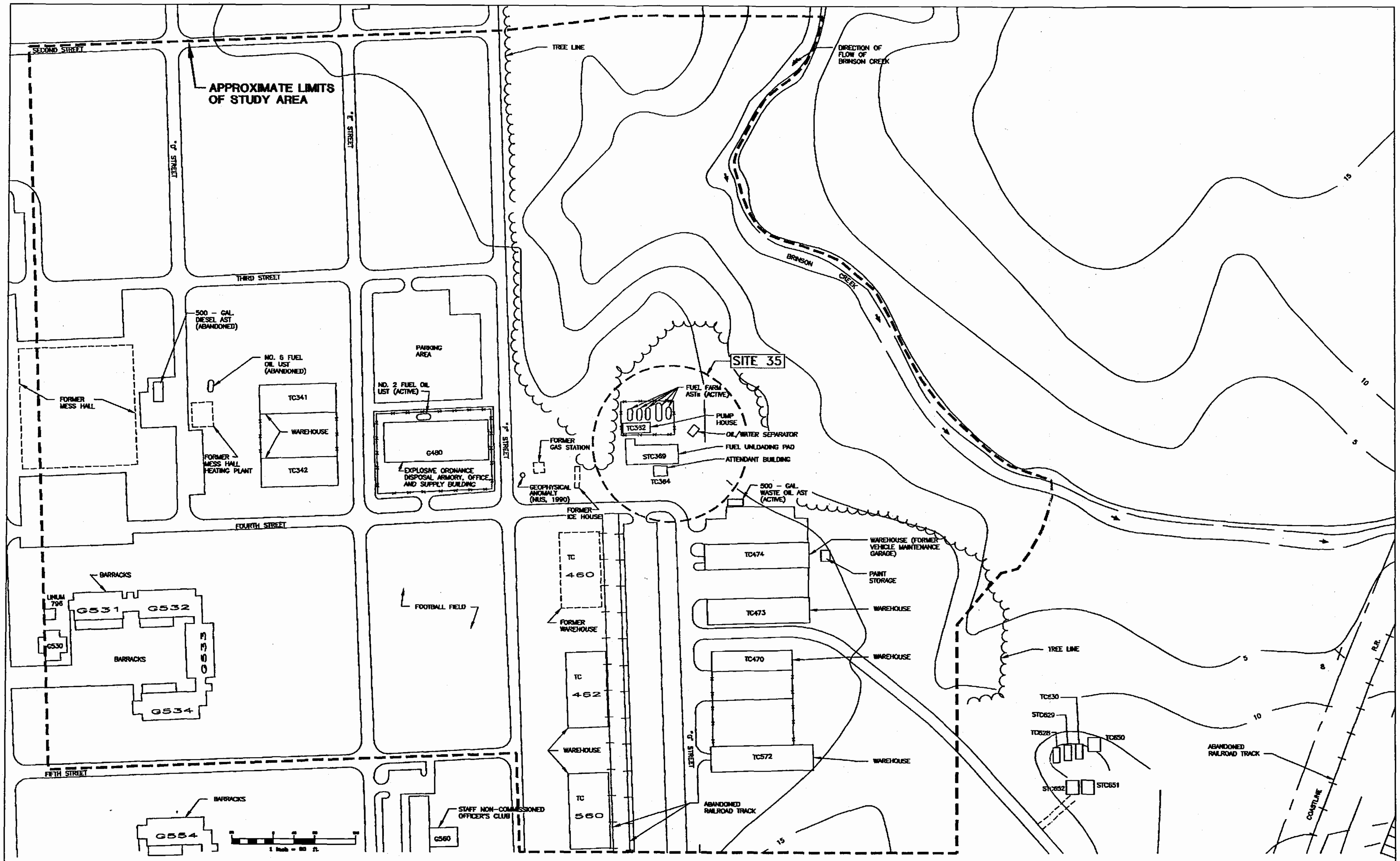


FIGURE 1-1
CAMP LEJEUNE AND SITE 35
LOCATION MAP
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER - 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01539UB12



LEGEND

-x-x- – FENCE LINE

—10— – CONTOUR LINES DEPICTING SURFICIAL RELIEF

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	232S06R1

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

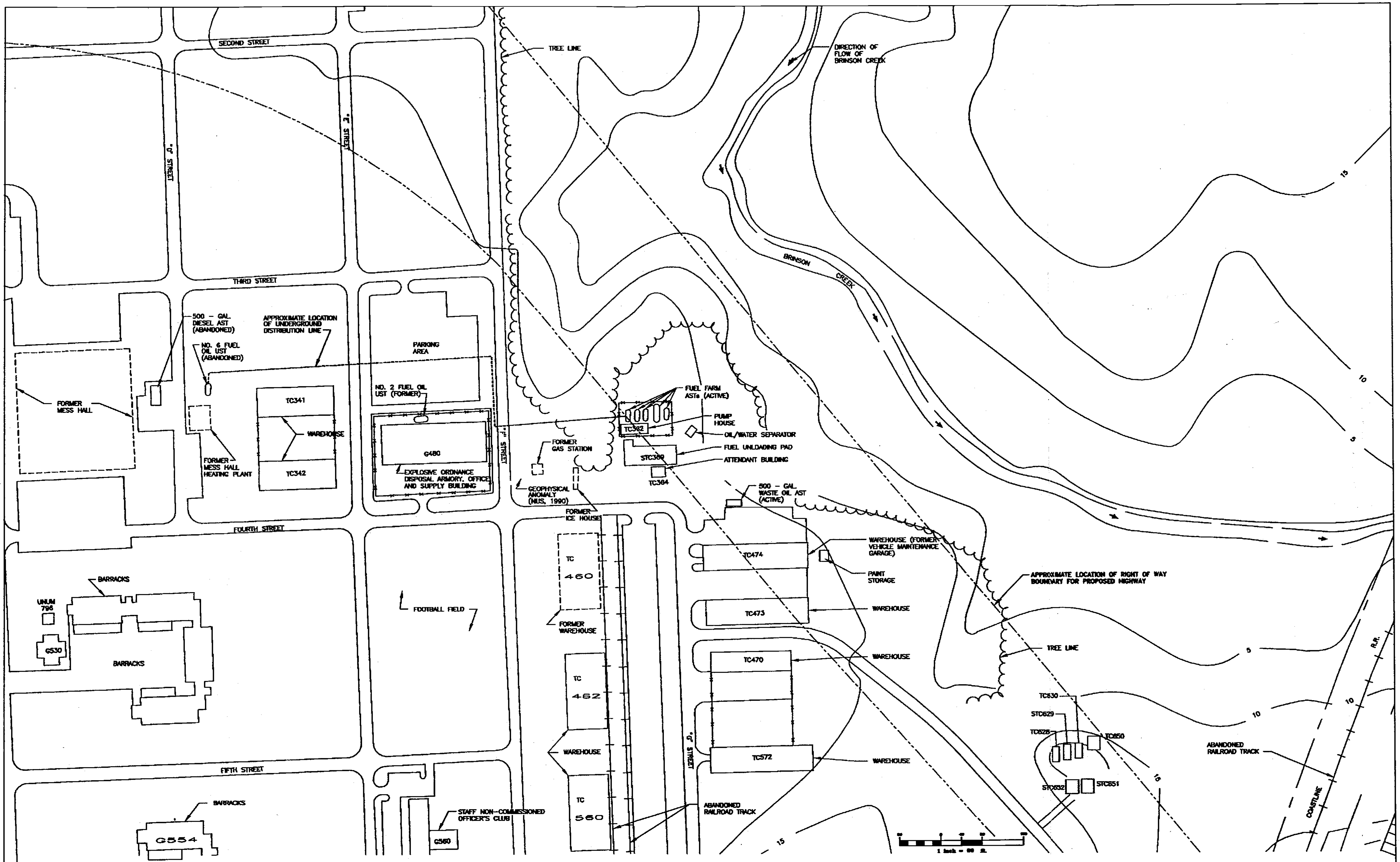
Baker
Baker Environmental, Inc.

SITE PLAN
CONTRACT TASK ORDER - 0232

SCALE 1" = 80'

DATE OCT. 1994

FIGURE No.
1-2



LEGEND

- —x—x— – FENCE LINE
- —10— – CONTOUR LINES DEPICTING SURFICIAL RELIEF
- ·········· APPROXIMATE LOCATION OF THE UNDERGROUND DISTRIBUTION LINE
- — — — APPROXIMATE LOCATION OF RIGHT OF WAY BOUNDARY FOR PROPOSED HIGHWAY

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	232506R1

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

LOCATION OF PROPOSED
HIGHWAY RIGHT OF WAY
CONTRACT TASK ORDER – 0232

SCALE 1" = 80'

DATE OCT. 1994

FIGURE No.
1–3

LEGEND

EMW-7	MONITORING WELL INSTALLED UNDER CS (1986) BY ESE.
EMW-1	MONITORING WELL INSTALLED BY NUS (1990).
MW-1	MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.
MW-1	MONITORING WELL INSTALLED UNDER UST INVESTIGATION (1992) BY ATEC.
MW-26	MONITORING WELL INSTALLED UNDER CSM FOLLOW-UP INVESTIGATION (1993) BY LAW. (NOTE: PW-28 REFERS TO A PUMPING TEST WELL.)
MW-5	MONITORING WELLS INSTALLED UNDER WST SITE ASSESSMENT (1994).
SB-1	STRATIGRAPHIC SOIL BORING DRILLED UNDER CSA (1991) BY LAW.
B-1	SOIL BORING DRILLED UNDER CSA (1991) BY LAW.
HA-1	HAND-AUGERED BORING DRILLED UNDER CSA (1991) BY LAW.
HP-18	"HYDROPUNCH" SAMPLING POINT UNDER CSA (1991) BY LAW
35SW1 35SE1	SURFACE WATER/SEDIMENT SAMPLING LOCATIONS INSTALLED UNDER CS (1984) BY ESE.
BCSB01	SHALLOW SOIL SAMPLES COLLECTED UNDER BAKER INTERIM RI (1993).
SB29	SOIL BORINGS ADVANCED BY BAKER UNDER INTERIM RI (1993).
35-SS01	SURFACE SOIL SAMPLE LOCATIONS COLLECTED UNDER BAKER RI (1994).
35MW-36B	MONITORING WELLS INSTALLED UNDER BAKER RI (1994).
35GWD-1	MONITORING WELL INSTALLED UNDER BAKER RI INVESTIGATION (1994).

NOTES:

1. SHALLOW SOIL SAMPLES BCSB11 AND 12 WERE OBTAINED APPROXIMATELY 1,500 AND 2,200 FEET UPSTREAM OF BCSB05. BOTH SAMPLES WERE OBTAINED FROM THE FLAT-LYING UNSATURATED SOIL LOCATED ALONG THE WEST BANK OF BRINSON CREEK.
2. THIS DRAWING INCLUDES ALL SOIL AND GROUNDWATER SAMPLING LOCATIONS APPLICABLE TO THIS SITE. SURFACE WATER, SEDIMENT, FISH, AND BENTHIC SAMPLE LOCATIONS ESTABLISHED UNDER THE RI BY BAKER (1994) ARE NOT DEPICTED.

LEGEND

-x-x-	FENCE LINE
—15—	CONTOUR LINES DEPICTING SURFICIAL RELIEF

DATE	OCT. 1994
SCALE	1"= 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	232521RI

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

POST RI/FS SAMPLING LOCATIONS
CONTRACT TASK ORDER - 0232

SCALE 1"= 80'
DATE OCT. 1994

FIGURE No.
2-4

2.0 STUDY AREA INVESTIGATION

The field program at Site 35 was initiated to characterize potential environmental impacts and threats to human health, ecology and the environment resulting from previous activities. Investigations conducted at the site were initiated in an attempt to define potential impacts to surface and subsurface soil, groundwater, sediments and surface waters. Specifically, this study was designed to provide:

- Data regarding the nature and extent of environmental impact on aquatic and benthic species in Brinson Creek which abuts the eastern boundary of the site.
- Additional soil and groundwater data to support a quantitative, site-wide environmental risk assessment.
- Soil and groundwater data sufficient to afford an evaluation of the source, nature, and extent of previously identified halogenated organic contamination in the shallow groundwater.

2.1 RI Field Program

The majority of the RI field activities conducted at Site 35 were initiated on April 11 continuing through and concluding on May 22, 1994. Additional work (primarily IDW management, surveying, aquifer characterization tests and groundwater elevation measurements) was conducted at the site between June 14 and September 10, 1994. The field program consisted of: a soil gas survey and groundwater screening investigation; a soil investigation; a groundwater investigation; a surface water and sediment investigation; an ecological investigation; a site survey; and investigative derived waste (IDW) handling. Details of these activities are discussed in the following sections.

2.1.1 Soil Gas Survey and Groundwater Screening Investigation

A soil gas investigation was conducted at the site from April 13 through 16, 1994. During the investigation, samples of soil gas (i.e., vadose zone) and groundwater (i.e., headspace) were analyzed on site via a gas chromatograph (GC). The purpose of this investigation was to assist in placement of soil borings/monitoring wells within the boundaries of the 40 acre site. The investigation was performed by Tracer Research Corporation (Tracer) and was supervised by Baker personnel. A copy of Tracer's report is provided in Appendix G. The following provides a brief description of the soil gas field procedures and results.

2.1.1.1 Sampling Procedures and Analytical Program

Initially, 55 sampling locations were established within the study area. The proposed locations were selected based on previous contamination identified at the site. A grid was established across the site to define the areas of the site where contamination is present. The results of the soil gas survey were used for placement of groundwater monitoring wells during the RI.

The locations were surveyed and marked with a bright orange wooden stake to assist Tracer in locating the sample point. The sample number was marked on the stake to ensure proper sample designation. An additional 18 sample locations were eventually added as the investigation proceeded. In all, soil gas samples were collected from 67 of the 73 locations. The primary reason for soil gas samples not being collected was the presence of shallow groundwater near the ground surface at five locations (35-SG-51 through 55) in the vicinity of Brinson Creek. At one other soil gas location (35-SG-15), Tracer failed to record the analytical result. Groundwater screening samples were collected from 72 locations (Figure 2-1). At the sample location (35-SGW-34) in which a groundwater sample was not collected, an impervious substrate was encountered.

Prior to the day's activities, enough sampling equipment (i.e., sample probes, drive points, etc.) for entire day's work was decontaminated by washing with soapy water and rinsing thoroughly. Internal surfaces were flushed dry using pre-purified nitrogen and external surfaces were wiped clean with clean paper towels. The polyethylene sampling tube was replaced after each sample point in order to minimize cross contamination.

The entire sampling system was purged of ambient air prior to the collection of each soil gas sample. The majority of the soil gas samples were collected by hydraulically pushing/pounding 7- and 9-foot, 3/4-inch diameter, hollow, steel sampling probes equipped with disposable drive points to the sampling depth. At some locations, the soil gas probes were manually advanced to the desired depth. Where asphalt or concrete was present a rotary hammer was employed for penetration prior to using the sampling probe.

Upon reaching the desired sampling depth, the sampling probe was fitted with an aluminum reducer and a length of polyethylene tubing leading to a teflon sampling tube attached to a vacuum pump. Two to five volumes of in-situ soil gas was withdrawn through the stainless steel probe and used to purge atmospheric air from the sampling system. The sample was collected in a glass syringe by inserting the needle through the polyethylene tubing and into the sample passageway. The volume of air within the syringe was purged by evacuating five to ten syringe volumes of gas prior to sample collection. Vacuum administered to the probe was monitored to ensure an adequate gas flow from the vadose zone.

Groundwater samples were collected by driving 7- to 14-foot, 3/4-inch, hollow, steel sampling probes equipped with disposable drive points to a depth of one to ten feet below ground surface. Once the groundwater surface was encountered, the probes were withdrawn several inches to permit water to flow into the resulting void. A polyethylene sampling tube was placed down the pipe and groundwater was collected from just beneath the water surface. Samples were placed in 40 ml vials, the vials were filled halfway and agitated. The headspace gas was drawn off the sample and analyzed.

All of the soil gas and groundwater samples were analyzed for trichloroethylene (TCE) and benzene using a Hewlett Packard 5890 Series II gas chromatograph (GC) equipped with a flame ionization detector (FID), electron capture detector (ECD) and two computing integrators. Benzene was detected on the FID, TCE was detected on the ECD and nitrogen was used as the carrier gas. Approximately 10 mL of soil gas and 40 mL of groundwater were collected for immediate analyses in the Tracer analytical van.

2.1.1.2 Results

Results of the soil gas investigation are summarized on Table 1 of Tracer's report (see Appendix G) and are illustrated on Figures 2-2 and 2-3. Benzene was detected in 11 of 67 soil gas samples ranging from 0.01 μg/L (35-SG-47) to 2.0 μg/L (35-SG-61). TCE was detected in the 19 of 67 samples ranging from 9×10^{-5} μg/L (35-SG-61) to 0.8 μg/L (35-SG-13). A conversion factor of 0.32

for benzene and 0.19 for TCE needs to be multiplied to the result in μg/L to yield ppm according to Tracer. The conversion from compound vapor mass to compound vapor volume is necessary for comparison of soil gas results to soil analysis. In order to convert the data, two gas laws are used:

1) 1 mole of any gas occupies approximately 25 L at room temperature and pressure.

2) 1 mole of a gas contains a mass equal to its molecular weight in grams.

Each compound will have a different conversion factor due to its molecular weight. The following formula was used to establish the conversion of μg/L to ppm:

[Sample concentration (μg/L)] {25/mole WT] = ppm

Benzene was detected in 13 of 72 groundwater screening samples ranging from 0.06 μg/L (35-SGW-47 and 35-SGW-48) to 16,000 μg/L (35-SGW-56). TCE was detected in 32 of 72 samples ranging from 4×10^{-4} μg/L (35-SGW-44, 35-SGW-49 and 35-SGW-56) to 160 μg/L (35-SGW-69). No conversion is needed for groundwater screening results.

Baker evaluated the results of the soil gas and groundwater screening investigation in the field as a basis for the placement of soil borings and groundwater monitoring wells set within the surficial aquifer. In general, areas with positive detections of benzene and TCE in soil gas corresponded to similar positive detection in surficial groundwater. Three distinct zones of soil gas and surficial groundwater contamination include: 1) an area southeast of Fuel Farm in the vicinity of Building TC474 (i.e., the former vehicle maintenance facility); 2) an area roughly 150 feet west of the Fuel Farm in the vicinity of the former gas station, and; 3) an area located about 500 feet southwest of the Fuel Farm near the intersection of Fourth and "E" Streets. Baker established surficial aquifer monitoring well locations with the intent of confirming both the positive and negative soil gas and groundwater screening results. Wells were also located beyond the limits of the soil gas and groundwater screening investigation in an attempt to establish the limits of contamination.

2.1.2 Soil Investigation

A soil investigation was conducted at Site 35 with the intention of assessing the nature and extent of contamination resulting from previous disposal practices and site activities and to define the limits of previously detected contamination in the vicinity of the Camp Geiger Area Fuel Farm. Additionally, the investigation was conducted to assess human health, ecological, and environmental risks associated with contact, inhalation and possible ingestion of surface and subsurface soil particles. The following describes the drilling procedures, sample locations, sample methods, and analytical program for the site.

2.1.2.1 Drilling Procedures

Twenty-six soil borings were advanced for the purpose of sample collection, geologic identification and description, and monitoring well installation at the locations depicted on Figure 2-4. Activities at the site commenced on April 15 and were completed on May 16, 1994 using a truck-mounted drill rig supplied and operated by Hardin Huber, Incorporated. Soil cuttings obtained during the drilling program were contained and handled according to procedures outlined in Section 2.3. Drilling and sampling activities were performed using Level D personal protection and operations were continuously monitored with a photoionization detector, a radiation meter and an LEL/O_2 meter.

Soil borings were advanced to three ranges of depth with different intentions for each type of boring. Procedures varied depending on the type of soil boring needed at each location. A total of 10 shallow soil borings were advanced for the purpose of monitoring well installation only. The borings were advanced 14 to 17 feet bgs using 6.25-inch inside diameter (ID) hollow-stem augers and were not logged by the site geologist due to the close horizontal proximity of a deeper boring. The borings were designed to allow construction of monitoring wells with screens that intersect the water table.

Eleven intermediate soil borings were terminated at the top of the semi-confining layer (encountered at approximately 41 to 47 feet bgs) separating the water table and the Castle Hayne Aquifers. These borings were advanced using fluid (bentonite slurry) rotary drilling methods for the purpose of sample collection, soil identification and description, and monitoring well installation. They were designed to allow construction of wells which would monitor the deep portion of the water table aquifer.

The intermediate borings were continuously sampled to the water table (approximately 10 to 12 feet) and every five feet thereafter to termination of the boring with a split-spoon sampling device following methods outlined in ASTM 1586-84. The sampling protocols were modified in some cases where the site geologist needed more information about a particular soil type or if the formation appeared to be unstable at a particular interval. Soils were considered unstable if problems occurred during drilling that were indicative of borehole collapse. When unstable soils were encountered, samples were not collected until the borehole was advanced beyond the problem interval. Each split-spoon soil sample was classified in the field by the site geologist. Soils were classified, recorded in a field logbook, and later transposed onto boring log records. Classification included characterization of soil type, grain size, color, moisture content, relative density (from Standard Penetration Test "blow counts"), plasticity and other pertinent information such as indications of contamination. Lithologic descriptions of site soils are provided on the Test Boring and Well Construction Records in Appendix H.

Five deep soil borings were advanced using fluid (bentonite slurry) rotary drilling methods for the purpose of sample collection, soil identification and description, and monitoring well construction. These borings were terminated approximately 5 to 10 feet below the semi-confining layer (ranging from 51.0 to 66.0 bgs), within the upper portion of the Castle Hayne Aquifer. Casing was installed into the semi-confining unit during monitoring well installation to seal any pathway for vertical migration created by drilling and sampling. The purpose of these borings was to define the vertical and horizontal extent of soil contamination in the vadose zone; monitor the upper portion of the Castle Hayne Aquifer; and potentially identify vertical migration through the semi-confining layer.

As with the intermediate soil borings, the deep borings were continuously split-spoon sampled to the water table (approximately 10 to 12 feet) and every five feet thereafter to termination of the boring. The sampling protocols were modified in some cases where the site geologist needed more information about a particular soil type or if the formation appeared to be unstable at a particular interval. Soils were considered unstable if problems occurred during drilling that were indicative of borehole collapse. When unstable soils were encountered, samples were not collected until the borehole was advanced beyond the problem interval. However, once the semi-confining layer was encountered, continuous sampling was again conducted in an effort to identify the approximate thickness of this soil layer. Each split spoon sample was classified and recorded in the same manner as the soils collected from the intermediate wells.

2.1.2.2 Soil Sampling

Soil samples were collected from surface locations and soil borings advanced across the site with the intentions of delineating the vertical and horizontal extent of contamination and providing data for human health and ecological risk assessments. Selection of boring locations were based on review of previous environmental investigations, Camp Lejeune historical records, and soil gas and groundwater screening investigation results. A summary of the sample numbers, sample depths and parameters analyzed is provided in Appendix I.

Surface soil samples were collected from 14 locations (35-SS01-00 through 35-SS14-00) across the site using a stainless steel hand auger. Samples were collected by slowly advancing the augers to approximately 6-inches bgs so that the soil cuttings could be retained for the analytical sample. The first few inches of top soil or matted roots were removed prior to advancing the augers. The auger buckets, extension rods, spoons and bowls were decontaminated prior to sample collection according to the procedures outlined in Section 2.2.

A single vadose zone, subsurface soil sample was collected from each intermediate and deep soil boring and submitted for analysis. Samples were selected based on volatile organic headspace analysis or proximity to the water table. Results of the headspace analyses are summarized in Appendix J. The sample was collected via a split spoon sampling device and placed in the appropriate laboratory supplied containers.

All soil samples retained for analysis were prepared and handled according to USEPA Region IV Standard Operating Procedures (SOPs) as outlined in the FSAP (Baker, 1994). Chain-of-custody documentation (provided in Appendix K), which included information such as sample number, date, time of sampling, and sampling party accompanied the samples to the laboratory. Samples were shipped overnight via Federal Express to Inchcape Testing Corporation (Inchcape) in Richardson, Texas for analysis.

2.1.2.3 Analytical Program

The analytical program initiated for the soil investigation at Site 35 focused on the suspected contaminants of concern which were based on previous disposal practices, site activities and findings of previous investigations. In general, soils at the site were analyzed for TCL volatiles, semivolatiles, pesticides, PCBs and TAL metals. A summary of each sample, the depth it was collected and parameters analyzed is provided in Appendix I. In addition to the contaminants of concern, a single soil sample was submitted for analysis of engineering parameters including total phosphorous, nitrogen, corrosivity, ignitability, reactivity, and microbial enumeration. The engineering parameters were obtained to assist in selecting potential applicable remedial technologies under the FS.

2.1.3 Groundwater Investigation

The groundwater investigation at the site consisted of several activities including construction of shallow, intermediate and deep monitoring wells, well development, groundwater sampling, static water measurements and aquifer testing. The intent of the investigation was to confirm the presence or absence of shallow, intermediate and deep groundwater contamination, evaluate the horizontal and vertical extent of potentially impacted groundwater and evaluate the shallow and deep groundwater flow patterns in the area.

The field procedures and sampling methods employed for this study were implemented in accordance with USEPA Region IV SOPs. These procedures also included sample handling and preservation, documentation and chain of custody procedures. Specific sampling procedures are detailed in the FSAP (Baker, 1994). The following sections describe the procedures for drilling/monitoring well installation, well development, groundwater sampling and static water level measurements.

2.1.3.1 Well Installation

Twenty-one Type II groundwater monitoring wells (wells without an outer casing sealing off a confining layer) were installed in each of the shallow and intermediate soil borings between April 26 and May 16, 1994 at locations depicted on Figure 2-4. These wells were installed in the water table aquifer to determine the horizontal and vertical extent of contamination existing within the aquifer, and evaluate the shallow groundwater flow patterns. The shallow wells were constructed in a manner that would allow the screened portion of the well to intercept the water table. The screen intervals were designed to compensate for seasonal fluctuation in the water table.

The wells were constructed of 2-inch nominal diameter, schedule 40, flush-joint and threaded poly vinyl chloride (PVC) casing with a 10-slot screen. The shallow wells were constructed with 10-foot screens and the intermediate wells were constructed with 5-foot screens. A medium-grained sand pack was placed in the annulus between the screen and the borehole wall extending above the screen interval (a minimum of 0.4 feet). A sodium bentonite seal (a minimum of 1 foot) was placed on top of the sand pack to prohibit intrusion of grout or surface run-off into the sand pack. The remaining annular space between the bentonite seal and the surface was filled with a cement/bentonite grout. A protective casing, well pad and cement-filled ballards completed the construction of each well and protected the wells from damage and tampering. Well tags containing well construction details and the notation "Caution Not Potable Water" were affixed to the wells. Well construction details are summarized in Table 2-1.

Five Type III groundwater monitoring wells (wells installed with an outer casing to seal off the confining layer) were installed in each of the deep soil borings between April 20, to May 1, 1994. These wells were designed to evaluate the vertical extent of shallow aquifer contamination and to evaluate the groundwater flow patterns of the deep aquifer. The wells were constructed in a manner that would position the screen directly beneath the semi-confining layer to monitor the upper portion of the Castle Hayne Aquifer. The wells were constructed in the same manner as the intermediate wells with the exception that a steel outer casing was installed to seal off vertical migration of contamination from the water table aquifer into the Castle Hayne Aquifer via the borehole.

2.1.3.2 Well Development

Upon completion and curing, each newly installed well was developed to remove fine-grained sediment from the screen and to establish hydraulic communication between the well and the formation. A minimum of three to five well volumes were removed from each well until the groundwater was essentially sediment-free. The wells were developed by a combination of surging and pumping techniques. Hoses used for development were dedicated to each well to minimize the potential for cross contamination and discarded upon completion. Measurements of ph, conductivity and temperature were recorded to assist in evaluating well stabilization. Groundwater recovered during development procedures was temporarily stored in drums, then transferred into an on-site tanker (see Section 2.3 for IDW handling). Well development forms summarizing the information are provided in Appendix L.

2.1.3.3 Static Water Level Measurements

Static water level measurements were collected at various times throughout the investigation. The measurements were recorded using an electronic measuring tape to the nearest 0.01 foot from top of casing. Complete rounds of data were collected from a select group of existing wells and all newly installed wells on June 14, July 20, and September 9, 1994. Tables 2-3, 2-4, and 2-5 summarize the measurements collected from the shallow, intermediate and deep monitoring wells. Data were collected within a four-hour period during each event.

2.1.3.4 Groundwater Sampling

This section describes the sampling procedures and analytical methods associated with the groundwater sampling program.

Groundwater samples were collected from each of 26 newly installed wells and 29 existing wells to confirm the presence or absence of contamination in the water table and Castle Hayne Aquifers. Prior to collecting the samples, the wells were purged of three to five well volumes of water. Temperature, conductivity and ph were collected after each well volume was removed to determine that the groundwater had stabilized prior to sampling.

Samples were collected using Teflon bottom loading bailers equipped with a monofilament leader dedicated to each well. The samples were introduced directly from the bailer into a laboratory-prepared sample container and stored on ice. Preparation of the groundwater samples incorporated similar procedures as to those described for soil samples and are outlined in the FSAP (Baker, 1994). Chain-of-custody documentation (provided in Appendix K) accompanied the samples to the analytical laboratory.

2.1.3.5 Analytical Program

A single round of groundwater samples were collected from the 29 existing and 26 newly installed wells. The samples were analyzed for TCL volatiles, semivolatiles, pesticides and PCBs; TAL metals; and engineering parameters such as BOD, COD, total organic carbon, total suspended solids, total dissolved solids, nitrogen, total phosphorous, microbial enumeration, and alkalinity. The engineering parameters were intended to assist in selecting potentially applicable remedial technologies. A summary of the sample numbers and parameters analyzed are provided in Appendix I. The samples were prepared and handled in accordance with the FSAP (Baker, 1994) and USEPA Region IV SOPs.

2.1.4 Surface Water/Sediment Investigation

Surface water and sediment samples were obtained along Brinson Creek to assess possible impacts from Site 35 and assist in human health and ecological risk assessments. Ten sampling stations were established along Brinson Creek including three upstream (35-SW/SD01 through 35-SW/SD03) and seven adjacent/downstream locations (35-SW/SD04 through 07 and 36 SW/SD05 through 07) between the site and the New River (Figure 2-5). Sampling locations labeled as 36-SW/SD05 through 07 were collected downstream at Site 35 to determine the effect that contaminants, if any, from Site 35 have had on downstream sediments and surface waters. The exact sampling locations were determined in the field and corresponded roughly with the aquatic/ecological survey sampling locations. One surface water (near bank) and two sediment samples (0 to 6 inches and 6 to 12 inches below the sediment surface) were collected from each location. The surface water and sediment samples were analyzed for TCL organics and TAL metals. The 0 to 6 inch sediment interval also was analyzed for total organic carbon (TOC) and particle-size distribution. Surface water samples were analyzed for hardness.

2.1.4.1 Surface Water Sample Collection

At each surface water sampling station samples were collected at the or near the western bank of Brinson Creek. Care was taken to ensure that the sampler did not contact and/or stir up the sediments, while still being relatively close to the sediment-water interface.

The surface water samples were collected by dipping the laboratory-supplied sample bottles directly into the water. Clean PVC gloves were worn by sampling personnel at each sampling station. For those sample bottles that contained preservative (e.g., sulfuric acid), the water was collected in a clean, decontaminated sampling container, and then slowly transferred into the appropriate laboratory-supplied sample bottle.

Water samples at the furthest downstream station were collected first, with subsequent samples taken at the next upstream station(s). Sediment samples were collected after the surface water samples to minimize sediment disturbance and suspension. If surface water samples were collected after collection of sediment samples, potentially contaminated sediments could be captured within the surface water sample and could potentially affect the results of the sample analyses.

All sample containers not containing preservative were rinsed at least once with the sample water prior to final sample collection. In addition, the sampling container used to transfer the water into sample bottles containing preservatives was rinsed once with sample water.

Care was taken when collecting samples for analysis of volatile organics compounds (VOCs) to avoid excessive agitation that could result in loss of VOCs. VOC samples were collected prior to the collection of the samples for analysis of other parameters. The sample bottles were filled by pouring down the side until the container was completely filled leaving no headspace. Each filled bottle was checked for bubbles and rejected if encountered.

Temperature, pH, salinity, and specific conductance of the surface water were measured in the field at each sampling location immediately following sample collection.

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

The following information was recorded in the field logbook:

- Project location, date and time
- Weather

- Sample location, number, and identification number
- Flow conditions (i.e., high, low, in flood, etc.)
- On site water quality measurements
- Visual description of water (i.e., clear, cloudy, muddy, etc.)
- Sketch of sampling location including boundaries of the water body, sample location (and depth), relative position with respect to the site, location of wood identifier stake
- Names of sampling personnel
- Sampling technique, procedure, and equipment used

2.1.4.2 Sediment Sample Collection

At each sediment sampling station samples were collected at a depth of 0 to 6 inches and 6 to 12 inches. Because the sediment samples were collected from the near bank where the water was shallow, it was not necessary to use a coring device proposed in the FSAP (Baker, 1994). Instead, a liner without the cover was used to collect the sediment samples. A new plastic liner tube, fitted with an eggshell catcher to prevent sample loss (if necessary), was used at each station.

The liner was pushed into the sediments to a minimum depth of 15 inches, or until refusal, whichever was encountered first. The sediments in the 0 to 6 inch interval and 6 to 12 inch interval were removed with a decontaminated extruder and placed into the appropriate sample containers. If less than 12 inches of sediments were obtained, the first 6 inches were placed in the 0 to 6 inch container, and the remaining sediment was placed into the 6- to 12-inch container.

2.1.4.3 Surface Water/Sediment Sample Analysis

Surface water/sediment samples were analyzed for TCL volatiles, semivolatiles, pesticides, PCBs, and TAL metals. The 0 to 6 inch sediment sample also was analyzed for TOC and particle size distribution. A summary of the sample numbers and parameters analyzed are provided in Appendix I. The samples were prepared and handled in accordance with the FSAP (Baker, 1994) and USEPA Region IV SOPs.

2.1.5 Ecological Investigation

The ecological investigation included sampling along Brinson Creek, which is the principle surface stream near Site 35, and along three streams in the nearby White Oak River watershed as part of an overall ecological background investigation (see Figure 2-6). The background streams include Webb Creek, Hadnot Creek, and Holland Mill Creek.

Biological samples collected as part of this investigation included fish, crabs, and benthic macroinvertebrates. The biological samples were collected to obtain population statistics for fish and benthic macroinvertebrates and to obtain fish and crab tissue samples for chemical analysis (TCL volatiles, semivolatiles, pesticides and PCBs, and TAL inorganics). Prior to initiating the sampling event at each station, the following information describing the site was recorded in the field log book:

- Average width, depth and velocity of the water body.

- Description of substrate.

- Description of "abiotic" characteristics of the reach such as pools, riffles, runs, channel shape, degree of bank erosion, and shade/sun exposure.

- Description of "biotic" characteristics of the reach including aquatic and riparian vegetation and wetlands.

Water quality measurements were collected during the benthic macroinvertebrate sampling, at a minimum, and during collection of some of the fish samples. On-site water quality measurements at these stations consisted of temperature, pH, specific conductance, salinity and dissolved oxygen. These measurements were conducted prior to sample collection.

2.1.5.1 Fish and Shellfish

This section discusses collection of the fish and shellfish (i.e., crabs) samples in Brinson Creek and the reference stations at Webb Creek, Hadnot Creek, and Holland Mill Creek.

A literature review was conducted to determine the fish species residing in the tidal areas of central North Carolina that may potentially be exposed to contaminants in the surface water/sediment exposure pathway. This review included compiling information from State and Federal natural resources agencies. In addition, Baker's experience in sampling similar areas formed a basis for a database of expected species for the area.

Three species of fish were to be sampled for tissue analysis, with each species being a representative of one of three trophic (feeding) groups, which included top carnivores (first order predator), forage fish (second order predator), and bottom feeders (third order predator). In addition, a minimum of ten individuals per specie, if available, of adult fish of preferably uniform size were composited and analyzed for whole body burden and fillet burden of chemicals, with the same species of fish being sampled from each station. A fish species was successfully collected if the above requirements were satisfied. These requirements were identified to Baker by the U.S. Fish and Wildlife Service as part of the Work Plan review.

Sampling variability can prevent the same species of fish from being sampled at each station because either the preferred species was not captured, or adequate numbers of uniform-size individuals were not captured. Therefore, if the preferred species was not successfully collected to satisfy the above requirements, a substitute species was collected that, if possible, exhibited a similar trophic position in the estuarine ecosystem.

The collected fish species were identified, measured, and counted. The small fish (less than 20 mm) were weighed in groups of 10 or 20 because of their low individual weight; the larger fish were weighed individually. The proportion of individuals as hybrids and the proportion of individuals with disease, tumors, fin damage, and skeletal anomalies was recorded at each station.

Fish that exhibited signs of being dead for an extended period of time (i.e., brown gills, bloating) were not retained for tissue analysis because of the potential for decomposition and leaching of contaminants from the organs into the edible portions of the fish.

Brinson Creek

This section discusses collection of the fish in Brinson Creek including the station locations and sampling procedures.

Station Locations

Fish were collected from three stations near Site 35 (35-FS01, 35-FS02, and 35-FS03) and three downstream stations near Site 36 (36-FS01, 36-FS02, and 36-FS03) (see Figure 2-5 for approximate station locations).

Station 35-FS01 was the furthest upstream fish station on Brinson Creek, adjacent to 35-SW/SD02. Station 35-FS02 was located adjacent to the site between 35-SW/SD04 and 35-SW/SD05. Finally, 35-FS03 was located downstream of the site adjacent to 35-SW/SD06. Stations 36-FS01, 36-FS02, and 36-FS03 were located on Brinson Creek adjacent to 36-SW/SD07, 36-SW/SD06, and 36-SW/SD05, respectively.

Sampling Procedures

Fish were collected at 35-FS01 using a Smith-Root Inc., backpack electrofisher powered by a 300-watt portable generator. A DC current was applied utilizing a "rattail" as the cathode and a hand-held electrode as the anode. The length of shocking time per subsection was recorded as seconds of applied current. Stunned fish were collected with one-inch mesh or smaller dip nets handled by members of the field sampling team.

Fish were collected at 35-FS02 and 35-FS03 using a combination of gill nets, hoop nets, electrofishing, catfish traps, and minnow traps. Fish were collected at 36-FS01, 36-FS02 and 36-FS03 using a combination of gill nets, hoop nets, catfish traps, and minnow traps. In addition, crabs were collected at 36-FS02 and 36-FS03 using crab pots. Crabs were not collected at 36-FS01, 35-FS01, 35-FS02 and 35-FS03 because the salinity was too low.

The gill nets used to collect the fish were monofilament, 50 or 100 feet in length, six-feet deep, and had a stretch mesh size ranging from 3 to 4 inches. The nets were deployed by securing the ends in the creek with 6.5 feet poles. Two yellow buoys marked with Baker Environmental, the hotel phone number, and the scientific collection permit number were attached to each net. The gill nets were checked within 12 hours of being deployed.

The hoops nets ranged in width at the outer-most loop from 2 to 3.5 feet in diameter, and were 4.5 to 14 feet in length. The square mesh size was 1 to 1.5 inches. The nets were used with either 10, 25 or 40 foot wings.

The hoop nets were deployed by attaching each wing to a 6.5 fence foot post that was driven into the sediments, with the wings forming a 45 to 90 degree angle. The back of the hoop net then was attached to a 6.5 foot fence post, and the net was stretched out to pull the wings taught. This post then was driven into the sediments to secure the net in place. The nets were checked at least once daily, because these nets typically do not kill the captured fish.

Catfish traps were deployed at each station. The catfish traps were approximately four to five feet in length and 15 inches in diameter. They were deployed by weighing down the traps and setting them in the channel. They were marked with a yellow buoy for easy retrieval.

Minnow traps, baited with dog food, were deployed at each station along the right bank facing downstream. The traps were checked periodically during the sampling trip.

Crab pots were used to collect blue crabs at each of the stations. The crab pots were either baited with chicken necks or dead fish obtained during the fish sampling. The crab pots were checked periodically throughout the sampling event.

Webb Creek

This section discusses collection of the fish samples in Webb Creek including the station locations and sampling procedures.

Station Location

The fish station WC02 was located on Webb Creek approximately 300 feet upstream from the Camp Lejeune railroad crossing. Station WC03 was located in the White Oak River approximately 25 feet downstream from its confluence with Webb Creek. See Figure 2-7 for approximate sample locations.

Sampling Procedures

Fish were collected in Webb Creek using gill nets, hoop nets, and minnow traps. The same sample collection and sample processing procedures used in Brinson Creek were conducted at the Webb Creek stations. All fish that were collected were processed for population statistics; no fish at these stations were collected for tissue analysis.

Hadnot Creek

This section discusses collection of the fish samples in Hadnot Creek including the station locations and sampling procedures.

Station Location

Fish were collected from four stations in Hadnot Creek (HC01, HC02, HC03 and HC04)(see Figure 2-8). HC01 was located approximately 100 feet upstream of Route 1104. Station HC02 was located approximately 2,500 feet upstream of Route 58. Station HC03 was located in the White Oak River approximately 100 feet upstream from its confluence with Hadnot Creek. Finally, station HC04 was located in Hadnot Creek by the road off of the Route 1105 crossing. In October, 1993, fish were collected by Baker in Hadnot Creek as part of another investigation (Baker, 1993). Fillet samples of these fish were chemically analyzed and the results are discussed in Section 7.0.

Sampling Procedures

Fish were collected in Hadnot Creek using hoop nets, gill nets, a haul seine, pole fishing, and the backpack electroshocker. The same sample collection and sample processing procedures used in the Brinson Creek were conducted at the Hadnot Creek stations. Pole fishing only was conducted during the October 1993 sampling.

At the stations where haul seines were utilized, a minimum of two haul seines were conducted. The haul seine was deployed with one person securing the seine on the shore and the other person walking out in a loop. The bottom of the net was kept in contact with the sediment to prevent fish from swimming under the net. Other field personnel aided in removing snags from the net and preventing fish from jumping over the net. When the person deploying the net arrived back at the shore, the net was pulled in, keeping the bottom of the net on the sediment. After the bag was lifted and the fish were carefully transferred into plastic tubs filled with water.

Holland Mill Creek

This section discusses collection of the fish samples in Holland Mill Creek including the station locations and sampling procedures.

Station Location

Fish were collected from three stations in Holland Mill Creek (HM01, HM02, and HM03)(See Figure 2-9). HM01 was located on Cartwheel Branch just upstream of Route 1444. Station HM02 was located at the confluence of Holland Mill Creek and Cartwheel Branch. Station HM03 was located in the White Oak River approximately 50 feet downstream from Holland Mill Creek.

Sampling Procedures

Fish were collected at these stations for population statistics. Fish were not collected at these stations for tissue analysis. Fish were collected in Holland Mill Creek using hoop nets, gill nets, a haul seine, and the backpack electroshocker. The same sample collection and sample processing procedures used in the Hadnot Creek stations were conducted at the Holland Mill Creek stations.

2.1.5.2 Benthic Macroinvertebrates

This section discusses collection of benthic macroinvertebrate samples in the Brinson Creek and the reference stations at Webb Creek, Hadnot Creek, and Holland Mill Creek.

Brinson Creek

Sampling Locations

Benthic macroinvertebrates were collected from four stations at Site 35 (35-BN01, 35-BN02, 35-BN03, and 35-BN04) and three stations at Site 36 (36-BN01, 36-BN02, and 36-BN03) (see Figure 2-5 for approximate station locations). All the stations were located in the same proximity as their respective adjacent sediment samples.

Station 35-BN01 was the furthest upstream benthic macroinvertebrate sampling location on Brinson Creek, adjacent to 35-SW/SD02. Station 35-BN02 was located adjacent to the 35-SW/SD04. Station 35-BN03 was located downstream of the site adjacent to 35-SW/SD06. Finally, station 35-BN04 was located adjacent to 35-SW/SD07. Stations 36-BN01, 36-BN02, and 36-BN03 were located on Brinson Creek adjacent to 36-SW/SD07, 36-SW/SD06, and 36-SW/SD05, respectively.

Sampling Procedures

Benthic macroinvertebrates were collected using a standard ponar grab sampler. The dimensions of the ponar are 23 x 23 cm (9 x 9 in.) for a sampling area of 529 cm^2 or 0.0523 m^2 (81 in^2). Each benthic macroinvertebrate sample was collected from the boat except for Station 35-BN01, which was a walk-in station.

The ponar was deployed from the boat, which was positioned in slightly different locations for each replicate to prevent re-sampling the same area. After retrieving the ponar with a sediment sample, it was opened into a clean tub and the sediments were removed with a teflon spatula. The sediments were transferred to a 0.5 mm sieve that was agitated (by hand) in water to remove the small particles. The remaining contents in the sieve were transferred into 16-ounce plastic sample jars. The jars were filled up to one-half full with sediments, and buffered formalin solution (10 percent by weight) was added to the remainder of the jar to preserve the benthic macroinvertebrates contained in the sediments. A 100 percent cotton paper label, marked in pencil with the sample number, was placed inside the jar. The outside of the jar was labeled with the sample number using a black permanent marker to identify the sample containers.

After all the benthic macroinvertebrate sampling at Brinson Creek was completed, the sample jars were transported to RMC Environmental Services, Inc. (RMC) of Spring City, Pennsylvania for sample sorting and taxonomic identification of the benthic macroinvertebrates.

Webb Creek

Benthic macroinvertebrates were collected in Webb Creek using the ponar grab deployed from the boat. The same sample collection and sample processing procedures used in Brinson Creek were conducted at the Webb Creek stations.

Hadnot Creek

Benthic macroinvertebrates were collected in Hadnot Creek using the ponar grab deployed from the boat. The boat was not used at HC01 or HC04 because the water was too shallow. Benthic macroinvertebrates were collected using the same procedures used for collecting benthic macroinvertebrates in Brinson Creek.

Holland Mill Creek

Benthic macroinvertebrates were collected in Holland Mill Creek using the ponar grab deployed from the boat. The boat was not used at HM01 because the water was too shallow. The same sample collection and sample processing procedures used in Brinson Creek were conducted at the Holland Mill Creek stations.

2.2 Decontamination Procedures

Decontamination procedures performed in the field were initiated in accordance with USEPA Region IV SOPs. The decontamination procedures outlined in the Final Sampling and Analysis Plan (SAP) were modified as follows. In general, sampling and drilling equipment were divided into two decontamination groups: heavy equipment and routine sample collection equipment. Heavy equipment included: the drill rig, hollow-stem augers, and drill rods. Routine sample collection equipment included: split-spoons, stainless-steel spoons and bowls, bailers, bailer wire, hand auger bucket, and sediment corer.

For heavy equipment, the following procedures were implemented:

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

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

- Clean with potable water and laboratory detergent (Alconox soap solution)
- Rinse thoroughly with deionized water
- Rinse with pesticide-grade isopropanol alcohol
- Air dry
- Wrap in aluminum foil, if appropriate

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

2.3 Investigative Derived Waste (IDW) Handling

Field investigation activities at Site 35 resulted in the generation of various IDW. This IDW included drilling mud, cuttings, development water, purge water, soils from sampling activities, and solutions used to decontaminate non-disposable sampling equipment. The general management techniques utilized for the IDW were:

1. Collection and containerization of IDW material.
2. Temporary storage of IDW while awaiting analytical data.
3. 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.

IDW liquids were sent off site to a licensed hazardous waste disposal facility. The IDW soils were returned to the source area since the analytical data indicated that they were nonhazardous. Appendix M provides information on the management and disposal of the IDW.

SECTION 2.0 REFERENCES

SECTION 2.0 REFERENCES

Baker. 1994. Remedial Investigation/Feasibility Study Sampling and Analysis Plan for Operable Unit No. 10. Marine Corps Base, Camp Lejeune, North Carolina.

Baker. 1994. Supplemental Aquatic Survey for Wallace Creek and Bearhead Creek. Final. Prepared for Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

SECTION 2.0 TABLES

TABLE 2-1

SUMMARY OF SHALLOW AND INTERMEDIATE WELL CONSTRUCTION DETAILS
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Date Installed	Consultant Supervising Well Installation	Top of PVC Casing Elevation (feet, above MSL)(1)	Ground Surface Elevation (feet, above MSL)	Stick-Up (feet, above ground surface)	Boring Depth (feet, bgs)(2)	Well Depth (feet, bgs)	Screen Interval Depth (feet, bgs)(3)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)
35MW-26B	5-13-94	Baker	15.05	15.4	-0.35	43.0	42.52	37.5-41.5	36.0	31.0
35MW-29A	4-27-94	Baker	20.62	18.6	2.0	17.0	15.77	6.0-15.0	4.5	2.5
35MW-29B	4-26-94	Baker	20.28	18.5	1.8	47.0	46.60	41.6-45.6	37.0	35.0
35MW-30A	5-11-94	Baker	18.38	16.3	2.0	17.0	15.81	5.81-14.81	4.5	3.0
35MW-30B	5-11-94	Baker	18.38	16.2	2.2	43.0	41.73	36.7-40.7	33.0	30.0
35MW-31A	5-1-94	Baker	18.32	16.4	1.9	14.0	13.01	3.05-12.0	2.5	1.0
35MW-31B	4-30-94	Baker	18.46	16.4	2.1	47.0	42.40	37.5-41.5	35.0	32.5
35MW-32A	5-14-94	Baker	18.23	16.1	2.1	15.0	13.87	3.90-12.90	3.0	2.0
35MW-32B	5-14-94	Baker	18.75	16.1	2.8	43.0	42.02	37.3-41.25	34.0	29.0
35MW-33A	5-12-94	Baker	16.68	16.9	-0.31	15.0	14.36	4.25-13.25	3.0	1.5
35MW-33B	5-12-94	Baker	16.62	16.8	-0.18	45.0	44.61	39.7-43.7	36.0	30.0
35MW-34A	5-10-94	Baker	16.77	14.7	2.0	15.0	14.07	4.0-13.0	3.5	2.5
35MW-34B	5-10-94	Baker	16.76	14.8	2.0	42.0	41.30	36.25-40.25	32.0	29.0
35MW-35A	5-3-94	Baker	15.45	13.6	1.8	15.0	14.47	4.8-13.8	3.0	1.0
35MW-35B	5-3-94	Baker	15.67	13.7	2.0	41.0	39.83	34.0-39.0	31.0	26.0
35MW-36A	5-9-94	Baker	13.30	11.3	2.0	16.0	13.23	3.25-12.25	2.5	1.5
35MW-36B	5-4-94	Baker	13.22	11.3	1.9	40.0	36.42	31.4-35.4	31.0	28.0
35MW-37A	5-15-94	Baker	20.30	18.3	2.0	16.0	15.09	5.0-14.0	4.0	2.5
35MW-37B	5-15-94	Baker	20.33	18.3	2.0	45.0	44.60	39.7-43.7	36.0	32.0
35MW-38A	5-16-94	Baker	19.74	18.1	1.6	16.0	15.34	5.25-14.25	3.5	2.0
35MW-38B	5-16-94	Baker	20.00	18.2	1.5	45.0	44.37	39.5-43.5	36.0	32.0

Notes: (1) MSL = mean sea level
(2) bgs = below ground surface
(3) Screen interval is measured from top to bottom slot of screen
"A" designation is shallow; "B" designation is intermediate.

TABLE 2-2

SUMMARY OF DEEP WELL CONSTRUCTION DETAILS
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Date Installed	Consultant Supervising Well Installation	Top of PVC Casing Elevation (feet, above MSL)[1]	Ground Surface Elevation (feet, above MSL)	Stick-Up (feet, above ground surface)	Boring Depth (feet, bgs)[2]	Well Depth (feet, bgs)	Outer Casing Depth (feet, bgs)	Screen Interval Depth (feet, bgs)[3]	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)
35GWD-1	4-26-94	Baker	19.95	18.0	2.0	67.0	61.00	46.0	56.1-60.1	55.0	45.0
35GWD-2	4-20-94	Baker	20.10	17.5	2.6	65.0	62.23	46.0	57.2-61.2	54.0	44.0
35GWD-3	4-27-94	Baker	19.03	16.7	2.6	68.0	65.28	45.0	60.3-64.3	57.0	44.0
35GWD-4	4-29-94	Baker	13.58	11.9	1.7	54.0	52.15	43.0	47.2-51.2	45.0	40.0
35GWD-5	5-1-94	Baker	10.23	7.7	2.5	59.0	56.13	8" - 16.0* 6" - 38.0*	51.2-55.2	45.0	37.0

Note: (1) MSL = mean sea level
(2) bgs = below ground surface
(3) Screen interval is measured from top to bottom slot of screen
* = Well 35GWD-5 had an 8-inch outer casing pushed to 16 feet and a 6-inch casing placed to 38 feet.

TABLE 2-3

SUMMARY OF WATER LEVEL MEASUREMENTS FROM SHALLOW WELLS
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Top of Casing Elevation (feet, above MSL)(1)	Depth to Groundwater (feet, below top of casing) (6-14-94)	Depth to Groundwater (feet, below top of casing) (7-20-94)	Depth to Groundwater (feet, below top of casing) (9-9-94)	Groundwater Elevation (feet, above MSL) (6-14-94)	Groundwater Elevation (feet, above MSL) (7-20-94)	Groundwater Elevation (feet, above MSL) (9-9-94)
EMW-1	19.21	10.00	10.58	9.24	9.21	8.63	9.97
EMW-3	7.13	--	3.55	2.82	--	3.58	4.31
EMW-5	18.05	9.27	9.65	8.92	8.78	8.40	9.13
EMW-6	18.52	13.80	14.26	13.35	4.72	4.26	5.17
EMW-7	16.00	10.82	11.34	10.40	5.18	4.66	5.60
MW-4S	20.52	9.09	9.67	7.70	11.43	10.85	12.82
MW-9S	18.92	9.08	9.57	8.36	9.84	9.35	10.56
MW-10S	18.99	8.79	9.20	8.02	10.20	9.79	10.97
MW-12S	19.91	12.83	13.38	12.36	7.08	6.53	7.55
MW-13S	16.92	12.12	12.68	11.74	4.80	4.24	5.18
MW-14S	17.78	11.41	11.90	10.93	6.37	5.88	6.85
MW-16S	20.10	14.84	15.29	14.38	5.26	4.81	5.72
MW-17S	16.83	12.76	13.21	12.32	4.07	3.62	4.51
MW-19S	8.76	4.90	5.30	3.94	3.86	3.46	4.82
MW-21S	17.48	10.67	11.10	10.20	6.81	6.38	7.28
MW-23S	8.74	6.66	6.96	5.24	2.08	1.78	3.50
MW-25S	13.33	9.13	9.54	8.74	4.2	3.79	4.59

TABLE 2-3 (CONTINUED)

SUMMARY OF WATER LEVEL MEASUREMENTS FROM SHALLOW WELLS
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Top of Casing Elevation (feet, above MSL)[1]	Depth to Groundwater (feet, below top of casing) (6-14-94)	Depth to Groundwater (feet, below top of casing) (7-20-94)	Depth to Groundwater (feet, below top of casing) (9-9-94)	Groundwater Elevation (feet, above MSL) (6-14-94)	Groundwater Elevation (feet, above MSL) (7-20-94)	Groundwater Elevation (feet, above MSL) (9-9-94)
35MW-26A	15.05	7.99	8.48	7.44	7.06	6.57	7.61
35MW-29A	20.62	9.48	9.95	8.49	11.14	10.67	12.13
35MW-30A	18.38	7.79	8.28	6.49	10.59	10.10	11.89
35MW-31A	18.32	10.91	11.32	10.37	7.41	7.00	7.95
35MW-32A	18.23	9.64	10.14	8.67	8.59	8.09	9.56
35MW-33A	16.68	9.72	10.30	9.24	6.96	6.38	7.44
35MW-34A	16.77	8.24	9.63	6.84	8.53	7.14	9.93
35MW-35A	15.45	8.66	9.07	7.94	6.79	6.38	7.51
35MW-36A	13.30	10.06	10.47	9.58	3.24	2.83	3.72
35MW-37A	20.30	8.36	8.91	7.31	11.94	11.39	12.99
35MW-38A	19.74	8.44	8.81	7.08	11.30	10.93	12.66

Note: (1) MSL = mean sea level

TABLE 2-4

SUMMARY OF WATER LEVEL MEASUREMENTS FROM INTERMEDIATE WELLS
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Top of Casing Elevation (feet, above MSL)(1)	Depth to Groundwater (feet, below top of casing) (6-14-94)	Depth to Groundwater (feet, below top of casing) (7-20-94)	Depth to Groundwater (feet, below top of casing) (9-9-94)	Groundwater Elevation (feet, above MSL) (6-14-94)	Groundwater Elevation (feet, above MSL) (7-20-94)	Groundwater Elevation (feet, above MSL) (9-9-94)
MW-9D	18.88	9.15	9.63	8.40	9.73	9.25	10.48
MW-10D	19.01	8.94	9.36	8.06	10.07	9.65	10.95
MW-12D	19.94	12.96	13.50	12.46	6.98	6.44	7.48
MW-13D	17.02	12.22	12.72	11.80	4.80	4.30	5.22
MW-14D	17.73	11.38	11.82	10.88	6.35	5.91	6.85
MW-16D	20.06	14.82	15.28	14.31	5.24	4.78	5.75
MW-17D	16.77	12.60	13.05	12.18	4.17	3.72	4.59
MW-19D	8.72	4.58	4.95	4.12	4.14	3.77	4.60
MW-21D	17.57	10.74	11.21	10.29	6.83	6.36	7.28
MW-23D	8.74	5.50	5.88	5.16	3.24	2.86	3.58
MW-25D	13.32	8.83	9.26	8.43	4.49	4.06	4.89
35MW-26B	15.05	8.19	8.60	7.54	6.86	6.45	7.51
35MW-29B	20.28	9.22	9.65	8.12	11.06	10.63	12.16
35MW-30B	18.38	7.93	8.38	6 .69	10.45	10.00	11.69
35MW-31B	18.46	11.31	11.75	10.73	7.15	6.71	7.73
35MW-32B	18.75	10.24	10.72	9.46	8.51	8.03	9.29
35MW-33B	16.62	9.76	10.25	9.20	6.86	6.37	7.42
35MW-34B	16.76	8.26	9.89	6.64	8.50	6.87	10.12
35MW-35B	15.67	8.98	9.50	8.40	6.69	6.17	7.27
35MW-36B	13.22	10.31	10.71	9.86	2.91	2.51	3.36
35MW-37B	20.33	8.82	9.91	7.56	11.49	10.40	12.74
35MW-38B	20.00	8.78	9.20	7.49	10.94	10.52	12.51

Note: (1) MSL = mean sea level

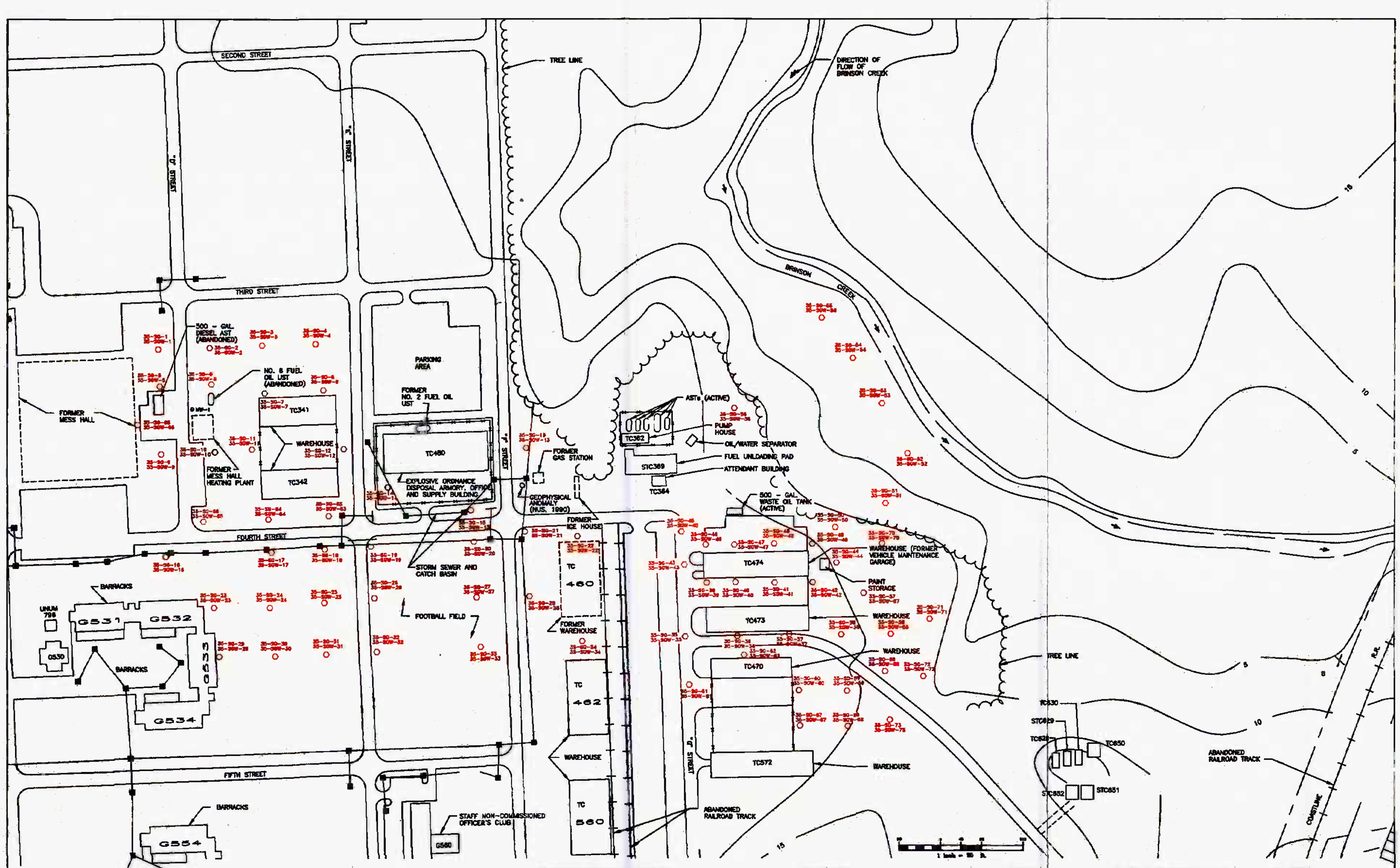
TABLE 2-5

SUMMARY OF WATER LEVEL MEASUREMENTS FROM DEEP WELLS
SITE 35, CAMP GEIGER AREA FUEL FARM
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Top of Casing Elevation (feet, above MSL)[1]	Depth to Groundwater (feet, below top of casing) (6-14-94)	Depth to Groundwater (feet, below top of casing) (7-20-94)	Depth to Groundwater (feet, below top of casing) (9-9-94)	Groundwater Elevation (feet, above MSL) (6-14-94)	Groundwater Elevation (feet, above MSL) (7-20-94)	Groundwater Elevation (feet, above MSL) (9-9-94)
35GWD-1	19.95	9.47	10.15	8.38	10.48	9.80	11.57
35GWD-2	20.10	14.66	15.11	14.13	5.44	4.99	5.97
35GWD-3	19.03	9.80	10.29	8.98	9.23	8.74	10.05
35GWD-4	13.58	8.41	8.88	7.93	5.17	4.70	5.65
35GWD-5	10.23	6.24	6.65	5.74	3.99	3.58	4.46

Note: (1) MSL = mean sea level

SECTION 2.0 FIGURES



LEGEND

35-SG-1
35-SGW-1
○ – INDICATES LOCATION OF SOIL GAS AND GROUNDWATER SCREENING LOCATION

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23250SRI

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SOIL GAS SURVEY AND
GROUNDWATER SCREENING SAMPLE LOCATIONS
CONTRACT TASK ORDER – 0232

SCALE 1" = 80'
DATE OCT. 1994

FIGURE No.
2 – 1

01539UB2Y

NOTES

N.S. GROUNDWATER SAMPLES WERE NOT COLLECTED AND SCREENED FROM THIS LOCATION

INT. INTERFERENCE OCCURED DURING SAMPLE ANALYSIS PROHIBITING THE GAS CHROMATOGRAPH FROM QUANTIFYING COMPOUND CONCENTRATION

LEGEND

35-SG-1
○ - INDICATES LOCATION OF GROUNDWATER SCREENING LOCATION
ND - COMPOUND WAS NOT DETECTED DURING SCREENING
(12.8) - BENZENE CONCENTRATION IN SOIL GAS ACCORDING TO SOIL GAS SURVEY IN Ug/Kg
(.38) - TRICHLOROETHYLENE CONCENTRATION IN SOIL GAS ACCORDING TO SOIL GAS SURVEY
—10⁺²— - BENZENE CONCENTRATION IN Ug/Kg
—10⁻²— - TRICHLOROETHYLENE ISOCONCENTRATION IN Ug/Kg
—10— - CONTOUR LINE DEPICTING SURFICIAL RELIEF

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJM
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CARD#	2325108

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

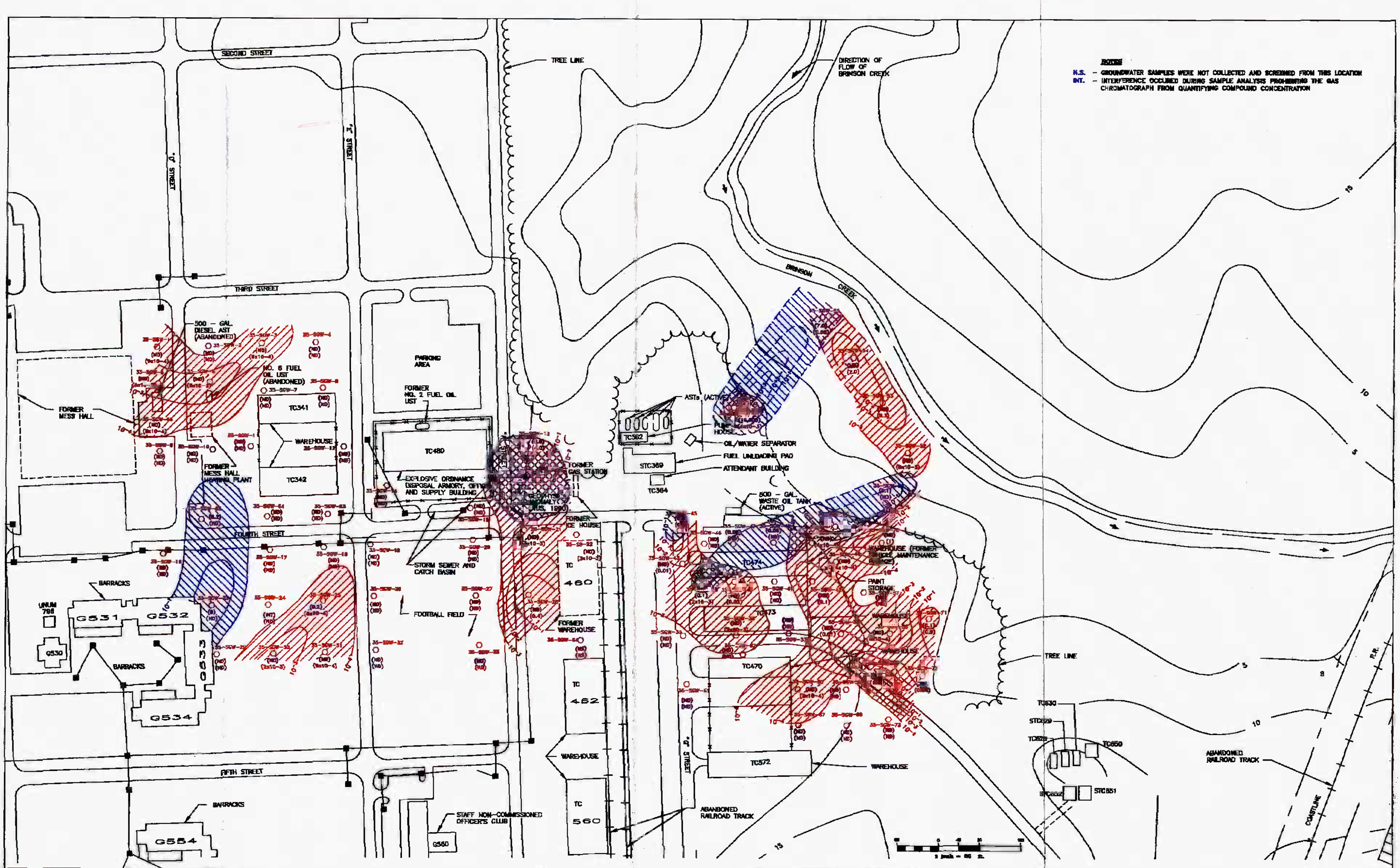
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SOIL GAS SURVEY RESULTS
CONTRACT TASK ORDER - 0232

SCALE 1" = 80'
DATE OCT. 1994

FIGURE No.
2-2



NOTES

N.S. – GROUNDWATER SAMPLES WERE NOT COLLECTED AND SCREENED FROM THIS LOCATION

INT. – INTERFERENCE OCCURED DURING SAMPLE ANALYSIS PROHIBITING THE GAS CHROMATOGRAPH FROM QUANTIFYING COMPOUND CONCENTRATION

LEGEND

35-SGW-1 ○ – INDICATES LOCATION OF GROUNDWATER SCREENING LOCATION
ND – COMPOUND WAS NOT DETECTED DURING SCREENING
(12.8) – BENZENE CONCENTRATION IN ug/L IN GROUNDWATER ACCORDING TO SOIL GAS SURVEY
(ND) – TRICHLOROETHYLENE CONCENTRATION IN ug/L IN GROUNDWATER ACCORDING TO SOIL GAS SURVEY
—10^{-1}— – BENZENE CONCENTRATION IN ug/L
—10^{-3}— – TRICHLOROETHYLENE ISOCONCENTRATION IN ug/L
—10— – CONTOUR LINE DEPICTING SURFICIAL RELIEF

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	W.M
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	232511RI

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

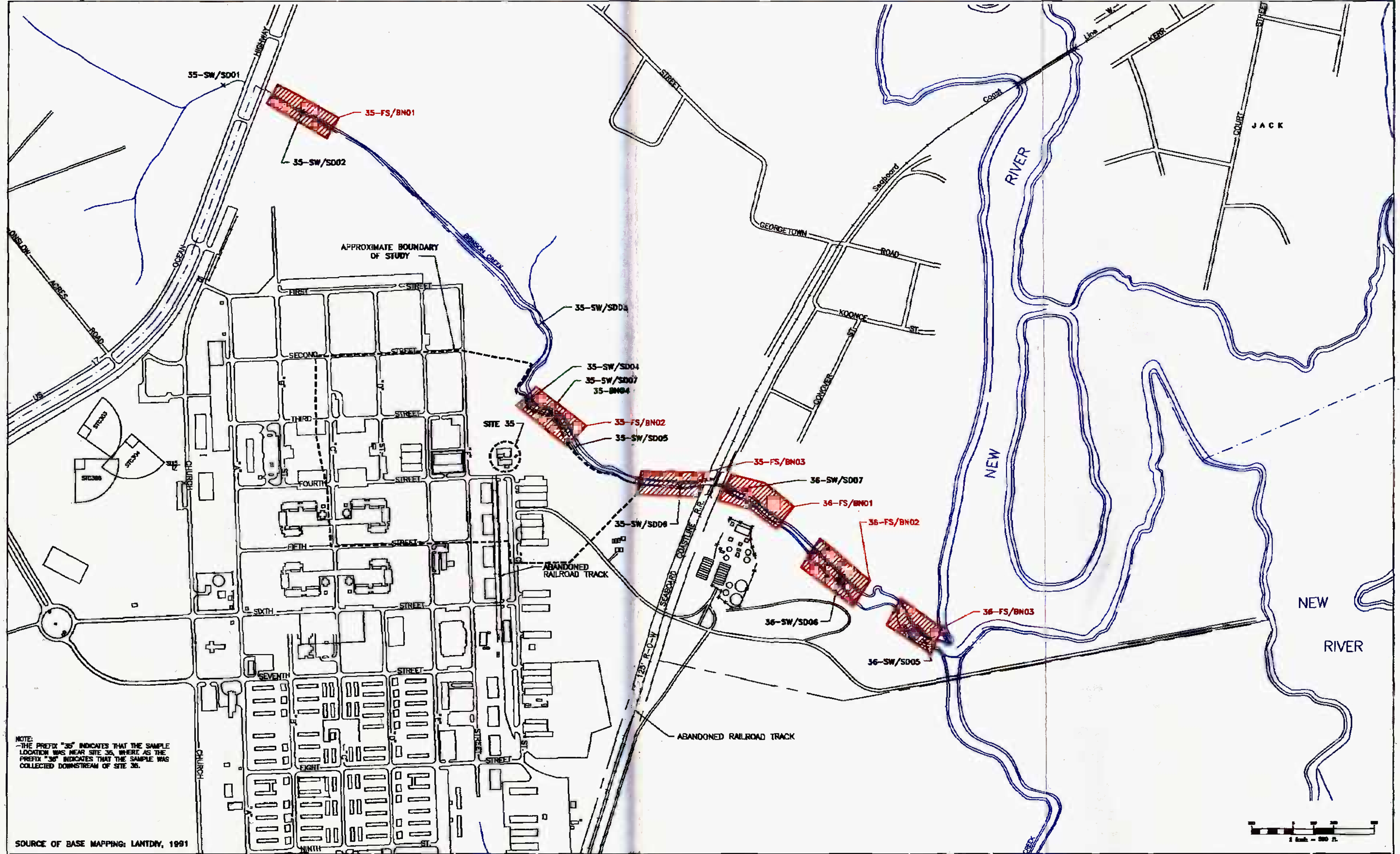
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

GROUNDWATER SCREENING RESULTS
CONTRACT TASK ORDER – 0232

SCALE 1" = 80'
DATE OCT. 1994

FIGURE No.
2–3



NOTE:
-THE PREFIX "35" INDICATES THAT THE SAMPLE LOCATION WAS NEAR SITE 35, WHERE AS THE PREFIX "36" INDICATES THAT THE SAMPLE WAS COLLECTED DOWNSTREAM OF SITE 36.

SOURCE OF BASE MAPPING: LANTDIV, 1991

LEGEND

35-SW/SD01 x 35-FS/BN01 - SAMPLE LOCATION FOR SURFACE WATER AND SEDIMENT

▨ - SAMPLE ZONE FOR FISH AND BENTHICS

DATE	OCT. 1994
SCALE	1" = 300'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23251781

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

SURFACE WATER, SEDIMENT,
BENTHIC AND FISH SAMPLE
LOCATION MAP
CONTRACT TASK ORDER - 0232

SCALE	1" = 300'	DATE	OCT. 1994

SHEET NO.
2-5

01539 U03V

LEGEND SOURCE USGS TOPOGRAPHY MAPS	DATE FEB 1995 SCALE 1 24000 DRAWN FS REVIEWED JSC S O # 62470-232-0000-07000 CADD# 232529RI	NORTH		SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS MARINE CORPS BASE, CAMP LEJEUNE NORTH CAROLINA BAKER ENVIRONMENTAL, Inc Coraopolis, Pennsylvania	Baker Baker Environmental, Inc	OFF-SITE BACKGROUND SAMPLING LOCATIONS IN THE WHITE OAK RIVER BASIN SCALE 1 24000 DATE FEBRUARY 1995	SHEET NO 2-6 OF

01537U02X

LEGEND

35GW-1	HAND-AUGERED BORING ADVANCED UNDER CS (1984) BY ESE.
EMW-7	MONITORING WELL INSTALLED UNDER CS (1986) BY ESE.
EMW-1	MONITORING WELL INSTALLED BY NUS (1990).
MW-1	MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.
MW-1	MONITORING WELL INSTALLED UNDER UST INVESTIGATION (1992) BY ATEC.
MW-26	MONITORING WELL INSTALLED UNDER CSM FOLLOW-UP INVESTIGATION (1993) BY LAW. (NOTE: PW-28 REFERS TO A PUMPING TEST WELL.)
SB-1	STRATIGRAPHIC SOIL BORING DRILLED UNDER CSA (1991) BY LAW.
B-1	SOIL BORING DRILLED UNDER CSA (1991) BY LAW.
HA-1	HAND-AUGERED BORING DRILLED UNDER CSA (1991) BY LAW.
HP-18	"HYDROPUNCH" SAMPLING POINT UNDER CSA (1991) BY LAW
35SW1 35SE1	SURFACE WATER/SEDIMENT SAMPLING LOCATIONS INSTALLED UNDER CS (1984) BY ESE
BCSB01	SHALLOW SOIL SAMPLES COLLECTED UNDER BAKER INTERIM RI (1993).
SB31	SOIL BORINGS ADVANCED BY BAKER UNDER INTERIM RI (1993).
MW-5	MONITORING WELLS INSTALLED UNDER WST SITE ASSESSMENT (1994) BY LAW

NOTES:

1. SHALLOW SOIL SAMPLES BCSB11 AND 12 WERE OBTAINED APPROXIMATELY 1,500 AND 2,200 FEET UPSTREAM OF BCSB05 BOTH SAMPLES WERE OBTAINED FROM THE FLAT-LYING UNSATURATED SOIL LOCATED ALONG THE WEST BANK OF BRINSON CREEK.

LEGEND

-x-x- - FENCE LINE
—15— - CONTOUR LINES DEPICTING SURFICIAL RELIEF
-+-+- - ABANDONED RAILROAD TRACKS

DATE	OCT. 1994
SCALE	1"= 80'
DRAWN	WJH
REVIEWED	JSC
S O #	62470-232-0000-07000
CADD#	232522RI

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL,Inc.
Coraopolis, Pennsylvania

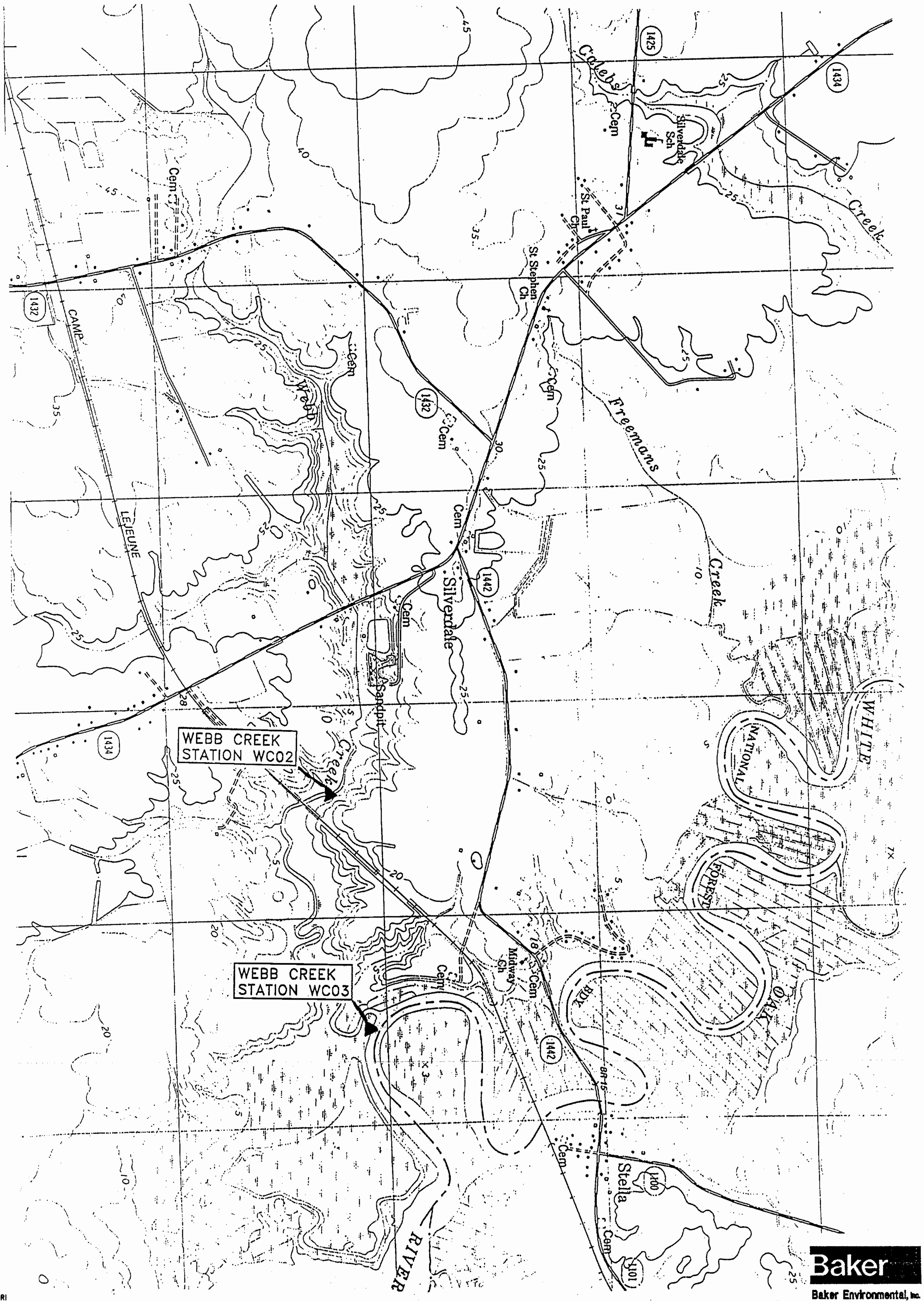
Baker
Baker Environmental, Inc.

PRE RI/FS WELLS AND SAMPLING LOCATIONS
CONTRACT TASK ORDER - 0232

SCALE 1"= 80'
DATE OCT. 1994

FIGURE No
1-4

01539 V04X



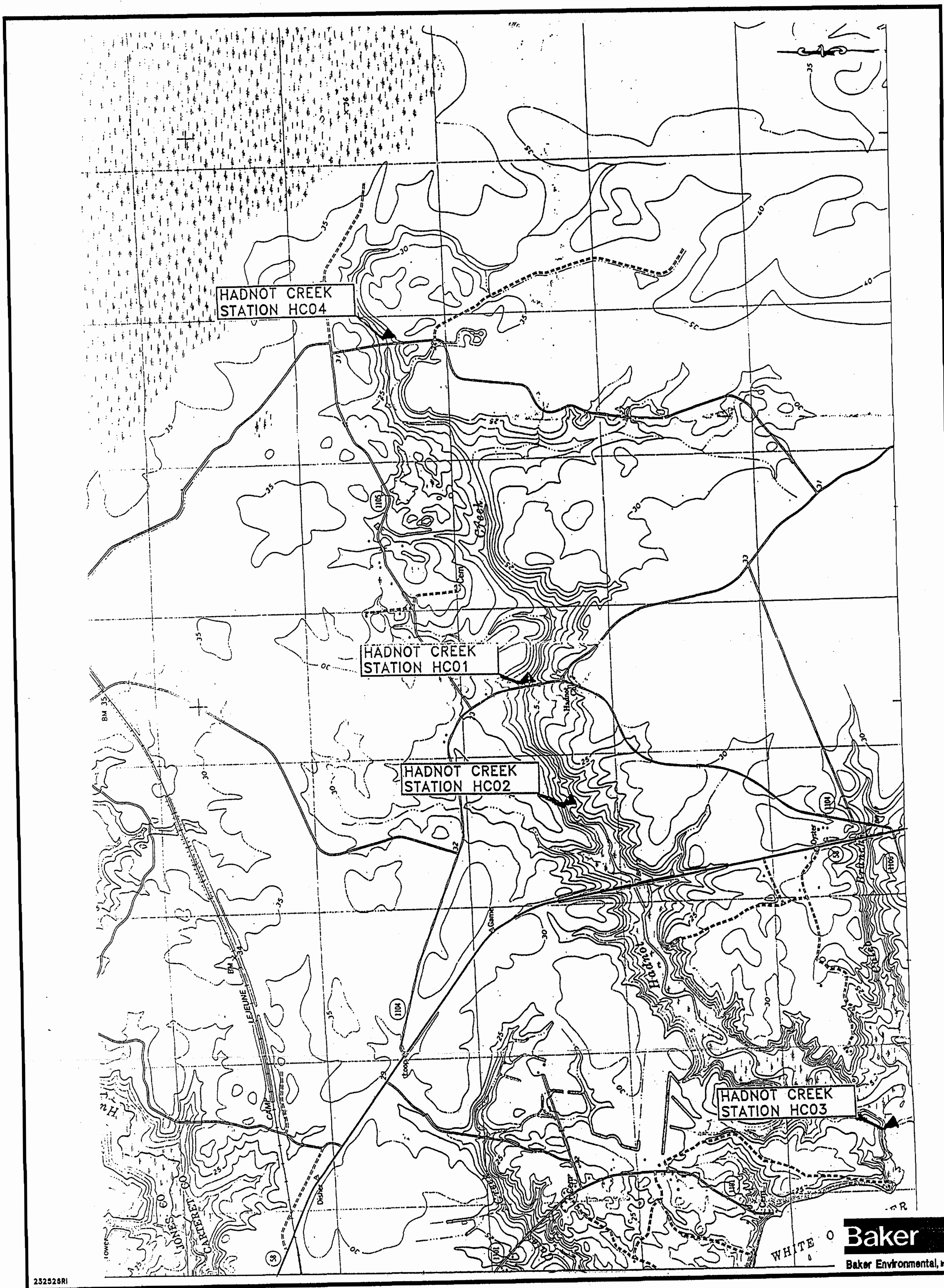
232525RI

Baker
Baker Environmental, Inc.

FIGURE 2-7
FISH AND BENTHIC MACROINVERTERBRATE
SAMPLING LOCATION IN WEBB CREEK
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER - 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: N.C. DIVISION OF MARINE
FISHERIES, REPORT AFC-9, NOV. 1975.

01539UB3Z



232526RI

FIGURE 2–8
FISH AND BENTHIC MACROINVERTERBRATE
SAMPLING LOCATION IN HADNOT CREEK
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER – 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: N.C. DIVISION OF MARINE FISHERIES, REPORT AFC–9, NOV. 1975.

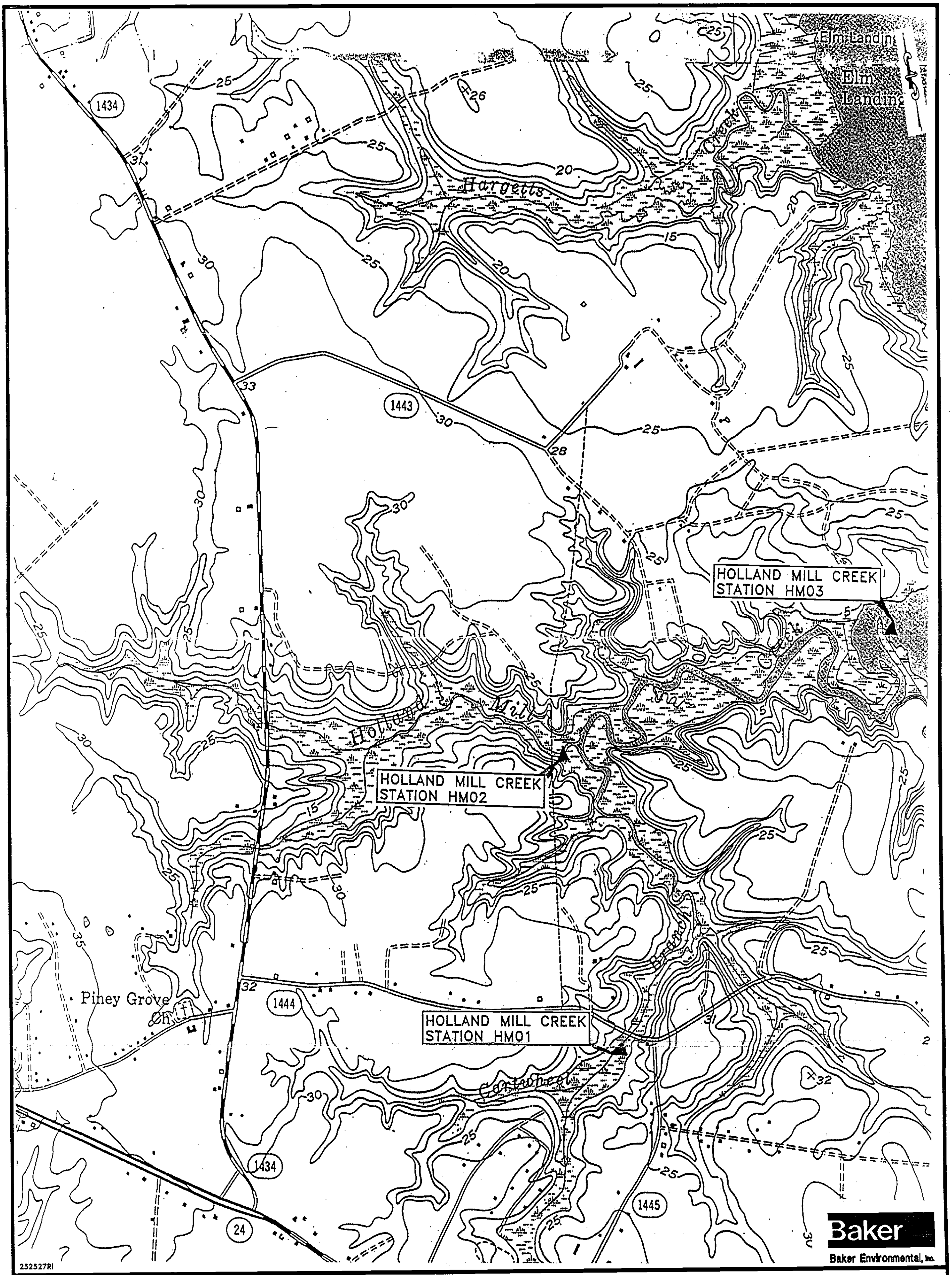


FIGURE 2-9
FISH AND BENTHIC MACROINVERTERBRATE
SAMPLING LOCATION IN HOLLAND MILL CREEK
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER - 0232
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: N.C. DIVISION OF MARINE FISHERIES, REPORT AFC-9, NOV. 1975.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section presents a discussion of the physical characteristics of Site 35, Camp Geiger Area Fuel Farm including: surface features, climatology, hydrology, geology (regional and site), soils, hydrogeology (regional and site), land usage, regional ecology, and a water supply well inventory of the area. This information was obtained from available literature pertaining to MCB Camp Lejeune and from the RI field activities.

3.1 Surface Features

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

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

The U.S. Army Corps of Engineers has mapped the limits of 100-year floodplain at Camp Lejeune at 7.0 feet above msl in the upper reaches of the New River (WAR, 1983); this increases downstream to 11 feet above msl near the coastal area (WAR, 1983). Site 35 does not lie within the 100-year floodplain of the New River.

The surface of the study area is primarily covered with vegetation, however, a significant portion is covered by roads, buildings, and parking areas. Northeastern and eastern portions of the site are bordered by Brinson Creek, wetlands, and woodlands.

The topography of Site 35 is relatively flat. An average elevation between 11 and 18 feet mean sea level (msl) was recorded during a recent survey of the site. Changes in elevation are gradual giving the site a flat appearance. The elevation drops adjacent to Brinson Creek defining the creek's flood plain. Surface runoff across the study area is primarily toward Brinson Creek via man-made drainage ditches, storm drains and catch basins and natural drainage patterns. Impervious surfaces such as roadways, paved parking lots, and buildings modify surface runoff and infiltration across the study area.

3.2 Climatology

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

Although coastal North Carolina lacks distinct wet and dry seasons, there is some seasonal variation in average precipitation. July tends to receive the most precipitation and rainfall amounts during summer are generally the greatest. Daily showers during the summer are not uncommon, nor are periods of one or two weeks without rain. Convective showers and thunderstorms contribute to the variability of precipitation during the summer months. October tends to receive the least amount of precipitation, on average. Throughout the winter and spring months precipitation occurs primarily in the form of migratory low pressure storms. MCB Camp Lejeune's average yearly rainfall is approximately 52 inches. Table 3-1 presents a climatic summary of data collected during 27 years (January 1955 to December 1982) of observations at Marine Corps Air Station (MCAS) New River.

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

MCB Camp Lejeune experiences hot and humid summers; however, ocean breezes frequently produce a cooling effect. The winter months tend to be mild, with occasional brief cold spells. Average daily temperatures range from 38° F to 58° F in January and 72° F to 86° F in July. The average relative humidity, between 75 and 85 percent, does not vary greatly from season to season.

Observations of sky conditions indicate yearly averages of approximately 112 days clear, 105 partly cloudy, and 148 cloudy. Measurable amounts of rainfall occur 120 days per year, on the average. Prevailing winds are generally from the south-southwest 10 months of the year, and from the north-northwest during September and October. The average wind speed for MCAS New River is 6.9473 miles per hour.

3.3 Surface Water Hydrology

The majority of MCB Camp Lejeune is situated near sea level (i.e., estuarine conditions which are tidally influenced). The New River is the dominant surface water feature and receives drainage from Brinson Creek. It flows in a southerly direction and empties into the Atlantic Ocean through the New River Inlet.

A single surface water (Brinson Creek) body forms the eastern boundary of the study area. Several surface drainage pathways lead to Brinson Creek with flows southeast to the New River. Brinson Creek is designated by the North Carolina Fisheries Rules as Class I inland fishing waters.

The New River is designated as Class SC, High Quality Water (HQW) (NC DEHNR, 1993, and NCMFC, 1992). Classic SC waters are saltwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. HQW are waters that are rated as excellent based on one or more of the following factors: biological and physical/chemical characteristics through division monitoring or special studies; native and special trout waters (and their tributaries) designated by the Wildlife Resources Commission; primary nursery areas designated by the Marine Fisheries Commission; and other functional nursery areas designated by the Wildlife Resources Commission; critical habitat designated by the Wildlife Resources Commission or the Department of Agriculture; all water supply watersheds which are classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II have been received from the appropriate local government and accepted by the Division of Environmental Management; and all Class SA waters (NC DEHNR, 1993). This section of the New River is classified as a primary fish nursery area, but it is not a water supply.

3.4 Geology

3.4.1 Regional Geology

MCB Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The sediments of the Atlantic Coastal Plain consist of interbedded sands, clays, calcareous clays, shell beds, sandstone, and limestone. These sediments are layered in interfingering beds and lenses that gently dip and thicken to the southeast (ESE, 1990). Regionally, they comprise 10 aquifers and nine confining units which overlie igneous and metamorphic basement rocks of pre-Cretaceous age. The combined thickness of these sediments is approximately 1,500 feet. These sediments were deposited in marine or near-marine environments and range in age from early Cretaceous to Quaternary time. Table 3-2 presents a generalized geologic and hydrogeologic units in coastal North Carolina (Harned et al., 1989).

United States Geological Survey (USGS) studies at MCB Camp Lejeune indicate that the area is underlain by sand and limestone aquifers separated by semi-confining units (i.e., in some portions of the base) of silt and clay. These aquifers include the water table (surficial), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear. The surficial aquifer ranges in thickness from 0-73 feet and averages 25 feet according to U.S.G.S (Cardinell et al, 1993). The estimated lateral hydraulic conductivity for the surficial aquifer is 50 ft/d and is based on a general composition of fine sand mixed with some silt and clay (Cardinell et al, 1993). Less permeable clay and silt beds function as confining units or semi-confining units which separate the aquifers and impede the flow of groundwater between aquifers. The vertical hydraulic conductivity of the Castle Hayne confining unit was estimated to range from 0.0014 to 0.41 ft/d and is comparable to those determined for silt (Cardinell et al, 1993). A generalized hydrogeologic cross-section of this area is presented in Figures 3-1 and 3-2. This cross-section illustrates the relationship between the aquifers in this area (Cardinell et al., 1993).

3.4.2 Site Geology

Numerous borings were advanced within the study area during the field investigations conducted by Baker. Subsurface soil descriptions are provided in the Test Boring and Well Construction Records in Appendix H. Additional information regarding the soils were obtained from the previous investigations. The following provides detailed description of the stratigraphy underlying the study area.

Soil conditions are generally uniform throughout the study area. In general, the shallow soils consist of unconsolidated deposits of silty sand, clayey silt, silt and sand. These soils represent the Quaternary age "undifferentiated" deposits which characterize the River Bend Formation and is underlain by the Castle Hayne Formation. Sands are primarily fine to medium grained and contain varied amounts of silt (0-50%), shell fragments (0-35%), clay (0-10%). Results of the standard penetration tests indicate that the sands have a relative density of loose to dense. Based on field observations, the sands classify as silty sand (SM) and/or poorly graded sand (SP) according to the USCS.

Silts are plastic to nonplastic, contain varied amounts of sand (0-50%) and clay (0-10%) and classify as ML or MH. Standard penetration tests indicate that the silts have a relative density of loose to dense for the nonplastic, and soft to very stiff for the plastic.

Geologic cross-sections were constructed to illustrate subsurface soil beneath the study area. As shown on Figure 3-3, several areas were traversed to provide a cross-sectional view of the study area. Three cross-sections were constructed: A-A' crosses west to east across the upper portion of the study area; B-B' crosses north to south; and C-C' crosses west to east across the lower portion of the study area.

Cross-section A-A' depicts subsurface soils to an elevation of -51.3 feet msl from the western boundary of the study area to the eastern boundary. As illustrated on Figure 3-4, the soil underlying this portion of the area consist of fine to medium sands, clayey silts, and silty sands.

In general, on the western portion of the study area, a fine sand with trace to some silt is underlain by another fine sand that is partially cemented with calcium carbonate and contains 10-20% shell fragments to a depth of approximately -25 msl. Underlying the partially cemented sand is a very dense to dense, greenish gray, fine sand containing some silt, trace to some shell fragments. This soil unit is the semi-confining unit separating the Quaternary sediments from the Castle Hayne Aquifer. The semi-confining unit appears to be approximately 8 to 12 feet thick, generally thickening toward the east. Beneath this unit resides the Castle Hayne Formation. Borings were only advanced 10 to 15 feet into this formation during the RI, therefore providing limited knowledge of specific details regarding the condition of the Castle Hayne beneath the study area. The upper portion of the Castle Hayne was described as a partially cemented, gray, fine sand with some shell fragment and limestone fragments encountered periodically.

On the eastern portion of the study area this entire sequence of soil types appears to be overlain by silty clay or a clayey silt. The unit is not uniform and varies from approximately 4 to 20 feet thick.

Cross-section B-B' depicts the subsurface soil conditions to an elevation of -42.1 feet (Figure 3-5). The soils consisted of clayey silts, sands, silty sands, peats, and clays. Overall the soils did not differ substantially from those encountered in the A-A' cross-section. In general, a fine to medium sand with trace to some silt was interbedded with silts, silty sands, clayey silts and clays to an elevation of -6 to -12 msl. The only difference was the 8 feet of peat observed in soil boring 35MW-34B. This boring was located in the southeastern portion of the study area.

Beneath the fine to medium sand resides the partially cemented, gray, fine sand with trace to some shell fragments. The semi-confining unit underlies this unit followed by the Castle Hayne Formation.

Cross-section C-C' illustrates the soils beneath the southern portion of the site to an elevation of -51.3 (Figure 3-6). In general, the soils consisted of the same types observed in the other cross-sections previously discussed. The only difference in this cross-section when compared with the others is the increase in interbedded soils on the eastern portion of the area.

Overall, the soils encountered during investigations within the study area are fairly consistent throughout. Note that within the study area, a laterally continuous semi-confining unit was present and between -26.0 and -28.1 feet msl. The location of the semi-confining unit separating the surficial from the Castle Hayne Aquifer was encountered approximately 40 feet below ground surface. This is consistent with the range reported by the U.S.G.S. but exceeds the average of 25 feet they had reported (Cardinell et al, 1993).

3.5 Surface Soils

Information regarding site soil conditions was obtained from the Soil Survey publication prepared by the U.S. Department of Agriculture - Soil Conservation Service (SCS) for Marine Corps Base Camp Lejeune, North Carolina (SCS, 1984). Due to past grading and surface activities at the site, the soils described in the SCS publication may differ from current site conditions.

According to the SCS Soil Survey the site is underlain by a single distinct soil unit, the Baymeade-Urban (BaB) Land Complex. Baymeade-Urban soils exhibit 0 to 6 percent slopes and only about 30 percent of their surface area has been altered through urbanization. Infiltration is rapid and surface water runoff slow in the remaining undisturbed areas. The seasonal high water table ranges from 4 to 5 feet bgs for Baymeade-Urban soils.

3.6 Hydrogeology

The following sections discuss the regional and site-specific hydrogeologic conditions. The information presented on the regional hydrogeology is from literature (Harned, et al., 1989); site-specific hydrogeologic information presented is from data collected during the field investigation.

3.6.1 Regional Hydrogeology

The surficial water table aquifer lies in a series of undifferentiated sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This aquifer is not used for water supply at MCB Camp Lejeune because of its low yielding production rates. A confining unit is present underlying the surficial aquifer within the eastern portion of MCB Camp Lejeune (Harned, et al., 1989).

The principal water supply aquifer for the Activity lies in a series of sand and limestone beds between 50 and 300 feet bgs. This series of sediments generally is known as the Castle Hayne Aquifer. The Castle Hayne Aquifer is about 150 to 350 feet thick in the area and is the most productive aquifer in North Carolina. Estimated transmissivity (T) and hydraulic conductivity (K) values for the Castle Hayne Aquifer range from 4,300 to 24,500 ft^2/day (32,200 to 183,300 gallons/foot/day) and 14 to 82 feet/day, respectively (Harned et al., 1989).

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

The aquifers that lie below the Castle Hayne consist of thick sequences of sand and clay. Although some of these aquifers are used for water supply elsewhere in the Coastal Plain, they contain saltwater in the MCB Camp Lejeune area and are not used (Harned et al., 1989).

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

Water levels in wells tapping the surficial aquifer vary seasonally. The surficial aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. Therefore, the water table generally is highest in the winter months and lowest in summer or early fall (Harned et al., 1989).

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

3.6.2 Site Hydrogeology

The following sections describe the site hydrogeologic conditions for the surficial (water table aquifer) and the deep (Castle Hayne Aquifer) water-bearing zones at Site 35. Hydrogeologic characteristics in the vicinity of the site were evaluated by reviewing existing information (e.g., USGS publications) and installing a network of shallow, intermediate and deep monitoring wells.

Groundwater was encountered at varying depths during the drilling program. This variation is primarily attributed topographical changes. In general, the groundwater was encountered between 5.5 and 8.5 feet bgs. The water table nears the surface in the area of Brinson Creek, where the topography drops.

Multiple rounds of groundwater level measurements were obtained from the shallow, intermediate and deep monitoring wells within the study area. Three complete rounds were obtained on June 14, July 12, and September 9, 1994 and are summarized on Tables 2-3, 2-4, and 2-5.

Shallow groundwater elevations exhibited some fluctuation over the three month period. The water table aquifer exhibited a 0.73 to 3.25 foot increase in elevation. The increase may be due to increased precipitation experienced during the latter portion of the summer and early fall of 1994. Typically at MCB, Camp Lejeune, a higher water table is noted in the spring and a lower water table is noted in the late fall. However, the spring of 1994 was reported by Activity personnel unseasonably dry and may have resulted in a decrease in the elevation of the groundwater. Approximately 1.67 inches of rainfall was recorded by Baker's rain gauge between March 12, 1994 and May 10, 1994. Typically, Camp Lejeune receives approximately 6.5 inches of rain during the months of March and April according to the Naval Oceanography Command Detachment (see Table 3-1).

Shallow groundwater flow patterns in the vicinity of the site on September 9, 1994 are depicted on Figure 3-7. The data indicates that the groundwater flow is toward the northeast, with an average gradient of 1.7×10^{-2} ft/ft.

Hydraulic conductivity test were performed at the site between September 9 and 10, 1994. The average hydraulic conductivity for the upper portion of the water table aquifer is 0.628 ft/day (2.22×10^{-4} cm/sec) and the average for the lower portion of the water table aquifer is 5.16 ft/day (1.8×10^{-3} cm/sec). These values were calculated using the Geraghty and Miller aquifer test solver (AQTESOLV) program which uses the Bouwer and Rice (1976) method for unconfined aquifers. The average values are consistent with expected values of hydraulic conductivity for the sands and silty sands at the site (Fetter, 1980). The copies of the AQTESOLV printouts are located in Appendix N and the results are summarized on Table 3-3.

A study of data from other aquifer tests (pump tests) performed at MCB Camp Lejeune was conducted by Baker to further evaluate aquifer characteristics and production capacities. The technical memorandum is provided in Appendix O. The information contained in this memorandum pertains primarily to the surficial aquifer. Average pumping rates range from 0.5 to 3 gallons per minute (gpm). Transmissivity ranges from 7.17 to 7,099.20 ft^2/day; storativity ranges from 1.51×10^{-3} to 7.48×10^{-2}; and hydraulic conductivity ranged from 0.48 to 1.42 ft/day.

Fluctuation of the groundwater elevations within the deep wells was observed over the three months, however the fluctuation was not as dramatic as in the shallow and intermediate wells. Fluctuations ranged from 0.88 to 1.77 feet. It is not uncommon for a semi-confined aquifer to not respond to precipitation or seasonal fluctuations with the same magnitude as an unconfined aquifer. The presence of the semiconfining unit will impede the vertical migration of precipitation causing a delayed and minimal effect on the head of the aquifer.

The upper portion of the Castle Hayne Aquifer also flows northeast across the site with a gradient of 1.4×10^{-2} (see Figure 3-8). The calculated hydraulic conductivity for this unit was calculated from a slug test at 6.03 ft/day (2.03×10^{-3} cm/sec). These values are consistent with the sands encountered in the upper portion of the Castle Hayne Formation beneath the site (Fetter, 1980). The result of the slug test is summarized in Table 3-4 and the data is provided in Appendix N.

3.7 Land Use and Demography

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 had 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.

Site 35, the Camp Geiger Area Fuel Farm, is presently used to dispense gasoline, diesel, and kerosene to government vehicles and to supply USTs in use at Camp Geiger and the New River Marine Corps Air Station. The fuel farm is planned for demolition for a proposed highway. Barracks are located within 1,000 feet of the site and many warehouses and storage facilities are located adjacent to and within the boundaries of the study area. A COMMARFORLANT Nuclear Biological Chemical Defense School Training Range is located adjacent to the southeast boundary of the site.

Sensitive environmental areas would include Brinson Creek and associated unnamed tributaries.

3.8 Regional Ecology

MCB Camp Lejeune is located in the Coastal Plain Province. 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 Province. 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 of stable sand dunes protected from the ocean. Live oak is an indicator species with pine, cedar, yaupon, holly, and laurel oak. Deciduous hardwoods may be present where forest is mature.
- Pocosins - Lowland forest community that develops on highly organic soils that are seasonally flooded. Characterized by plants adapted to drought and acidic soils low in nutrients. Pond pine is dominant tree with dense layer of evergreen shrubs. Strongly influenced by fire.
- Cypress\Tupelo Swamp Forest - Occurs in the lowest and wettest areas of floodplains. Dominated by bald cypress and tupelo.
- Freshwater Marsh - Occurs upstream from tidal marshes and downstream from non-tidal freshwater wetlands. Cattails, sedges, and rushes are present. On the coast of North Carolina swamps are more common than marshes.
- Salt Marsh - Regularly flooded, tidally influenced areas dominated by salt-tolerant grasses. Saltwater cordgrass is a characteristic species. Tidal mud flats may be present during low tide.
- Salt Shrub Thicket - High areas of salt marshes and beach areas behind dunes. Subjected to salt spray and periodic saltwater flooding. Dominated by salt resistant shrubs.
- Dunes/Beaches - Zones from the ocean shore to the maritime forest. Subjected to sand, salt, wind, and water.

- Ponds and Lakes - Low depressional areas where water table reaches the surface or where ground is impermeable. In ponds, rooted plants can grow across the bottom. Fish populations managed in these ponds include redear, bluegill, largemouth bass, and channel catfish (USMC, 1987).

- Open Water - Marine and estuarine waters as well as all underlying bottoms below the intertidal zone.

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, marshes, pocosins, and wooded swamps.

The base also contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds. The soil types range from sandy loams to fine sand and muck, with the dominant series being sandy loam (USMC, 1987). 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, Brinson Creek, and Duck Creek.

Because of the natural resources on the base, forested areas are actively managed for timber. Game species are also managed for hunting and ponds are maintained for fishing. Game species managed include wild turkey, white-tailed deer, black bear, grey and fox squirrels, bobwhite quail, eastern cottontail and marsh rabbits, raccoons, and wood ducks. However, no portion of Site 35 is part of a managed hunting area and as such, hunting is not permitted anywhere on Site 35.

Brinson Creek and the portion of the New River that includes Brinson Creek are classified by the NC DEHNR as SC NSW. The SC classifies the water body as tidal saltwater, which allows for aquatic life propagation and survival, fishing, wildlife, and secondary recreation. The NSW is for nutrient sensitive waters, which require limitations on nutrient inputs (NC DEHNR, 1993). Brinson Creek is designated by the North Carolina Fisheries Rules as Class I - inland fishing waters, whereas the New River is designated by Class C - coastal fishing waters (NCMFC, 1992).

Hadnot Creek, Holland Mill Creek (including Cartwheel Branch) and the section of the White Oak River that encompasses Hadnot Creek, Holland Mill Creek, and Webb Creek are classified as SA from their source to the White Oak River. The SA classifies the water body as a tidal saltwater with shellfishing for market purposes and the following uses: primary recreation, aquatic life propagation and survival, fishing, wildlife, and secondary recreation. Webb Creek is classified as C from its source to the White Oak River. The C classifies the water body as a fresh water with the following uses: aquatic life propagation and survival, fishing, wildlife, and secondary recreation. The section of the White Oak River that encompasses these three creeks is designated by the North Carolina Fisheries Rule as Class C - coastal fishing waters (NCMFC, 1992).

3.9 Site-Specific Ecology

During March 1994, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 35. The study included the lower downstream reach of Brinson Creek because of its proximity to Site 35. Vegetative communities and wildlife habitats present on-site were identified during the evaluation. Figure 3-9 depicts the habitats identified.

Three different habitat types are found at Site 35, including loblolly pine/hardwood forest, scrub/shrub wetland, and cleared open field. Small pockets of wetland are also found within the open field (Figure 3-9).

The area between Camp Geiger and the railroad and between Camp Geiger and Brinson Creek is classified as loblolly pine/hardwood forest according to Baker's habitat evaluation. The dominant conifers included loblolly pine (Pinus taeda) and red cedar (Juniperus virginiana). Some bald cypress (Taxodium distichum), is also present. Dominant deciduous trees include yellow poplar (Liriodendron tulipifera), sweetgum (Liquidambar styraciflua), and red maple (Acer rubrum). Potential bioreceptors found in this area include white-tailed deer (Odocoileus virginianus); gray fox (Urocyon cinereoargenteus); and, small mammals such as squirrels, rabbits (Syvilagus), moles, and voles. Song birds, as well as some upland game birds, probably occur in this area.

A narrow area of palustrine deciduous wetland is located within the floodplain of Brinson Creek and its tributary. The dominant vegetation in this wetland includes red maple, sweet gum, coastal plain willow (Salix caroliniana), and southern bayberry (Myrica cerifera). In some locations, the stream edge is dominated by narrow-leaved cattail (Typha augustifolia). Receptors expected to occur in this area include white-tail deer and small fur-bearing mammals such as raccoon (Procyon lotor), opossum (Didelphis marsupialis), mink (Mustela vison), and otter (Lutra canadensis). American wood cock (Philohela minor), wood ducks (Aix sponsa), and ruddy ducks (Oxyura jamaicensis) may feed in this area.

A narrow strip of open field is located across Brinson Creek from Camp Geiger. This area is a cleared right-of-way and is dominated by grasses and herbaceous plants. Small pockets of persistent emergent wetland are also present and are characterized by hydrophilic vegetation. White-tail deer, song birds, and various small mammals probably occur in this area.

Figure 3-9 displays the four habitat types were identified adjacent to Site 35 including loblolly pine/hardwood forest, open field, palustrine evergreen, and barren ground. The following paragraphs pertain to the area adjacent to Site 35 located in the lower downstream reach or Brinson Creek.

Most of the area was classified as loblolly pine/hardwood forest during Baker's habitat evaluation. Dominant conifers include loblolly pine and red cedar and dominant hardwoods. The dominant hardwoods include yellow poplar, sweetgum, and red maple. Possible receptors living in this area include white-tail deer, gray fox, and small mammals like squirrels, rabbits, mice, moles, and voles. Song birds also inhabit this area.

An open field that appears to be fallow is present north of Brinson Creek. Upland grasses, soybeans, and seedlings of surrounding forest trees are dominant in this area, which appears to be in the early stages of succession from field to forest. This area is prime habitat for wildlife grazing and feeding. Possible bioreceptors include white-tail deer, rabbit, raccoon (Procyon lotor), wild turkey (Meleagris gallopavo), bobwhite (Colinus virginanus), and mourning dove (Zenaida macroura).

North of the confluence of Brinson Creek and the New River, a palustrine wetland is located. Dominant vegetation in this wetland area includes cattail, Spartina sp., and Phragmites sp. Possible bioreceptors in this area include otter, raccoon, and small mammals. A pair of adult osprey (Pandion haliaetus) were observed feeding in the immediate area.

An open, barren area is present north of the tributary of Brinson Creek and is described as a tree mulching area. No vegetation was observed here. Limited bioreceptors would be expected in this area, although young wild turkey may feed on insects in the open area.

3.10 Sensitive Environments

This section describes the sensitive environments that were evaluated in the area near Site 35. These sensitive environments include wetlands, threatened and endangered species, and other potentially sensitive environments.

3.10.1 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 are identified 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 map (Figures 3-9).

According to the NWI maps, wetland are present along Brinson Creek, along the unnamed tributary to Brinson Creek, and where Brinson Creek flows into the New River. A palustrine, forested, deciduous (PF06) wetland is located along Brinson Creek from Camp Geiger to the railroad. Wetlands along the tributary are classified as palustrine, forested, broad-leaved, deciduous (PF01) and wetlands at the confluence of Brinson Creek and the New River are classified as palustrine, forested, evergreen (PFO7). Wetlands of various classification are also identified along the New River.

Site-specific wetland delineations were not conducted at the areas adjacent to Site 35 including Site 35, although potential wetland areas were noted during the habitat evaluation. These wetlands are illustrated on the biohabitat map.

3.10.2 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 may be protected in the future.

Surveys have been conducted to identify threatened and endangered species at Camp Lejeune and several programs are underway to manage and protect them. Of these protected species present at the base, the red-cockaded woodpecker (Picoides borealis), American alligator (Alligator Missippiensis), and sea turtles are all covered by specific protection programs (Table 3-5).

The red-cockaded woodpecker requires a specific habitat in mature, living longleaf or loblolly pine trees. The birds live in family groups and young are raised cooperatively. At Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Research on the bird at Camp Lejeune began in 1985 and information has been collected to determine home ranges, population size and composition, reproductive success, and habitat use. An annual roost survey is conducted and 36 colonies of birds have been located.

The American alligator is considered endangered in the northern-most part of its range, which includes North Carolina. It is found in freshwater, estuarine, and saltwater wetlands in Camp Lejeune and base wetlands are maintained and protected to protect alligators. Signs have been erected where alligators are known to live. Annual surveys of Wallace, Southwest, French, Duck, Mill, and Stone Creeks have been conducted since 1977 to identify alligators and their habitats on base.

Two protected sea turtles, the Atlantic loggerhead (Caretta carreta) and Atlantic green turtle (Chelonia mydas), nest on Onslow Beach at Camp Lejeune. The green turtle was found nesting in 1980; the sighting was the first time the species was observed nesting north of Georgia. The turtle returned to nest in 1985. Turtle nests on the beach are surveyed and protected, turtles are tagged, and annual turtle status reports are issued.

Four bird species, black skimmer (Rynchops niger), piping plover (Charadrius melodus), Bachmans sparrow (Aimophila aestialis), and peregrine falcon (Falco peregriaus) have also been identified during surveys at Camp Lejeune. The black skimmer and piping plover are sea and shore birds, respectively. Skimmers nest on low sandy islands and sand bars along the coast and piping plovers prefer beaches with broad open sandy flats above the high tide line. Skimmers feed above open water and piping plovers feed along the edge of incoming waves. Like the black skimmer and piping plover, Bachmans sparrows are very specific in their habitat requirements. They live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout southern Camp Lejeune.

In addition to the protected species that breed or forage at Camp Lejeune, several protected whales migrate through the coastal waters off the base during spring and fall. These include the Atlantic right whale (Eubalaena glacialis), finback whale (Balaenoptera physalus), sei whale (Balaehoptera berealis), and sperm whale (Physeter Catodon). 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.

An Endangered Species and Special-Interest Communities Survey was conducted at Camp Lejeune (LeBlond, 1991) to identify threatened or endangered plants and areas of significant natural interest. From this list, the Rough-leaf loosestrife was the only federally threatened or endangered plant species found on the Marine Corps Base. In addition, several state endangered or threatened and federal and state candidate species were found on the MCB. The results of this survey are included in Appendix P. Previous survey results and maps of locations where protected species have been identified were consulted to produce the biohabitat maps.

With the exception of the American Alligator, no endangered species have been recorded or are expected to occur at Site 35. An alligator was observed in Brinson Creek during site investigation activities.

3.10.3 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 for MCB Camp Lejeune. These sensitive environments and their presence or absence at Site 35 is discussed below.

- Marine Sanctuary - Site 35 is not located within a Marine Sanctuary (NCMFC, 1992).
- National Park - Site 35 is not located within a National Park (NPS, 1991).
- Designated Federal Wilderness Area - Site 35 is not located within a Designated Federal Wilderness Area (WS, 1989).
- 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). The waters (not shoreline) of Brinson Creek are considered a Public Trust Area and as such are considered an Area of Environmental Concern that is under the jurisdiction of CAMA.
- Sensitive Areas Identified under the National Estuary Program (NEP) or Near Coastal Waters Program (NCWP) - Site 35 is not located within a Sensitive Area identified under the NEP or NCWP (USEPA, 1993).
- Critical Areas Identified under the Clean Lakes Program - Site 35 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1991).
- National Monument - Sites 35 is not located near a National Monument (NPS, 1991).
- National Seashore Recreational Area - Site 35 is not located within a National Seashore Recreational Area (NPS, 1991).
- National Lakeshore Recreational Area - Site 35 is not located within a National Lakeshore Recreational Area (NPS, 1991).
- National Preserve - Site 35 is not located within a National Preserve (NPS, 1991).
- National or State Wildlife Refuge - Site 35 is not located within a National or State Wildlife Refuge (NCWRC, 1992).
- Unit of the Coastal Barrier Resource Program - Site 35 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 35 is not located within an Administratively Proposed Federal Wilderness Area (WS, 1989, 1993).

- Spawning Areas Critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters - Due to size restrictions, no critical spawning areas have been identified within the reach of Brinson Creek studied in this investigation (USMC, 1993). No specific spawning areas critical for the maintenance of fish/shellfish species in Brinson Creek have been designated as such by state agencies (NC DEHNR, 1993).

- Migratory pathways and feeding areas critical for maintenance of anadromous fish species within river reaches or areas in lakes or coastal tidal waters in which fish spend extended periods of time - Surface waters associated with Site 35 are not migratory pathways or feeding areas critical for the maintenance of an anadromous fish species because there is not a significant population of anadromous fish in Brinson Creek (USMC, 1993).

- National river reach designated as Recreational - The New River and Brinson Creek are not designated as National Recreational Rivers (NPS, 1990, 1993).

- Federal designated Scenic or Wild River - The New River and Brinson Creek are not Federally designated Scenic or Wild Rivers (NPS, 1990, 1993).

- State land designated for wildlife or game management - Site 35 is not located within a State game land (NCWRC, 1992).

- State designated Scenic or Wild River - The New River and Brinson Creek are not State designated Scenic or Wild Rivers (NCMFC, 1992).

- State designated Natural Area - Site 35 is not located within a State designated Natural Area or Area of Significant Value (LeBlond, 1991).

- State designated areas for protection or maintenance of aquatic life - No areas within the boundaries of Site 35 are designated as primary nursery areas or are unique or special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses (NC DEHNR, 1993).

- Areas of Significant Value - Site 35 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 35 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

3.11 Identification of Water Supply Wells

Water supply wells within a one-mile radius of Site 35 are illustrated on Figure 3-10. Supply well information was obtained in "USGS Water Resources Investigation Report 89-4096" (Harned, et al., 1989). As shown on Table 3-4, 17 wells were identified within one mile of the site. Information was not available for many of the wells, however, enough was available to formulate the following conclusions. Nine of the wells were installed in 1941 and 1942, two were estimated to have been installed in the 1950s, three were installed in the 1970s, one was installed in 1980 and two wells did not indicate the dates in which they were installed. The total depth of the wells range from 67 to 477 feet based on the available information. Screen depths range from 25 to 120 feet with some wells having multiple screens with varying lengths.

Figures 3-7 and 3-8 indicate that local groundwater flow (shallow and deep) is towards Brinson Creek. Figure 3-10 indicates that none of the supply wells that surround Site 35 are downgradient of contaminant plume. The closest of these is 1,320 feet to the north. Given the location and distance of these wells in relationship to Site 35 and local geological/hydrogeological conditions, it is unlikely that contaminants present at Site 35 would migrate to these supply wells and impact the quality of the drinking water.

SECTION 3.0 REFERENCES

SECTION 3.0 REFERENCES

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SECTION 3.0 TABLES

TABLE 3-1

CLIMATIC DATA SUMMARY FOR MCAS NEW RIVER
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

	Temperature (Celsius)			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	4.2	76	54	34	44	11	2	0	1	14
February	7.0	1.5	3.8	74	57	36	46	9	3	0	1	11
March	8.0	0.8	3.5	78	64	42	53	10	2	0	5	7
April	6.5	0.5	3.0	79	73	51	62	8	2	--	14	--
May	8.4	1.7	4.3	86	80	60	70	10	3	2	25	0
June	11.8	2.4	5.8	85	85	67	76	11	4	6	19	0
July	14.3	4.5	8.0	85	88	72	80	14	5	12	31	0
August	12.6	1.7	6.1	87	87	71	80	12	4	11	31	0
September	12.2	1.4	4.7	87	83	66	75	9	3	3	27	0
October	6.5	0.7	2.8	82	74	54	64	7	2	--	16	--
November	5.7	0.6	2.6	80	66	44	55	7	1	0	6	4
December	6.1	0.4	4.0	77	58	37	48	9	2	0	2	11
Annual	14.3	0.4	52.8	81	72	53	63	117	33	34	188	47

Notes: -- Less than 0.5 days
" - inches

Source: Naval Oceanography Command Detachment, Asheville, North Carolina. Measurements obtained from January 1955 to December 1982.

TABLE 3-2

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

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

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

Source: USGS, 1989.

TABLE 3-3

SUMMARY OF HYDRAULIC CONDUCTIVITY TESTS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB, CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	Hydraulic Conductivity Falling Head Test		Hydraulic Conductivity Rising Head Test	
	ft/day	cm/sec	ft/day	cm/sec
35MW-30A	1.18	4.16×10^{-4}	1.50	5.31×10^{-4}
35MW-31A	0.346	1.22×10^{-4}	0.269	9.51×10^{-5}
35MW-35A	0.119	4.20×10^{-5}	0.115	4.06×10^{-5}
35MW-32B	6.22	2.20×10^{-3}	5.15	1.82×10^{-3}
35-MW36B	2.91	1.03×10^{-3}	3.20	1.13×10^{-3}
35MW-37B	7.06	2.49×10^{-3}	6.44	2.27×10^{-3}
35GWD-1	6.80	2.40×10^{-3}	6.03	2.13×10^{-3}

Average Hydraulic Conductivity for shallow wells:
0.628 ft/day (2.22×10^{-4} cm/sec)

Average Hydraulic Conductivity for intermediate wells:
5.16 ft/day (1.82×10^{-3} cm/sec)

Notes: Hydraulic conductivity test results were analyzed using Bouwer and Rice method as presented in the Geraghty and Miller "AQTESOLV" program, version 1.10.

Hydraulic conductivity tests were conducted on September 28 and 29, 1994, using an In-Situ Environmental Data Logger (Model SE-1000C) and pressure transducer.

Monitoring wells with an "A" or "B" designation indicate wells completed within the shallow aquifer at shallow and intermediate depths, respectively. The well with "GWD" designation was completed in the upper-most portion of the Castle Hayne Aquifer.

Falling Head Test data was not used in the calculation of the average hydraulic conductivity for shallow wells. Falling Head Tests are inappropriate for wells that have screens that split the water table.

TABLE 3-4

SUMMARY OF WATER SUPPLY WELLS WITHIN A ONE-MILE RADIUS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Well No.	USGS Identification Number	Date Drilled	Drilling Company	Screen Depth (feet)	Screen Depth (feet)	Approximate Distance and Direction from Site (feet)
MCAS-203	3443230772653.1	--	--	173	--	4620/South
MCAS-106	3443260772701.1	1954 (est.)	--	--	--	4290/South
TC-1251	3443290772710.1	1975	Carolina Well and Pump Co.	240	120-140 160-170	4290/South-Southwest
TC-1253	3443370772729.1	1975	Carolina Well and Pump Co.	250	120-135 155-170	4290/Southwest
MCAS-1254	--	--	--	--	--	5280/Southwest
TC-901	3443450772727.1	1941	Layne Atlantic Co.	77	46-56 66-76	3465/Southwest
TC-700⁽¹⁾	3443560772727.1	1941	--	76	27.5-76	2970/West-Southwest
TC-504	3444090772804.1	1942	Layne Atlantic Co.	113	50-60 75-85	5280/West
TC-600	344405077728.1	1941	Layne Atlantic Co.	70	48-70	2640/West
NC-52⁽¹⁾	3444180772729.1	1941	Layne Atlantic Co.	70	25-66	2640/West
TC-502⁽¹⁾	3444070772728.1	1941	Virginia Machine and Well Co.	182	110-184	2640/West-Northwest
T-15⁽¹⁾	3444250772707.1	1959	Heater Well Co.	477	--	1320/North
X-25616⁽¹⁾	3444350772640.1	1978	NC Division of Environmental Mgmt.	185	--	2970/North-Northeast
TC-100⁽¹⁾	3444280772729.1	1941	Layne Atlantic Co.	67	--	3300/Northwest
TC-104⁽¹⁾	3444300772729.1	1941	Virginia Machine and Well Co.	182	107-182	3300/Northwest
TC-202	3444120772755.1	1942	--	80	35-40 45-50 55-60 65-70 75-80	3300/Northwest
TC-325	3444120772755.2	1980	Carolina Well and Pump Co.	--	--	4620/West

Notes: (1) Wells are listed as open hole wells according to the U. S. Geological Survey, Water Resources Investigations Report 89-4096.
-- No data was available.
est. - estimated

Source: According to U. S. Geological Survey, Water Resources Investigations Report 89-4096.

TABLE 3-5

PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

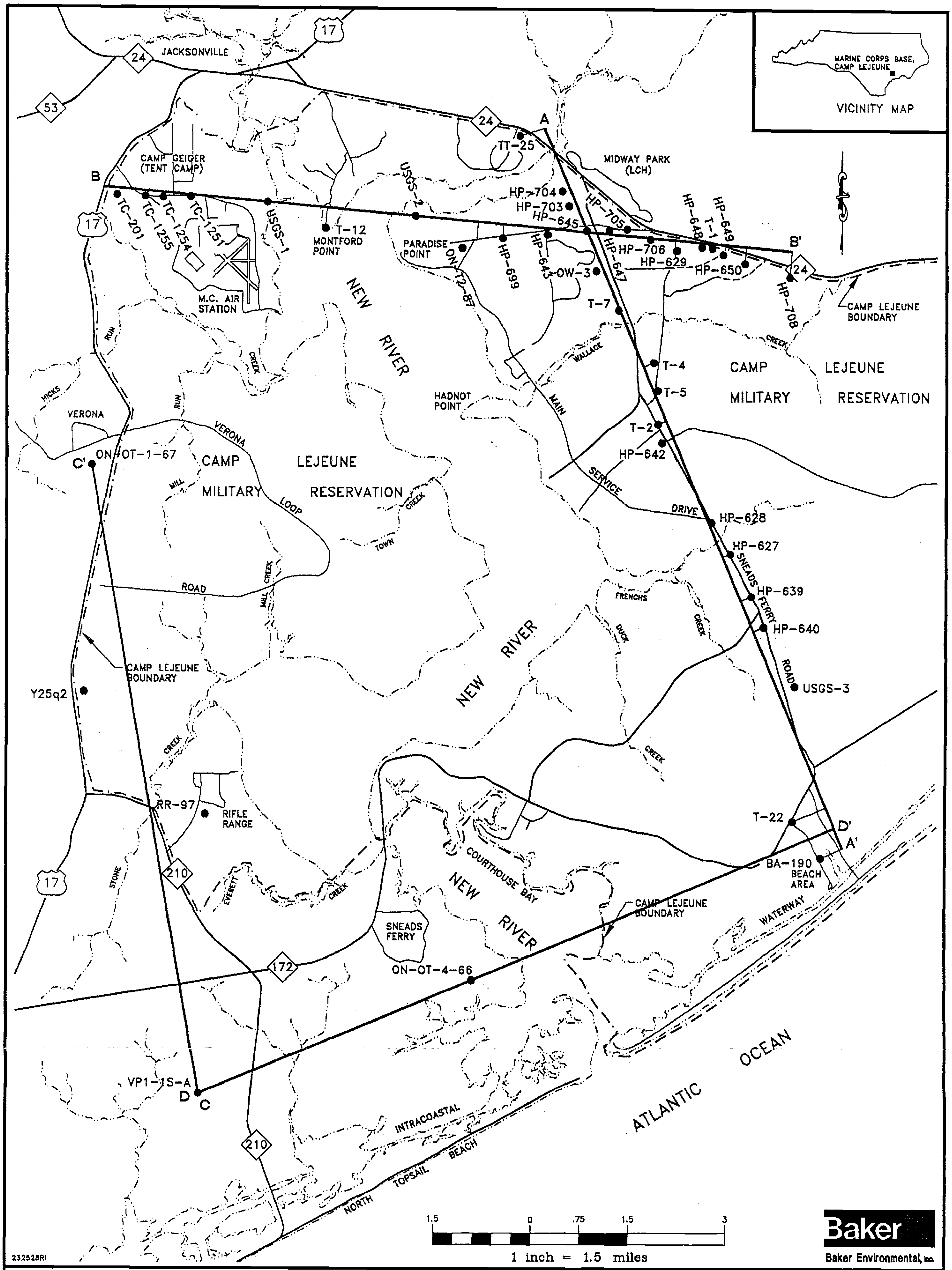
Species	Protected Classification
American alligator (Alligator mississippienis) (2)	T(f), T(s)
Bachmans sparrow (Aimophilia aestivalis)(1)	SC
Black skimmer (Rhynochops niger)(1)	SC
Green (Atlantic) turtle (Chelonia m. mydas) (2)	T(f), T(s)
Loggerhead turtle (Caretta caretta) (2)	T(f), T(s)
Peregrine 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

SECTION 3.0 FIGURES

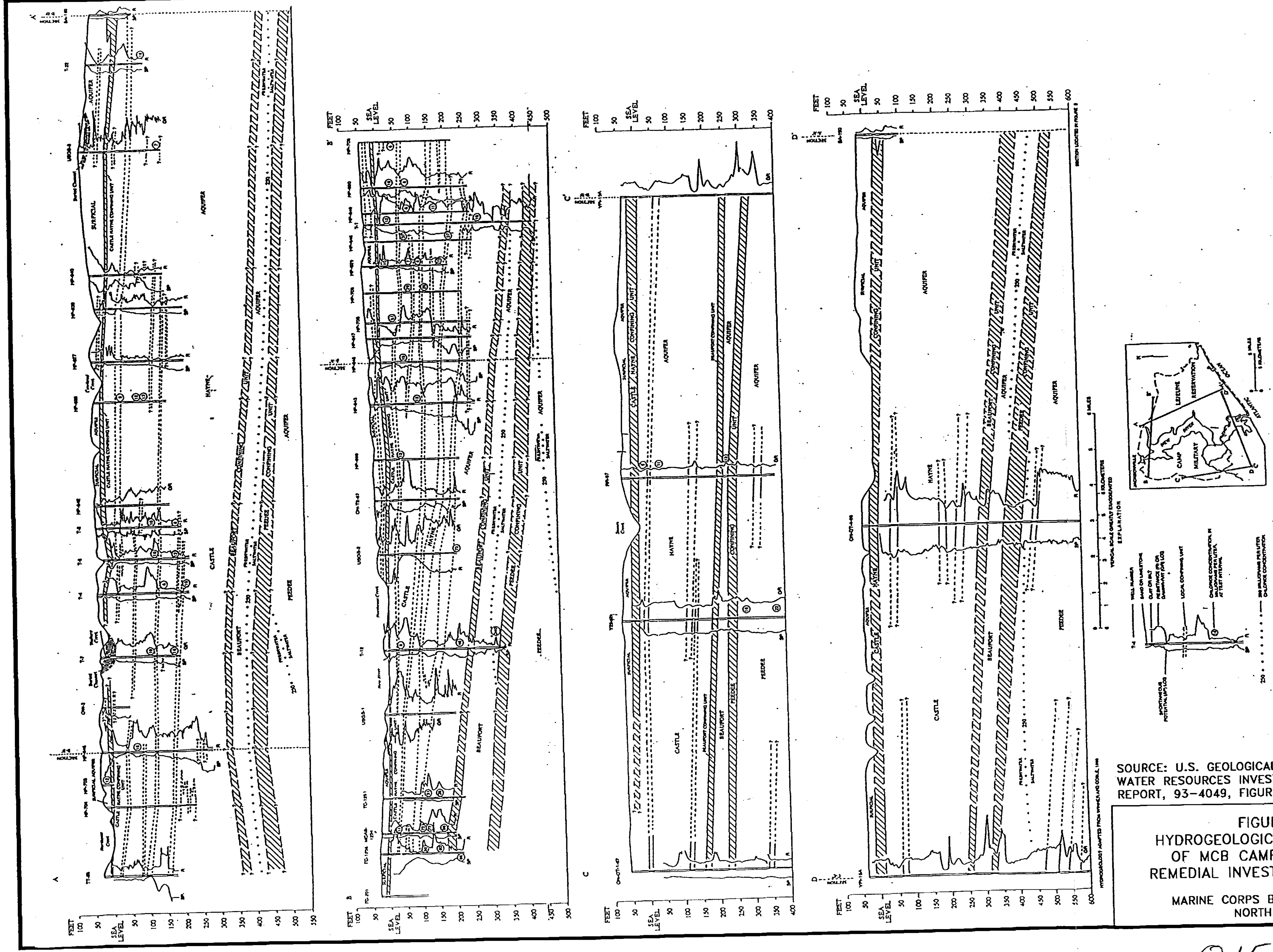


SOURCE: U.S. GEOLOGICAL SURVEY, WATER-RESOURCES INVESTIGATIONS REPORT, 93-4049, FIGURE 9

FIGURE 3-1
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0232

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

232530R1

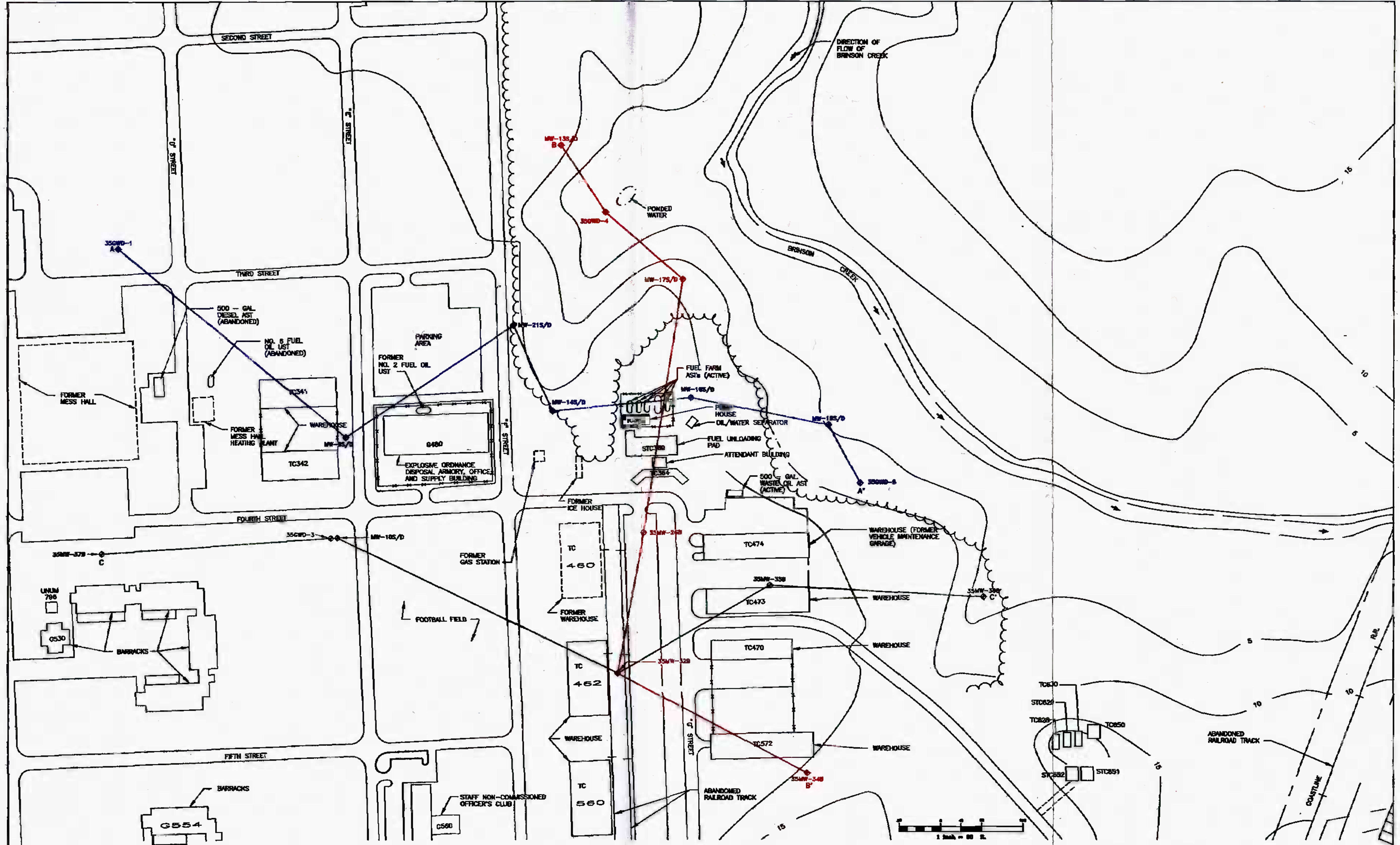


SOURCE: U.S. GEOLOGICAL SURVEY, WATER RESOURCES INVESTIGATIONS REPORT, 93-4049, FIGURE 9

FIGURE 3-2
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB CAMP LEJEUNE AREA
REMEDIAL INVESTIGATION CTO-0232

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01539U062



LEGEND

-x-x- - FENCE LINE

—15— - CONTOUR LINES DEPICTING SURFICIAL RELIEF

35GWD-5 ◆ - MONITORING WELL LOCATION AND DESCRIPTION

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	2325129I

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

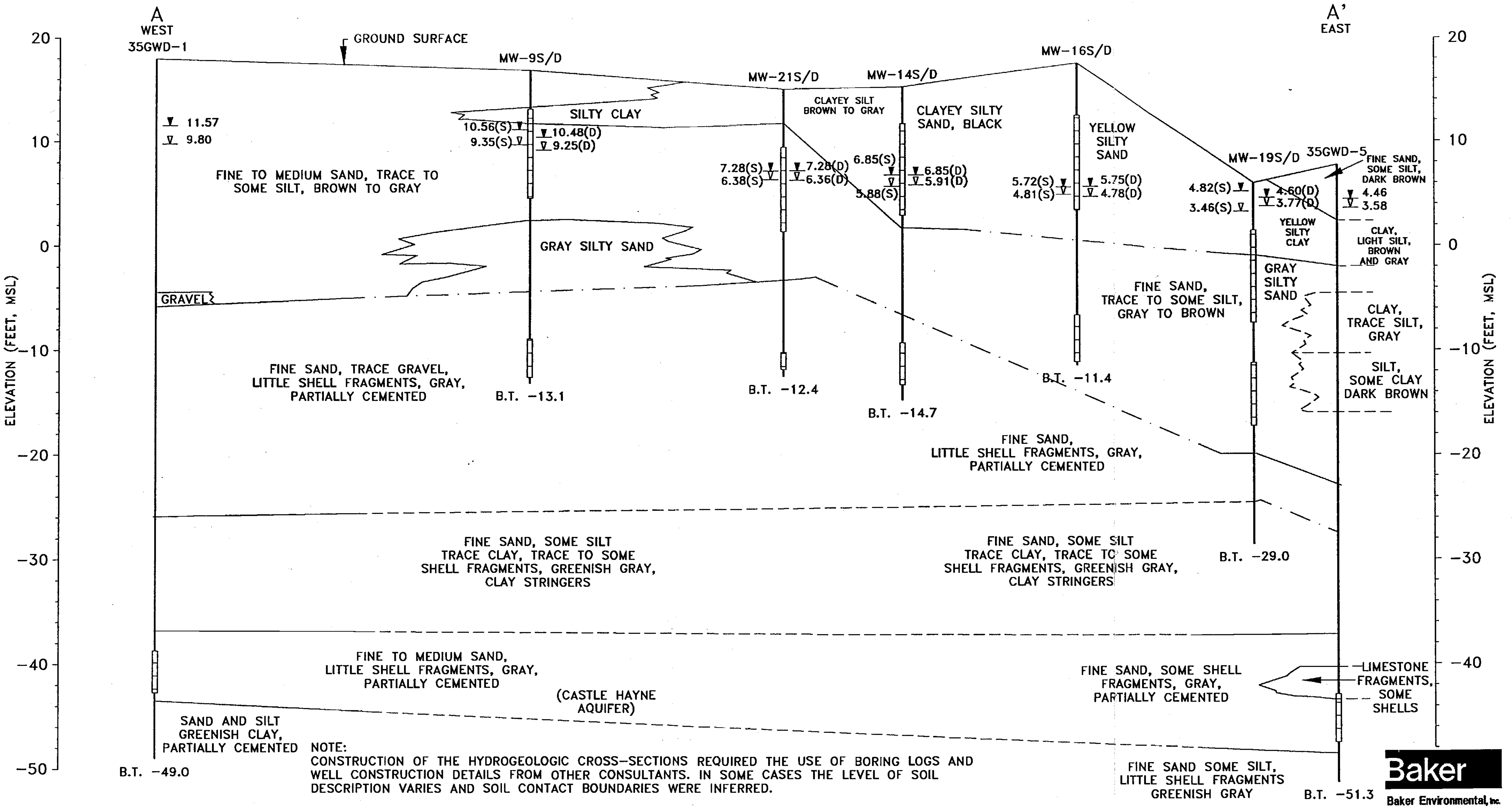
CROSS-SECTION LOCATIONS AT SITE 35
CONTRACT TASK ORDER - 0232

SCALE	1" = 80'
DATE	SEPT. 1994

FIGURE No.
3-3

015391107V

212513RI



NOTE:
CONSTRUCTION OF THE HYDROGEOLOGIC CROSS-SECTIONS REQUIRED THE USE OF BORING LOGS AND WELL CONSTRUCTION DETAILS FROM OTHER CONSULTANTS. IN SOME CASES THE LEVEL OF SOIL DESCRIPTION VARIES AND SOIL CONTACT BOUNDARIES WERE INFERRED.

Baker
Baker Environmental, Inc.

LEGEND

▼10.48 GROUNDWATER ELEVATION COLLECTED ON 9-9-94 (MSL)
▽9.25 GROUNDWATER ELEVATION COLLECTED ON 7-20-94 (MSL)
B.T. -49.0' BORING TERMINATED, ELEVATION MSL
▯ WELL SCREEN INTERVAL
— · — INFERRED SOIL CONTACT
——— ESTIMATED SOIL CONTACT
— — — PROJECTED SOIL CONTACT

160 0 80 160 320
Horizontal Scale: 1 inch = 160 ft.

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

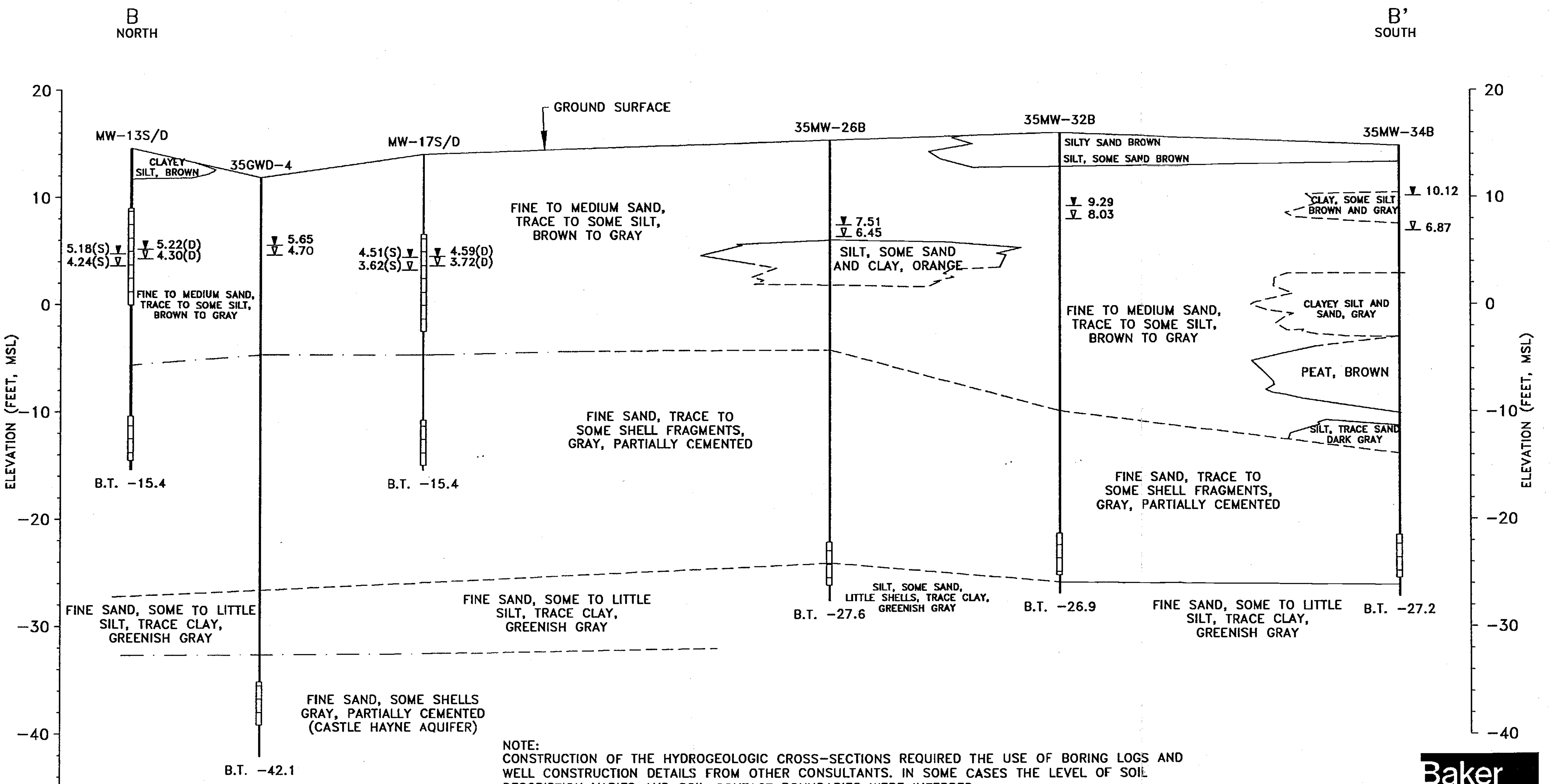
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-4
HYDROGEOLOGIC CROSS-SECTION A-A'
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER 0232

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01539UB4Z

232514RI



NOTE:
CONSTRUCTION OF THE HYDROGEOLOGIC CROSS-SECTIONS REQUIRED THE USE OF BORING LOGS AND WELL CONSTRUCTION DETAILS FROM OTHER CONSULTANTS. IN SOME CASES THE LEVEL OF SOIL DESCRIPTION VARIES AND SOIL CONTACT BOUNDARIES WERE INFERRED.

Baker
Baker Environmental, Inc.

LEGEND

▼ 5.22	GROUNDWATER ELEVATION COLLECTED ON 9-9-94 (MSL)
▽ 4.30	GROUNDWATER ELEVATION COLLECTED ON 7-20-94 (MSL)
B.T. -42.1'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
— · —	INFERRED SOIL CONTACT
———	ESTIMATED SOIL CONTACT
— — —	PROJECTED SOIL CONTACT

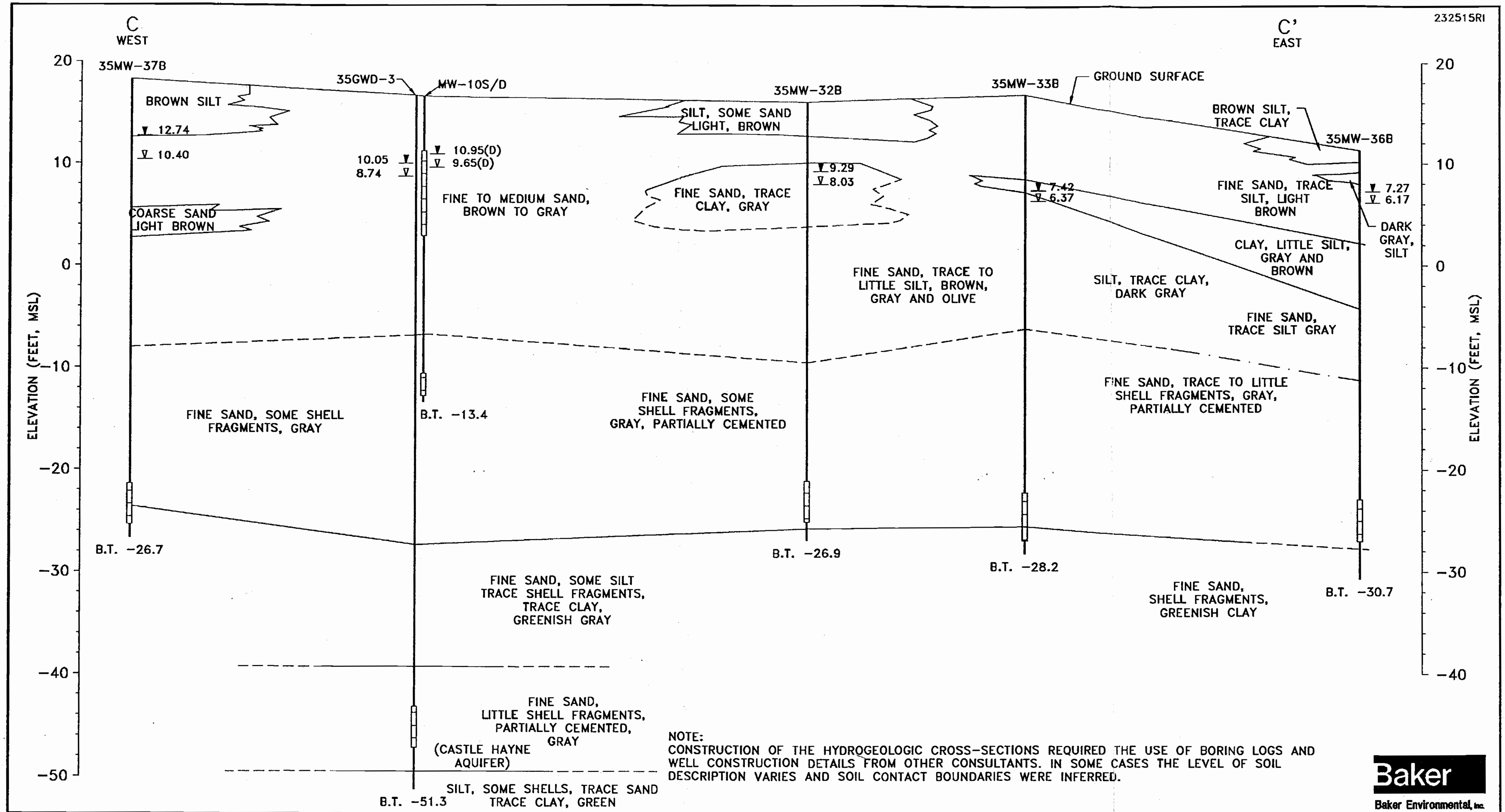
130 0 65 130 260
Horizontal Scale: 1 inch = 130 ft.

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

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

FIGURE 3-5
HYDROGEOLOGIC CROSS-SECTION B-B'
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER - 0232

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



NOTE:
CONSTRUCTION OF THE HYDROGEOLOGIC CROSS-SECTIONS REQUIRED THE USE OF BORING LOGS AND WELL CONSTRUCTION DETAILS FROM OTHER CONSULTANTS. IN SOME CASES THE LEVEL OF SOIL DESCRIPTION VARIES AND SOIL CONTACT BOUNDARIES WERE INFERRED.

Baker
Baker Environmental, Inc.

LEGEND

▼ 12.74	GROUNDWATER ELEVATION COLLECTED ON 9-9-94 (MSL)
▽ 10.40	GROUNDWATER ELEVATION COLLECTED ON 7-20-94 (MSL)
B.T. -26.7'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
— · —	INFERRED SOIL CONTACT
———	ESTIMATED SOIL CONTACT
— — —	PROJECTED SOIL CONTACT

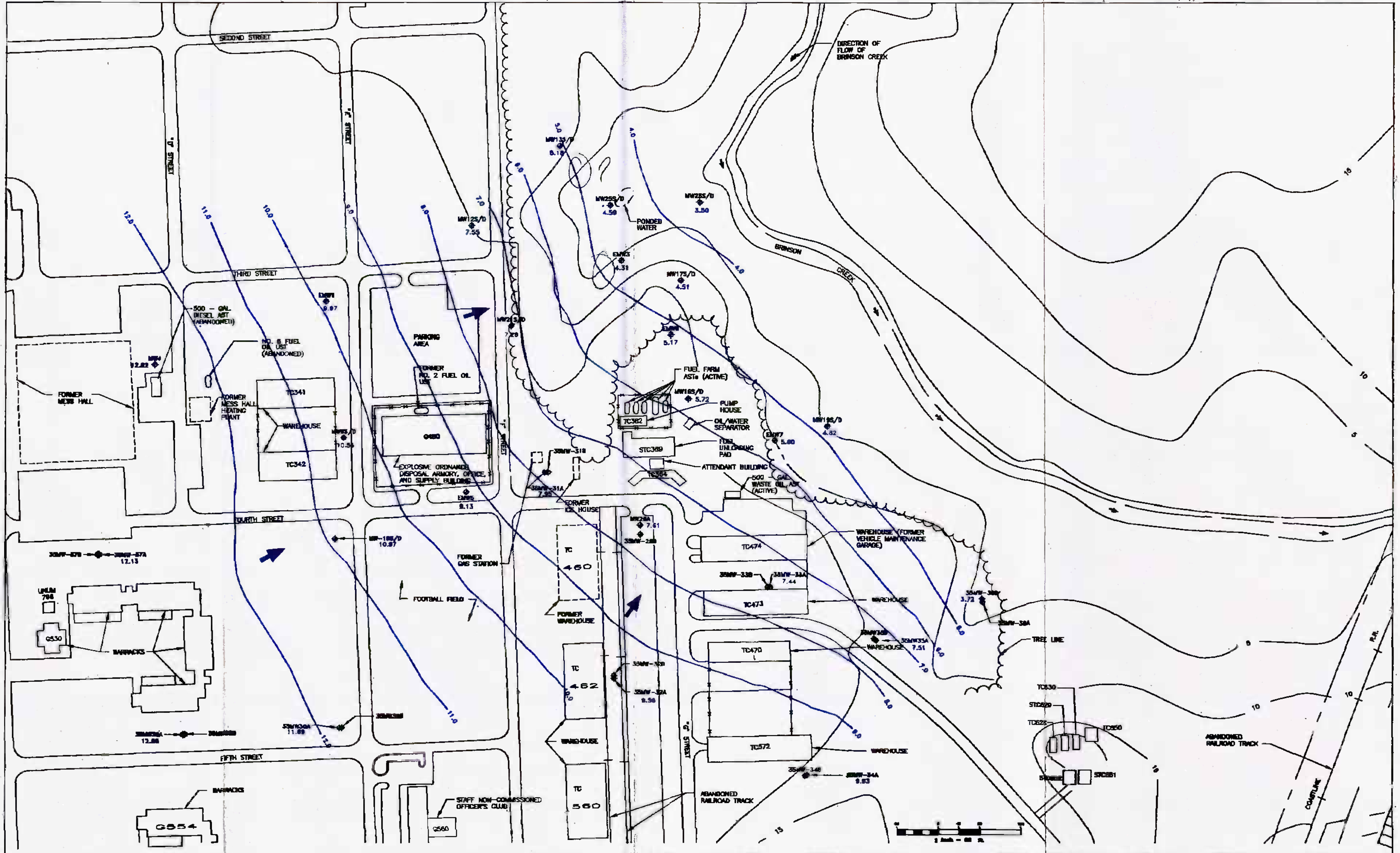
160 0 80 160 320
Horizontal Scale: 1 inch = 160 ft.

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

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

FIGURE 3-6
HYDROGEOLOGIC CROSS-SECTION C-C'
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER - 0232

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND	
◆◆	- FENCE LINE
—15—	- CONTOUR LINES DEPICTING SURFICIAL RELIEF
MW19S/D ◆ 4.82	- MONITORING WELL LOCATION AND DESCRIPTION (MEASURED STATIC WATER LEVEL IN BLUE)
—11.0—	- GROUNDWATER CONTOUR
→	- INDICATES DIRECTION OF GROUNDWATER FLOW

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	W.M
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	232323RI

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

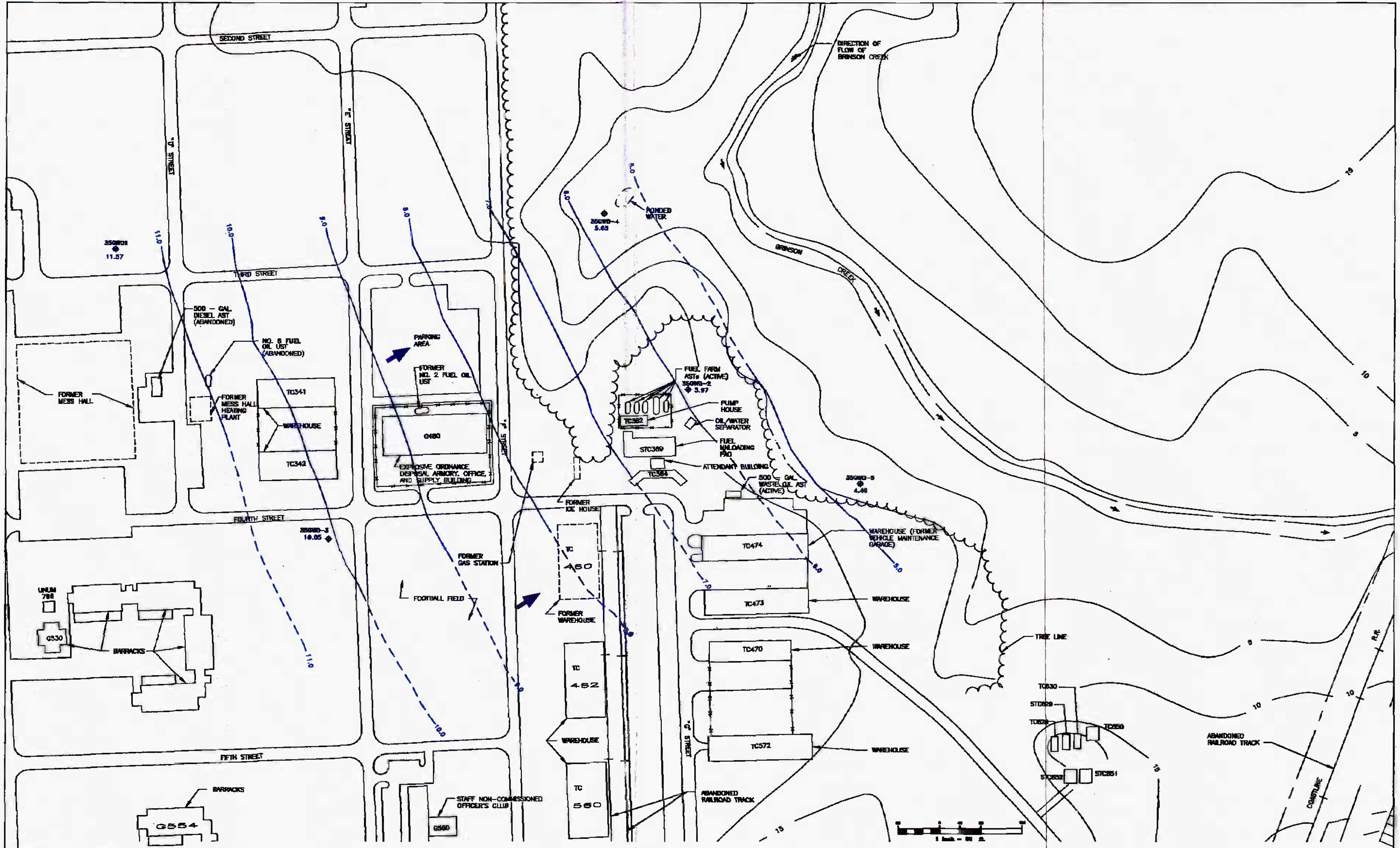
Baker
Baker Environmental, Inc.

GROUNDWATER CONTOUR MAP DEPICTING
FLOW IN THE SURFICIAL AQUIFER
CONTRACT TASK ORDER - 0232

SCALE 1" = 80'
DATE OCT. 1994

FIGURE No.
3-7

01539UB5Y



LEGEND

- ✱✱ – FENCE LINE
- 15 – CONTOUR LINES DEPICTING SURFICIAL RELIEF
- ◆ 35GWD-5 – MONITORING WELL LOCATION AND DESCRIPTION
- —11.0— – GROUNDWATER CONTOUR
- - -11.0- - – INFERRED GROUNDWATER CONTOUR
- ➔ – INDICATES DIRECTION OF GROUNDWATER FLOW

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	W.H
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	2325108

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

GROUNDWATER CONTOUR MAP DEPICTING FLOW IN THE UPPER-MOST PORTION OF THE CASTLE HAYNE AQUIFER
CONTRACT TASK ORDER – 0232

SCALE 1"= 80'
DATE OCT. 1994

FIGURE No.
3-8

SOURCE OF BASE MAPPING: LANTDIV, 1991

LEGEND

35-SW/SD01 X - SAMPLE LOCATION FOR SURFACE WATER AND SEDIMENT
▨ - LOBLOLLY PINE/HARDWOOD FOREST
▨ - PALUSTRINE FORESTED DECIDUOUS WETLAND (PFO6)
▤ - OPEN FIELD
▨ - PALUSTRINE FORESTED EVERGREEN WETLAND (PFO7118)
▤ - OPEN BARREN AREA
▥ - PALUSTRINE FORESTED WETLAND (PFO1)
☐ - INDUSTRIAL AREA, RAIL LINE
⬭ - WATER BOUNDARY

DATE	OCT. 1994
SCALE	1" = 300'
DRAWN	W.J.H
REVIEWED	JSC
E.O.#	62470-232-0000-07000
CAD#	2320x405

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

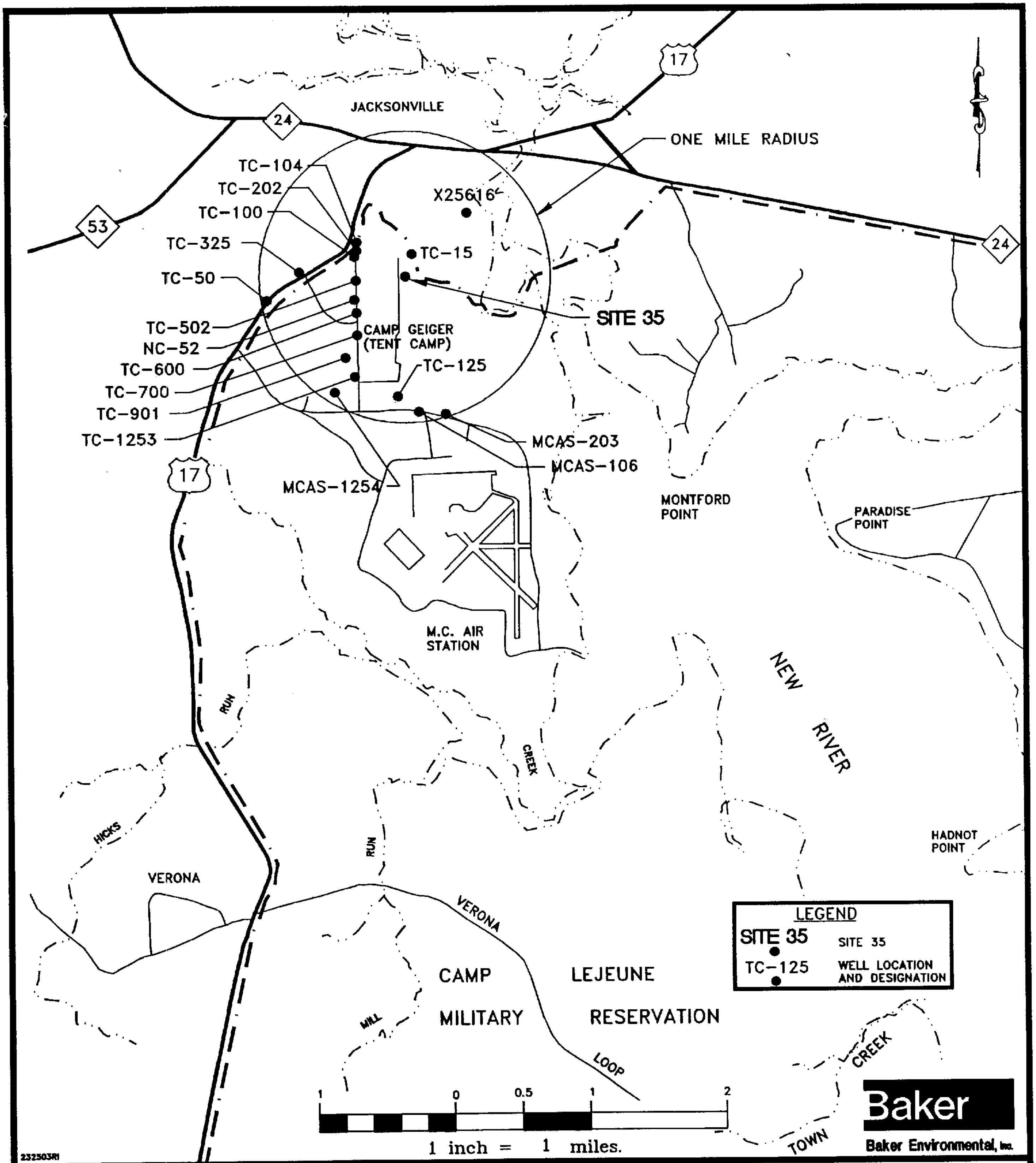
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

BIOHABITAT MAP
SITE 35 AND VICINITY
CONTRACT TASK ORDER - 0232

SCALE 1" = 300'
DATE OCT. 1994

SHEET NO.
3-9



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

FIGURE 3-10
SUPPLY WELL LOCATION MAP
SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
CONTRACT TASK ORDER 0232

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the analytical findings of the RI and a discussion of the nature and extent of contamination for the various media (soil, groundwater, sediment, surface water and fish tissue).

Analytical parameters can be segregated into two broad categories: organics and inorganics. The organic parameters included in the analytical program do not occur naturally. Therefore, any organics detected in the samples collected from the site can be attributed to either contamination at the site or to sampling/laboratory contamination. However, many of the inorganic parameters included in the analytical program can occur naturally. For example, lead is an element that occurs naturally in most soils in low concentrations but is considered a contaminant if its concentration is well above background levels or its presence can be attributed to site operations. In order to accurately present the nature and extent of contamination, the detected parameters that are either common laboratory contaminants (organics) or are naturally occurring on site (inorganics) must be segregated from those that can be attributed to site or off-site activities.

Third party validation was performed on the complete set of data received from the analytical laboratory. The validation procedures followed the National Functional Guidelines for Organic and Inorganic Analyses. Data validation serves to reduce some of the inherent uncertainty associated with the analytical data by establishing the usability of the data. Data qualified as "J" (estimated) were retained as valid data for the site. Data can be qualified as estimated for many reasons including a slight exceedance of holding times, high or low surrogate recovery, or if the reported value is below the Contract Required Detection Limit (CRDL) or Contract Required Quantitation Limit (CRQL), or intrasample variability. Organic data qualified "B" (detected in blank) or "R" (rejected) were not included in the analytical database due to the unusable nature of the data. Due to the comprehensive sampling and analytical program at the site, the loss of some data points qualified "B" or "R" did not significantly effect the overall quality of the analytical database, or the RI conclusions.

A discussion of non-site related analytical results is presented in Section 4.1 and site related results are presented in Section 4.2. Section 4.3 discusses the extent of contamination at the site.

4.1 Non-Site Related Analytical Results

Many of the organic compounds and inorganic constituents detected in the various environmental media investigations at Site 35 are attributable to non-site related conditions. Two primary sources of non-site related results include laboratory (blank) contaminants and naturally occurring inorganic elements. Non-site related results for the site are discussed below.

4.1.1 Laboratory Contaminants

Blank samples 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 the blanks were compared to 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, 1989b). The maximum concentrations of detected common laboratory contaminants in blanks were as follows:

		10x
Acetone	43J µg/L	430
Methylene Chloride	5J µg/L	50
Toluene	0.6 µg/L	6
bis-(2-Ethylhexyl)phthalate	56 µg/L	560

Blanks containing organic constituents that were not considered common laboratory contaminants (i.e., all other TCL compounds) were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds at 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:

		5x
Chloroform	8.0 µg/L	40
Methoxychlor	0.5J µg/L	2.5
Endrin Aldehyde	0.11J µg/L	.55
Total Xylenes	1.4 µg/L	7.0

All detected "phthalates" were not included as detectable concentrations at site-related contaminants. They were deemed attributed to field/laboratory contamination resulting from handling and decontaminating equipment. These compounds can originate from protective gloves, plastic bottles with, decontamination solutions, etc. As discussed in the CLP SOW for Organics and the Functional Guidelines for Organics acetone, 2-butanone, methylene chloride, toluene and phthalate esters are considered by EPA to be common laboratory contaminants (USEPA, 1989).

4.1.2 Naturally Occurring Inorganic Elements

In order to delineate inorganic contamination due to site operations from inorganic elements naturally occurring in site media, the results of the sample analyses (concentrations) were compared to information regarding background conditions. The following guidelines were used for each media:

Soil:	MCB Camp Lejeune Background Samples (Table 4-5)
Groundwater:	Site and Base Background Samples (Appendix AA)
Surface Water:	Off-Base Reference Stations (White Oak River Basin) (Appendix S)
Sediment:	Off-Base Reference Stations (White Oak River Basin) (Appendix S)

Base-specific background concentrations in soil were compiled to evaluate background levels of organic and inorganic constituents in the surface and subsurface soil. Organic contaminants were not detected in the base-specific background samples. Therefore, it is likely that all organic contaminants detected in the surface and subsurface soil, within OU No. 10, are attributable to the practices which have or are currently taking place within the areas of concern.

Monitoring wells located upgradient of Site 35 provide groundwater data to assess background conditions in groundwater. Background wells are often installed to assess the natural state or quality of groundwater. Natural in this sense implies that the groundwater has not been altered due to human activity. In some cases, these monitoring wells provide data that is representative of naturally occurring conditions. In other cases, these wells may not be representative of naturally occurring conditions if other base-related activities have altered the natural state of groundwater. In the latter case, these wells would produce "control" samples. Control samples are samples which may not represent background conditions, but represent the current state of groundwater quality upgradient of the site. During the past four years, a number of background wells have been installed throughout the base as part of individual site investigations. Most of the background wells installed throughout the base produce control samples. The data collected from these wells have generated data that is representative of "base-wide" groundwater quality.

Many of the inorganics detected in groundwater are naturally occurring in the environment. These inorganics include aluminum, arsenic, barium, cadmium, calcium, copper, iron, magnesium, manganese, nickel, vanadium, and zinc. In order to determine whether the inorganic constituent detected in groundwater is elevated due to site activities, it is important to compare the concentrations with background wells, literature values, and Federal and State groundwater standards. However, in some cases, inorganic constituents such as iron and manganese may exceed Federal or State standards under natural conditions. When this occurs, it is important to determine whether the elevated concentrations are due to a source, such as buried debris or contaminated soil. Without a correlation to a source, the presence of the inorganic constituent may be due to the natural state of the groundwater.

In some cases, elevated inorganics in groundwater (or surface water) could be due to the presence of suspended particulates in the samples. At MCB Camp Lejeune, shallow groundwater has exhibited elevated total metals at practically every site investigated. On the other hand, elevated total metals in deep groundwater are rarely encountered with the exception of iron and manganese, which are believed to be naturally occurring in the environment throughout the region. The reason for this difference is related to the amount of suspended particulates in the samples which contain inorganic compounds. As the preservative is added to a sample with suspended solids, the inorganics leach out of the sediment and into the water biasing the analysis high. Samples collected from the shallow aquifer are believed to contain more suspended solids due to the loosely compacted soils in the shallow aquifer. Samples collected from the deep aquifer, using the same sampling techniques, do not contain a significant amount of suspended particulates due to the different geology of the deeper aquifer.

In order to assess whether inorganic constituents in surface water or sediments are elevated due to site activities, background surface water and sediment quality were determined. In this case, samples were collected upstream of the site as well as off base. Upstream samples in some cases may be impacted to some degree from other activities such as runoff from highways or other human or industrial activities (e.g., NPDES outfall). Surface water data from upstream sampling locations can be compared to downstream data in order to assess whether site activities have changed the quality of the surface water or sediments.

The samples collected off base were collected from the White Oak River and its tributaries (Hadnot Creek). This river basin was recommended by the North Carolina DEHNR. Samples collected from this river basin are considered as reference data for comparison against samples collected from on base surface water. In addition to surface water and sediment, fish and benthic macroinvertebrates were collected from the White Oak River and tributaries.

Naturally occurring inorganics in surface water include the same inorganics as in groundwater mentioned previously.

4.2 Summary of Analytical Results

The following sections present a summary of site related analytical results, by media. Positive detection tables, which include only those results which were detected in the sample, are included at the end of Section 4.0. Note that these tables do not include QA/QC samples (e.g., field duplicates). A more complete summary of the analytical results, including nondetects and all QA/QC samples, is provided in the appendices (see Table of Contents).

4.2.1 Soil Investigation

This section presents a summary of contaminants observed in surface and subsurface soil collected at the site. The contaminants are divided into two categories, inorganics and organics. In addition to the results of chemical analyses, results from the engineering parameters will be summarized by each media.

Positive detection analytical summaries of organics and inorganics in surface soils are presented on Tables 4-1 and 4-2, respectively. Positive detection summaries of organics and inorganics in subsurface soils are presented on Tables 4-3 and 4-4, respectively.

4.2.1.1 Organics

Surface soil samples collected at the site were analyzed for Target Compound List (TCL) organics (volatiles, semivolatiles, pesticides and PCBs) and Target Analyte List (TAL) metals (see Sampling Summary, Appendix I). Although 14 surface soil samples were submitted to the laboratory for analysis, 35-SS14-00 was not analyzed by mistake. Subsurface soil samples were analyzed for TCL volatiles and semivolatiles and TAL metals (see Sampling Summary, Appendix I). The organics are subdivided into three categories: volatiles, semivolatiles, and pesticides/PCBs.

Volatiles

As shown on Table 4-1, surface soil (samples collected from ground surface to a depth of 12 inches) analytical results indicated the presence of volatile organics. The following summarizes the results:

- Carbon disulfide was detected in only one of 13 samples at a concentration of 33 μg/kg (35-SS07-00).
- Toluene was detected in only one of 13 samples at a concentration of 19 J μg/kg (35-SS05-00).
- Total xylenes were detected in one of 13 samples at a concentration of 43 μg/kg (35-SS13-00).

No other volatiles were detected in the surface soil samples collected at the site. However, subsurface soil analytical results, which are summarized on Table 4-3, indicate the presence of tetrachloroethene at the site. Tetrachloroethene was detected in 4 of 19 samples with concentrations ranging from 8 μg/kg (35-MW33BS-05) to 60 μg/kg (35-MW30BS-04).

Semivolatiles

SVOCs were detected in four of the 11 surface soil samples analyzed (Table 4-1). The SVOCs primarily contained polynuclear aromatic hydrocarbons (PAHs). Surface soil sample 35-SS05-00 exhibited the overall highest concentrations of PAHS. Three other samples including 35-SS04-00, 35-SS09-00, 35-SS11-00 also exhibited PAHs, but to a lesser degree.

PAHs were not prevalent in subsurface soil; however, only three subsurface soil samples were collected. Pyrene and benzo(b)fluoranthene were detected in soil boring MW35 (see Table 4-3).

Pesticides/PCBs

As shown on Table 4-1, ten surface soil samples were analyzed for pesticides/PCBs. Pesticides were detected in all ten surface soil samples, however PCBs were not detected in any of the samples collected at the site. With the exception of sample 35-SS13-00, the pesticide levels are fairly uniform as would be expected if applied for pest control.

The range of the detected concentrations and the location of the maximum (shown in parentheses) concentrations of each pesticide detected in surface soil samples collected at Site 35 are as follows:

- beta-BHC: 0.53J to 1.6J µg/kg(35-SS11-00)
- Dieldrin: 0.35J to 212 µg/kg (35-SS13-00)
- 4,4'-DDE: 1.6J to 1570 µg/kg (35-SS13-00)
- Endrin: 0.68J to 7.9 µg/kg (35-SS04-00)
- Endosulfan II: 0.42J to 2.9J (35-SS04-00)
- 4,4'-DDD: 0.56J to 3240 µg/kg (35-SS13-00)
- 4,4'-DDT: 1.6J to 262 µg/kg (35-SS09-00)
- Endrin ketone: 1.2J µg/kg (35-SS04-00)
- Endrin aldehyde: 1.6J (35-SS04-00)
- alpha-chlordane: 4.1 to 36 µg/kg (35-SS11-00)
- gamma-chlordane: 27 µg/kg (35-SS11-00)

Pesticides/PCBs were not requested for analysis on subsurface soils collected at the site since this investigation focused on BTEX and chlorinated hydrocarbons. The purpose of analyzing for pesticides/PCBs in surface soil was to assess human health and ecological risks from the site.

4.2.1.2 Inorganics

As shown on Table 4-2, 19 of 23 inorganics were detected in the surface soils collected at the site. Potassium, silver and sodium were not detected. Mercury data was rejected by the validator ("R") for every sample and zinc data for every sample but two (35-SS04-00 and 35-SS09-00). The concentration ranges of most of the inorganics detected were similar to the background ranges of surface soils at Camp Lejeune. Background soil results are provided on Table 4-5.

Nineteen of the 23 inorganics were detected in the eight subsurface soil samples collected for inorganic analysis at the site (see Table 4-4). Beryllium and sodium were the only two inorganics not detected. Detectable concentrations of mercury, antimony and all but one positive detection of zinc was rejected during data validation. The concentrations for most of the detected inorganics were similar to background concentrations in subsurface soils at Camp Lejeune. Table 4-6 summarizes background subsurface soil concentrations.

4.2.1.3 Engineering Parameters

Two soil samples (35-GWD03-04 and 35-ST01) were obtained for analysis of various engineering parameters (see Sampling Summary, Appendix I). Results of the analyses are presented in Appendix S.

Sample 35-GWD03-04 was obtained from soil boring 35GWD-3 at a depth of 6 to 8 feet bgs, at the soil/groundwater interface. Boring 35GWD-3 was drilled near the corner of Fourth and "E" Streets, an area where shallow groundwater contamination was identified in past studies and confirmed under this RI. Sample 35-GWD03-04 was analyzed for nutrient levels (i.e., nitrogen and phosphorous), Total Organic Carbon (TOC), and Total Plate Count (i.e., a measure of microbial activity) to provide data to aid, as part of the FS, in the evaluation of in-situ bioremediation. In addition, this sample was analyzed for TCLP and RCRA hazardous waste characteristics to provide data to support the disposition of soil cuttings.

Sample 35-ST01 was obtained from soil boring 35GWD-1 at a depth of 47 to 49 feet, within the suspected semi-confining layer separating the lower portion of the surficial aquifer from the upper portion of the Castle Hayne Aquifer. Various geotechnical analyses were performed on this sample including Atterberg Limits, particle-size distribution, permeability, and hydraulic conductivity to provide additional data regarding the physical characteristics of this substratum. This data is potentially useful in both the RI and FS.

Results of the Shelby Tube sample collected at soil boring location 35-GW01 indicated that the soil is composed of the following constituents:

Gravel/Coarse Sand (>2.00mm)	0.1%
Medium/fine sand (0.075 to 2.00mm)	70 - 71.5%
Silt (0.005 to 0.75mm)	20.9 - 23.4%
Clay/Colloids (<0.005mm)	6.6 - 7.6%

The constant head hydraulic conductivity was determined to be 8.2 millidarcies; the intrinsic permeability was determined to be 1830 millidarcies. The liquid and plastic limit was determined to be 0.1%.

The results of sample 35-GWD03-04 are as follows:

Reactive Cyanide	ND
TKN	50.7J mg/kg
Phosphorous	ND
Reactive Sulfide	ND
TOC	ND
Corrosivity	Non-corrosive
Ignitability	Non-ignitable
Reactivity	Non-reactive
Total Plate Count	3,980 CFU/g

4.2.2 Groundwater Investigation

Groundwater results are grouped into three distinct categories based on the screened interval of the monitoring well from which the samples were collected. The categories are: results from the upper portion of the surficial aquifer; results from the lower portion of the surficial aquifer; results from the upper portion of the Castle Hayne Aquifer. Groundwater samples collected at the site were analyzed in accordance with the FSAP (Baker, 1994) for purgeable halocarbons and purgeable aromatic hydrocarbons (EPA Methods 601/602), TCL semivolatiles, TCL pesticides/PCBs and TAL inorganics (see Sampling Summary, Appendix I). Groundwater analytical results are provided on Table 4-7 for organics, and Tables 4-8 and 4-9 for inorganics (i.e., total and dissolved).

4.2.2.1 Results from the Upper Portion of the Surficial Aquifer

The analytical results are subdivided into two categories based on analytical parameters detected in samples: organics and inorganics. One groundwater sample was obtained for the analysis of various engineering parameters.

Organics

Organics data are subdivided into three subcategories: volatile organic compounds, semivolatile organic compounds, and pesticides/PCBs.

Volatiles

Shallow groundwater samples were analyzed for volatile organic compounds primarily via EPA Method 601 and 602 (including MTBE). The range of the detected compound and the location of the maximum concentration (in parenthesis) are summarized as follows:

- 1,1,2,2-tetrachloroethane was detected in 2 of the 25 samples submitted for analysis. Concentrations were 20.5 and 64.7 μg/L (35-MW35AW-01).
- 1,1,2-trichloroethane was detected in 2 of the 25 samples analyzed. Concentrations were 1.0 and 1.9 μg/L (35-MW32AW-01).
- 1,1-dichloroethane was detected in only one of the 25 samples at a concentration of 2.5 μg/L (35-MW36AW-01).
- 1,1-dichloroethene was detected in 2 of 25 samples analyzed. Concentrations were 0.8 and 2.1 μg/L (35-MW36AW-01).
- Tetrachloroethene was detected in only one of the 25 samples at a concentration of 1.9 μg/L (35-MW35AW-01).
- Trichloroethene was detected in 8 of 25 samples ranging from 3.8 to 299 μg/L (35-MW14S-02).
- cis-1,2-dichloroethene was detected in 8 of 25 samples ranging from 14.8 to 682 μg/L (35-MW14S-02).

- trans-1,2-dichloroethene was detected in 8 of 25 samples ranging from 2.6 to 47 µg/L (35-MW14S-02).

- Benzene was detected in 15 of 25 samples ranging from 0.2 to 1660 µg/L (35-MW22S-02).

- Ethylbenzene was detected in 20 of 25 samples ranging from 0.4 to 824 µg/L (35-MW21S-02).

- MTBE was detected in 7 of 25 samples ranging from 6.6J to 92.5 µg/L (35-MW14S-02).

- Toluene was detected in 20 of 25 samples ranging from 0.3 to 984 µg/L (35-MW16S-02).

- Xylene was detected in 22 of 25 samples ranging from 0.6 to 1700 µg/L (35-MW16S-02).

Semivolatiles

Thirteen samples from the upper portion of the surficial aquifer were analyzed for TCL SVOCs. SVOCs were detected in six samples collected at the site. The sample from monitoring well MW-21S (35-MW21S-02) exhibited the overall highest concentrations (see Table 4-7) [e.g., naphthalene (499 µg/L), 2-methylphenol (668 µg/L), dibenzofuran (23 µg/L), fluorene (22 µg/L), phenanthrene (52 µg/L), anthracene (7J µg/L), and carbazole (12 µg/L)]. Results of the remaining five samples are summarized on Table 4-7.

Pesticides/PCBs

Two of the three samples that were analyzed for TCL pesticides/PCBs exhibited detectable pesticide concentrations. The sample from monitoring well MW-29A (35-MW29AW-01) had the overall highest concentration of pesticides [beta-BHC (0.022J µg/L), heptachlor (0.011J µg/L) and aldrin (0.017J µg/L)]. No PCBs were detected.

Inorganics

Thirteen samples were analyzed for TAL inorganics (i.e., total and dissolved) and the results of are summarized on Tables 4-8 and 4-9. Twelve of the 13 samples submitted for TAL inorganics exceeded either the Federal MCL or NCWQS for drinking water: antimony (MCL of 6 µg/L), arsenic (MCL and NCWQS of 50 µg/L), barium (MCL and NCWQS of 2000 µg/L), beryllium (MCL of 4 µg/L), cadmium (MCL and NCWQS of 5 µg/L), chromium (MCL of 100 µg/L; NCWQS of 50 µg/L), lead (Federal Action Level and NCWQS of 15 µg/L), manganese (NCWQS of 50 µg/L), mercury (MCL of 2 µg/L; NCWQS of 1.1 µg/L) and nickel (MCL and NCWQS of 100 µg/L). The following samples exhibited elevated concentrations of total and/or dissolved inorganics above the standards:

●	35-EMW05-03	chromium	-	91.4 µg/L (total)
		manganese	-	75.8 µg/L (total)

•	35-EMW07-03	beryllium	-	16.7 µg/L (total)
		chromium	-	283 µg/L (total)
		manganese	-	281 µg/L (total)
		nickel	-	104 µg/L (total)
•	35-MW09S-02	arsenic	-	86.5 µg/L (total)
		beryllium	-	14 µg/L (total)
		chromium	-	451 µg/L (total)
		lead	-	35.7 µg/L (total)
		manganese	-	273 µg/L (total)
		mercury	-	2.9 µg/L (dissolved)
•	35-MW10S-02	arsenic	-	165 J µg/L (total)
		barium	-	2230 µg/L (total)
		beryllium	-	40 µg/L (total)
		chromium	-	1120 µg/L (total)
		lead	-	57.6 µg/L (total)
		manganese	-	462 µg/L (total)
		nickel	-	221 µg/L (total)
•	35-MW14S-02	barium	-	2210 µg/L (total)
		beryllium	-	30 µg/L (total)
		cadmium	-	6.8 J µg/L (total)
		chromium	-	743 µg/L (total)
		lead	-	23.6 µg/L (total)
		manganese	-	195 µg/L (total)
			-	73 µg/L (dissolved)
•	35-MW16S-02	beryllium	-	34 µg/L (total)
		cadmium	-	8.2 J µg/L (total)
		chromium	-	735 µg/L (total)
		lead	-	29.9 µg/L (total)
		manganese	-	408 µg/L (total)
			-	89 µg/L (dissolved)
		nickel	-	127 µg/L (total)
•	35-MW19S-02	beryllium	-	11 µg/L (total)
		cadmium	-	10.2 J µg/L (total)
		chromium	-	301 µg/L (total)
		lead	-	64 µg/L (total)
		manganese	-	684 µg/L (total)
			-	157 µg/L (dissolved)
		mercury	-	1.6 µg/L (dissolved)
		nickel	-	174 µg/L (total)
•	35-MW21S-02	arsenic	-	103 J µg/L (total)
			-	64 µg/L (dissolved)
		cadmium	-	11.1 µg/L (total)
		chromium	-	1050 µg/L (total)
		lead	-	31 µg/L (total)

	manganese	-	121 µg/L (total)
	nickel	-	138 µg/L (total)
• 35-MW22S-02	barium	-	2280 µg/L (total)
	beryllium	-	63.5 µg/L (total)
	cadmium	-	340 µg/L (total)
	chromium	-	1540 µg/L (total)
	manganese	-	497 µg/L (total)
		-	186 µg/L (dissolved)
	nickel	-	524 µg/L (total)
• 35-MW25S-02	manganese	-	735 J µg/L (total)
		-	733 µg/L (dissolved)
• 35-MW29A-01	antimony	-	10.2 J µg/L (total)
	barium	-	3440 µg/L (total)
	cadmium	-	11 µg/L (total)
	chromium	-	292 µg/L (total)
	manganese	-	662 µg/L (total)
		-	56 µg/L (dissolved)
	mercury	-	5.6 µg/L (dissolved)
	nickel	-	294 µg/L (total)
• 35-MW33AW-01	chromium	-	194 µg/L (total)
	lead	-	18.2 J µg/L (total)
	manganese	-	58.8 µg/L (total)
	mercury	-	2.2 µg/L (dissolved)

Engineering Parameters

One sample (35-MW21S-02) was obtained for the analysis of various engineering parameters (see Sampling Summary, Appendix I). The results of these analyses, presented Appendix Q, are intended for use in the FS to aid in the evaluation of groundwater treatment alternatives.

Additionally, a single groundwater sample (35-MW21S-02) from well MW-21S was analyzed for TOC (4,960 mg/L), alkalinity (396 mg/L $CaCO_3$), microbial enumeration (4.9 CFU/mL), BOD (142 mg/L), COD (540 mg/L), TKN (1.5 mg/L), TDS (419 mg/L) total phosphorous (0.95 mg/L) and TSS (2,330 mg/L).

4.2.2.2 Results from the Lower Portion of the Surficial Aquifer

The analytical results are subdivided into two categories based on analytical parameters detected in samples: organics and inorganics.

Organics

Organics data are subdivided into three categories: volatile organic compounds, semivolatile organic compounds, and pesticides/PCBs.

Volatiles

Groundwater samples were analyzed for volatile organic compounds via EPA Method 601 and 602 (including MTBE). The range of the detected compound and the location of the maximum concentration (in parenthesis) are summarized as follows:

- 1,1-dichloroethane was detected in 2 of the 18 samples at concentrations of 3.4 µg/L and 7.6 µg/L (35-MW36BW-01).
- 1,1-dichloroethene was detected in 2 of 18 samples analyzed. Concentrations were 5.7 and 6.9 µg/L (35-MW36BW-01).
- Trichloroethene was detected in 12 of 18 samples ranging from 0.4 to 900 µg/L (35-MW19D-02).
- cis-1,2-dichloroethene was detected in 14 of 18 samples ranging from 3.2 to 973 µg/L (35-MW10D-02).
- trans-1,2-dichloroethene was detected in 10 of 18 samples ranging from 0.4 to 176 µg/L (35-MW19D-02).
- Benzene was detected in 12 of 18 samples ranging from 0.3 to 22 µg/L (35-MW33B-02).
- Ethylbenzene was detected in 17 of 18 samples ranging from 0.3 to 41 µg/L (35-MW33BW-01).
- MTBE was detected in 8 of 18 samples ranging from 22.3 to 319 µg/L (35-MW19D-02).
- Toluene was detected in 17 of 18 samples ranging from 0.5 to 59 µg/L (35-MW22D-02).
- Xylene was detected in 17 of 18 samples ranging from 0.6 to 135 µg/L (35-MW37BW-01).

Semivolatiles

Ten samples from the lower portion of the surficial aquifer were analyzed for TCL SVOCs. No SVOCs were detected in any of the samples collected at the site. Results of the samples are summarized on Table 4-7.

Pesticides/PCBs

Two of the three samples that were analyzed for TCL Pesticides/PCBs contained detectable concentrations of pesticides. The sample from monitoring well MW-29B (35-MW29BW-01) exhibited the overall highest concentration of pesticides [delta-BHC (0.05J µg/L) and 4,4'-DDD (0.21J µg/L)]. No PCBs were detected.

Inorganics

Ten samples were analyzed for TAL inorganics (i.e., total and dissolved) and the results are summarized on Tables 4-8 and 4-9. All 10 samples submitted for TAL inorganics exceeded either the Federal MCL or NCWQS for drinking water: barium (MCL and NCWQS of 2000 μg/L), beryllium (MCL of 4 μg/L), cadmium (MCL and NCWQS of 5 μg/L), chromium (MCL of 100 μg/L; NCWQS of 50 μg/L), manganese (NCWQS of 50 μg/L), mercury (MCL of 2 μg/L; NCWQS of 1.1 μg/L) and nickel (MCL and NCWQS of 100 μg/L). The following samples exhibited elevated concentrations of total and/or dissolved inorganics above the standards:

● 35-MW09D-02	chromium	-	96 μg/L (total)
	mercury	-	1.4 μg/L (dissolved)
● 35-MW10D-02	beryllium	-	6 μg/L (total)
	chromium	-	206 μg/L (total)
	manganese	-	83 μg/L (total)
● 35-MW14D-02	chromium	-	64 μg/L (total)
	mercury	-	5.2 μg/L (dissolved)
● 35-MW16D-02	chromium	-	81 μg/L (total)
	manganese	-	344 μg/L (total)
		-	244 μg/L (dissolved)
● 35-MW19D-02	beryllium	-	12 μg/L (total)
	cadmium	-	15 μg/L (total)
	chromium	-	201 μg/L (total)
	manganese	-	1420 μg/L (total)
	nickel	-	148 μg/L (total)
● 35-MW21D-02	chromium	-	81 μg/L (total)
	manganese	-	65 μg/L (total)
● 35-MW22D-02	beryllium	-	11.8 μg/L (total)
	cadmium	-	6.1 μg/L (total)
	chromium	-	268 μg/L (total)
	manganese	-	299 μg/L (total)
		-	87 μg/L (dissolved)
	nickel	-	119 μg/L (total)
● 35-MW25D-02	chromium	-	74.2 J μg/L (total)
	manganese	-	55 J μg/L (total)
● 35-MW29BW-01	manganese	-	52 J μg/L (total)
	mercury	-	6 μg/L (dissolved)
● 35-MW33BW-01	mercury	-	3.7 μg/L (dissolved)

4.2.2.3 Results from the Upper Portion of the Castle Hayne Aquifer

The analytical results are subdivided into two categories based on analytical parameters detected in samples: organics and inorganics.

Organics

Organics data are subdivided into three categories: volatile organic compounds, semivolatile organic compounds, and pesticides/PCBs.

Volatiles

Groundwater samples were analyzed for volatile organic compounds via EPA Method 601 and 602 (including MTBE). The range of the detected compound and the location of the maximum concentration (in parenthesis) are summarized as follows:

- Benzene was detected in 2 of 5 samples at a concentration of 0.7 µg/L each (35-GWDW2-01 and 35-GWDW3-01).
- Ethylbenzene was detected in all five samples ranging from 0.7 to 2 µg/L (35-GWDW3-01).
- Toluene was detected in 4 of 5 samples ranging from 0.8 µg/L to 1 µg/L.
- Xylene was detected in 5 of 5 samples ranging from 1.6 µg/L to 4.7 µg/L.

Semivolatiles

One sample (35-GWD5-01) was collected from the upper portion of the Castle Hayne Aquifer and analyzed for TCL SVOCs; however, none were detected in the sample. Results of the sample are summarized on Table 4-7.

Pesticides/PCBs

One sample (35-GWD5-01) was analyzed for TCL Pesticides/PCBs, but none were detected. Results of the sample are summarized on Table 4-7.

Inorganics

One sample (35-GWD5-01) was analyzed for TAL inorganics and the results are summarized on Tables 4-8 (total) and 4-9 (dissolved). The sample did not exhibit any elevated concentrations of total and/or dissolved inorganics above the standards.

4.2.3 Sediment Investigation

This section presents a summary of contaminants observed in the sediments collected at the site. Seven sample stations were established along Brinson Creek upstream and adjacent to Site 35. Three sample stations were established at Site 36, which is located downstream from the study area. Two samples were obtained from each station including one from the 0 to 6-inches interval and another form the 6 to 12-inch interval. The contaminants are divided into two categories, inorganics and organics. Positive detection analytical summaries of organics and inorganics in sediments are presented on Tables 4-10 and 4-11.

4.2.3.1 Organics

Sediment samples collected at the site were analyzed for TCL organics (volatiles, semivolatiles, pesticides and PCBs) and TAL metals. The organics are subdivided into three categories: volatiles, semivolatiles, and pesticides/PCBs.

Volatiles

As shown on Table 4-10, sediment results indicated the presence of Toluene detected in only one of 20 samples at a concentration of 8J µg/kg (35-SD03-06). This sample was collected from 0 to 6 inches.

Semivolatiles

No SVOCs were detected in any of the 20 samples analyzed (Table 4-10); however, tentatively identified compounds (TICs) indicative of petroleum were detected at very high concentrations in samples collected adjacent to and downstream of Site 35. It is believed that the TICs "masked" the TCL SVOCs during sample analysis. Samples collected adjacent to and downstream of the site exhibited a strong petroleum odor and appearance. Please refer to Section 4.3.3.1 for a complete discussion of TICs and their impact on sample results.

Pesticides/PCBs

As shown on Table 4-10, 20 sediment samples were analyzed for pesticides/PCBs. Pesticides were detected in 19 of the samples; however, PCBs were not detected in any of the samples. The range of the detected concentrations and the location of the maximum (shown in parentheses) concentrations of each pesticide are as follows:

- beta-BHC: 0.59J µg/kg (35-SD07-06)
- delta-BHC: 0.92J to 1.0J µg/kg (35-SD06-06)
- Heptachlor: 0.91J to 2.3J µg/kg (35-SD03-06)
- Heptachlor epoxide: 0.43J to 1.4J µg/kg (35-SD07-612)
- Dieldrin: 1.4J to 52 µg/kg (36-SD06-06)
- 4,4'-DDE: 1.0J to 1200 µg/kg (36-SD05-612)
- Endrin: 0.44J to 0.85J µg/kg (35-SD05-612)
- Endosulfan II: 0.84J to 3.5J (35-SD04-612)
- 4,4'-DDD: 1.1J to 1140 µg/kg (36-SD05-612)
- 4,4'-DDT: 0.66J to 46J µg/kg (36-SD05-612)
- Methoxychlor: 0.49J to 3.4J µg/kg (35-SD07-612)
- Endrin ketone: 2.8J to 3.1J µg/kg (35-SD05-06)
- Endrin aldehyde: 1.0J to 7.6J (36-SD05-06)
- alpha-chlordane: 0.51J to 13J µg/kg (36-SD07-06)
- gamma-chlordane: 3.6 to 9.7 µg/kg (35-SD07-612)

Note that the high pesticide levels were detected at sampling station 36-SD05, which is located approximately 1,300 feet downstream from Site 35, adjacent to Site 36.

4.2.3.2 Inorganics

Twenty-two of 23 inorganics were detected in the sediment samples collected at the site (silver was not detected) (Table 4-11). Mercury data was rejected ("R") for every sample but one (35-SD02-06). Although most of the requested parameters were detected in the sediments, lead was detected in eight samples above the EPA Region IV Sediment Screening Value (SSV) established by NOAA (35 mg/kg). The highest concentration was detected in sample 36-SD06-06 at 15,100 mg/kg; however, exceedances were detected in 35-SD03-612 (77.9 mg/kg), 35-SD05-06 (92 mg/kg), 35-SD05-612 (54.2 mg/kg), 35-SD06-06 (82.6-mg/kg), 35-SD07-06 (42J mg/kg), 35-SD07-612 (79J mg/kg), 36-SD05-06 (115 mg/kg), and 36-SD07-06 (44.9 mg/kg).

4.2.4 Surface Water Investigation

This section presents a summary of contaminants detected in the surface water samples collected at the site. Surface water samples were collected at each station where sediment samples were collected.

No organics were detected in any surface water samples collected along Brinson Creek. Eighteen of the 23 TAL inorganics were detected in the surface water samples (Table 4-12). Only one of the 10 samples exhibited lead and zinc at concentrations which exceed Federal (8.5 and 86 µg/L, respectively) and North Carolina (25 and 86 µg/L, respectively) surface water standards. Lead was detected at a concentration of 97J µg/L and zinc was reported at 129J µg/L in surface water sample 35-SW07.

Mercury was detected in two samples (35-SW01 and 35-SW04) at concentrations which exceed Federal and North Carolina Standards (0.025 µg/L). Samples 35-SW01 and 35-SW04 exhibited mercury concentrations of 3J and 3.2 µg/L, respectively

4.2.5 Ecological Investigation

The ecological investigation included the evaluation of fish and benthic populations, as well as an analytical evaluation of fish tissue. The results of the fish and benthic macroinvertebrate population studies are presented in Section 7.0 (Ecological Risk Assessment) of this report. The following sections provide brief discussions of the chemical results for the fish and crab tissue samples collected from Brinson Creek. Table 4-13 is a summary of the biota tissue samples collected for chemical analysis. The number of organisms, species type, and sample type (i.e., whole body or fillet) are presented. Samples collected from Brinson Creek were sent for tissue analysis. The fish species to be evaluated included largemouth bass, American eel, warmouth, bluegill, stripped mullet, longnose gar, pumpkinseed, mud catfish, crayfish, white catfish, and blue crab. The fish tissue was analyzed as either a fillet sample or a whole body sample. It should be noted that the blue crab fish samples were analyzed as fillet samples and the crayfish samples were analyzed as whole body samples.

The analytical parameters included TCL organics and TAL metals. Appendix R contains the statistical summary results for the organic and metals analyses for Brinson Creek tissue samples. These tables include the minimum and maximum detected concentration, the location of the maximum detection and the frequency of detection. Tables 4-14 through 4-19 contain the positive detections from all of the analytical results for the fish and crab tissue samples. Background fish fillet and crab tissue were previously collected from Hadnot Creek for analysis (Baker, 1994). These results are included in Appendix S.

4.2.5.1 Organics

The organic compounds detected in the fillet and whole body samples included VOCs and pesticides.

Volatiles

Fillet Samples

Five VOCs were detected in the fish fillet samples collected from Brinson Creek. Table 4-14 presents the VOCs detected in the fish fillet samples. The concentration ranges for the VOCs were the following:

	Minimum (µg/kg)	Maximum (µg/kg)
Acetone	58	372,323
2-Butanone	63	5,108
Carbon Disulfide	196	1,328
Methylene Chloride	26	16,317
Toluene	24	24

Whole Body Samples

Six VOCS were detected in the fish whole body samples collected from Brinson Creek. The whole body fish tissue results for VOCs are presented on Table 4-15. The concentration ranges for the detected VOCs in whole body samples were the following:

	Minimum (µg/kg)	Maximum (µg/kg)
1,1-Dichloroethane	37	37
Acetone	39	24,684
Carbon Disulfide	348	1,367
Methylene Chloride	17	42
Toluene	33	33
Xylene (total)	58	58

Semivolatile Organic Compounds

There were no SVOCs detected in the fillet and whole body fish tissue samples collected from Brinson Creek.

Pesticides/PCBs

Fillet Samples

As depicted on Table 4-16, 14 pesticides were detected in the fish fillet samples collected from Brinson Creek. The concentration ranges for the detected pesticides in the fillet samples were the following:

	Minimum (µg/kg)	Maximum (µg/kg)
Aldrin	2.3	6.6
beta-BHC	4.2	11
gamma-BHC	2.1	5.5
alpha-Chlordane	3.5	46
Dieldrin	4.3	48
4,4'-DDD	19	256
4,4'-DDE	39	572
4,4'-DDT	2.5	15
Endosulfan II	3.6	9.6
Endrin	2.5	52
Endrin Aldehyde	2.8	13
Endrin Ketone	3.6	3.8
Heptachlor	2.6	4.3
Heptachlor Epoxide	3.9	3.9

Whole Body Samples

As depicted on Table 4-17, 14 pesticides were detected in the fish whole body samples collected from Brinson Creek. The concentration ranges for the detected pesticides were the following:

	Minimum (µg/kg)	Maximum (µg/kg)
aldrin	2.6	2.6
beta-BHC	4.8	8.3
gamma-BHC	8	8
alpha-Chlordane	2.9	60
gamma-Chlordane	12	22
Dieldrin	3.2	59
4,4'-DDD	5.2	319
4,4'-DDE	27	434
4,4'-DDT	5.8	58
Endosulfan II	3.4	3.4
Endrin	3	27
Endrin Aldehyde	3.3	6.5
Endrin Ketone	3.1	14
Heptachlor	7.8	7.8

There were no PCBs detected in the fillet and whole body fish tissue samples collected from Brinson Creek.

4.2.5.2 Inorganics

Fillet Samples

As depicted on Table 4-18, 19 TAL inorganic compounds were detected in the Brinson Creek fillet tissue samples. The range of detected concentrations for these chemicals in the fish fillet tissue samples collected from Brinson Creek are as follows:

	Minimum (µg/kg)	Maximum (µg/kg)
Aluminum	19.3	27.3
Arsenic	1.4	1.8
Barium	0.41	2.2
Cadmium	0.16	0.8
Calcium	676	13,300
Chromium	3.0	4.0
Cobalt	6.9	6.9
Copper	2.3	27.5
Iron	20.4	53.6
Lead	0.51	0.61
Magnesium	833	1,550
Manganese	0.86	3.1
Mercury	0.29	1.3
Potassium	9,180	20,200
Selenium	0.6	5.8
Silver	1.0	3.3
Sodium	1,970	21,900
Vanadium	1.7	1.7
Zinc	18.2	130

Whole Body

As depicted on Table 4-19, 16 TAL inorganic compounds were detected in the Brinson Creek whole body tissue samples. The range of detected concentrations for these chemicals in the fish whole body tissue samples collected from Brinson Creek are as follows:

	Minimum (mg/kg)	Maximum (mg/kg)
Aluminum	23.7	53.2
Barium	0.89	5
Cadmium	0.25	0.88
Calcium	1,910	50,800
Chromium	2.3	3.6
Copper	3.2	70.3
Iron	60.9	392
Lead	2.5	2.5
Magnesium	705	1,540
Manganese	1.6	11.2
Mercury	0.68	0.7

Potassium	8,970	12,100
Selenium	0.43	1.0
Silver	1.0	2.1
Sodium	2,710	17,200
Zinc	42.3	102

4.3 Extent of Contamination

This section addresses the extent of contamination in the soil, groundwater, surface water, and sediment sampled at Site 35. Ecological media (i.e., fish, crabs, and benthic macroinvertebrates) results are further discussed in Section 7.0, Ecological Risk Assessment.

4.3.1 Soil

Positive detections of organic and inorganic compounds for surface and subsurface soils at Site 35 are depicted on Figures 4-1, 4-2, and 4-3. A discussion of the extent of soil contamination with respect to VOCs, SVOCs, pesticides/PCBs, and inorganics follows.

4.3.1.1 Organics

Volatiles

Samples 35-SS05-00, 35-SS07-00 and 35-SS13-00 exhibited the only detections of VOCs from surface soils collected at the site (Figure 4-1). As discussed in Section 4.2.1, sample 35-SS05-00 contained low concentrations of toluene, sample 35-SS07 contained carbon disulfide and sample 35-SS13-00 contained detectable levels of total xylenes. The sample locations are not associated with a common potential contaminant source within the study area, therefore, lending to the conclusion that the results are not related. In the case of the toluene detection at 35-SS05, it is difficult to associate this contamination with a particular source of contamination. This sample was obtained within a well-maintained grassy area adjacent to barracks. This area, along with other open fields at Camp Geiger, is frequently used for training which reportedly, in the past, may have involved the use of solvents to clean the gun barrels. The source of the carbon disulfide detected at 35-SS07 near Building G480 is unknown. The detection of xylenes (35-SS13) is logical in that this sampling point is in the vicinity of an active 500-gallon waste oil AST and Building TC474 (former maintenance warehouse). Surface soil samples collected during previous investigations within the study area were not analyzed for VOCs and therefore can not be compared to the results obtained by Baker.

Tetrachloroethene was the only VOC detected in the subsurface soils that could be attributed to site conditions. It was detected in four borings (35-MW37B, 35-MW30B, 35-MW32B, and 35-MW33B) drilled south of Fourth Street (Figure 4-2). Two of the detections are located in the vicinity of various warehouses located south of the Fuel Farm along "G" Street. Potential sources of contamination in this area are Building TC474, the active hazardous chemicals storage area located between Building TC470 and TC572, and the railroad tracks. This compound may be attributable to groundwater contamination because elevated concentrations of halogenated hydrocarbons were detected in groundwater in this area, and because no visual evidence of soil contamination was observed.

The detection of tetrachloroethene in subsurface soils at boring 35MW-30B and 35MW-37B, near the barracks west of the Fuel Farm, was unexpected. No records exist of contaminated soil disposal or other activities in the area. Based on available aerial photographs dated 1962, a structure previously occupied this area; however, there are no records to document the types of activities at this location.

Previous investigations within the study area were primarily concerned with total petroleum hydrocarbons (TPH) and BTEX compounds. Areas of elevated TPH and BTEX in subsurface soils were identified under the Interim Remedial Action RI/FS (Baker, 1994) and are subject to remediation in 1995 as per an Interim Record of Decision executed on September 15, 1994.

Semivolatiles

SVOCs were detected in surface soil samples collected within the study area. Samples 35-SS05-00 and 35-SS09-00 exhibited the highest concentrations of total SVOCs as illustrated on Figure 4-1. Tables 4-1 and 4-3 should be referenced for information pertaining to a specific SVOC compounds in surface and subsurface soil, respectively. SVOCs detected in 35-SS11-00 and 35-SS04-00 may be related to past activities associated with the Fuel Farm or the oil/water separator located near the ASTs. The levels of SVOCs detected in sample 35-SS05-00 and 35-SS09-00 do not have an obvious source.

The only subsurface soil sample exhibiting elevated concentrations of SVOCs was obtained from Boring 35-MW35B. No source for the compounds is either obvious or suspected in the vicinity of the soil boring. No previous investigations have been conducted in this area.

Pesticides/PCBs

As illustrated in Figure 4-1, pesticides are present in surface soils throughout the study area. This is common at sites within MCB Camp Lejeune because of the application of pesticides for insect population control over the years of operation. The highest concentrations of pesticides were located in vicinity of the Fuel Farm along the tree line where the developed area is adjacent to wooded areas. These areas are the most likely areas of heavy pesticide application for insect control. The elevated pesticide levels at the fuel farm are likely associated with application of pesticides to control insect population. Pesticides were not investigated during previous studies at the site, therefore, no comparative data is available.

No PCBs were detected in the surface soil samples at the site nor were they investigated during the previous investigations.

4.3.1.2 Inorganics

The distribution of inorganics detected in subsurface and surface soil at Site 35 under the RI is depicted in Figures 4-2 and 4-3, respectively. Inorganic levels in surface and subsurface soil were similar to base-wide inorganic levels (see Tables 4-5 and 4-6). Surface soil samples 35-SS04-00 and 35-SS13-00 as well as subsurface soil sample 35-GWDS05-03 exhibited inorganics at levels higher than 2 x base background average or the maximum base background detection. One of two reasons may be responsible for these apparent results. The elevated concentrations may be due to past activities at Building TC474 (formerly a vehicle maintenance garage) or simply outside the estimated range of based background.

The activities at Building TC474 that could cause elevated concentrations of metals would include disposal of batteries, metal items, or metal fragments. This would explain the high concentrations of chromium, magnesium, manganese, and zinc.

However, the base background averages may be low on average. The average has been based on 30 samples which is a statistically low number of samples to use for an average. As time passes the average may increase or decrease as sample results are added to the database. Therefore, these samples may simply be outside the range because the range is low and not a true representation of the entire base.

4.3.2 Groundwater Contamination

The following subsections summarize the extent of organic and inorganic contamination in the upper portion of the surficial aquifer, the lower portion of the surficial aquifer, and the upper portion of the Castle Hayne Aquifer.

4.3.2.1 Upper Portion of Surficial Aquifer

Halogenated (chlorinated) and nonhalogenated hydrocarbons (e.g., BTEX) were detected in shallow groundwater at the site. As depicted on Figure 4-4, detections of compound concentrations that exceed the Federal MCLs or the NCWQS were highlighted with color indicating that the compound was detected at levels exceeding one or both of the standards.

Organics

Volatiles

BTEX compounds were detected in nearly every well that was sampled during the RI. However, the only compounds detected at the site which exhibited concentrations above groundwater standards were benzene and ethylbenzene. The wells containing the highest levels of benzene are concentrated in the areas where petroleum leaks or spills were suspected to have occurred. Monitoring wells MW-16, MW-22 and EMW-7 contained concentrations of benzene which exceeded the federal MCL and NCWQS. Ethylbenzene concentrations in MW-16 and MW-22 exceeded the NCWQS standard, but did not exceed the federal MCL. These wells were installed during previous investigations at the site to assess the extent of groundwater contamination in the vicinity of the Camp Geiger Area Fuel Farm.

It is apparent that based on groundwater flow patterns in the vicinity of the Fuel Farm, a plume of nonhalogenated hydrocarbons is moving eastward in relatively the same direction as groundwater flow. The plume appears to be centered in the vicinity of MW-22.

Additionally, monitoring wells MW-21 and MW-25 contained benzene and ethylbenzene concentrations which exceeded either the Federal MCLs or the NCWQS or both. These wells are located north of the Camp Geiger Area Fuel Farm and are believed to be unrelated to the previously mentioned plume (i.e., near MW-22). However, these wells are located in an area where it is suspected that an undetermined amount of petroleum product was released onto the surface and allowed to migrated toward Brinson Creek. The release was suspected to have occurred near the location of MW-21 and flowed along natural drainage paths toward Brinson Creek. This is the most probable cause for the elevated concentrations of benzene and ethylbenzene residing within the groundwater beneath this portion of the site. Samples collected from wells MW-11, MW-12 and MW-13 during Law's investigation delineated the northwestern edge of contamination in the area of wells MW-21 and MW-25.

Monitoring wells MW-21 and MW-25 were installed during Law's investigation of the Camp Geiger Area Fuel Farm. Samples collected during their investigation contained similar levels of these two contaminants. This could indicate that the contamination is not moving very rapidly or that the soils continue to contaminate the groundwater in this area and therefore acting as a continued source of contamination. Soils in this area of the site are being remediated as part of an interim remedial action measure scheduled to begin in June 1995.

Benzene and ethylbenzene levels were detected at concentrations greater than the federal MCLs and the NCWQS in monitoring well MW-2. This well was installed during ATEC's investigation of the UST in the vicinity of building TC341, which is located west of the Fuel Farm. ATEC's results were similar to the levels detected during this RI. This contamination appears to ordinate from the abandoned UST located near the former Mess Hall Heating Plant. The extent of this contamination appears to be limited in size.

Monitoring wells MW-10 and 35MW-29A contain benzene concentrations which slightly exceed the NCWQS. Monitoring well MW-10 was installed prior to the RI by Law during their assessment of the Camp Geiger Area Fuel Farm as a background well. The concentration of benzene detected by Law is the same as levels observed by Baker. The source of benzene in this area may be related to former activities near the barracks. The extent of this plume appears to follow the flow of groundwater eastward toward Brinson Creek. Downgradient wells EMW-05, MW-32A, and MW-26A also exhibited benzene and ethylbenzene, at slightly lower concentrations.

Halogenated hydrocarbon contamination (TCE and cis-1,2-DCE) was detected in the shallow wells at the site with concentrations exceeding the Federal MCLs and NCWQS. The highest level of TCE was detected in monitoring well MW-14. This well is located directly west of Site 35 and appears to be part of a plume that originates in the vicinity of MW-10 and travels northeast toward Brinson Creek along a pathway marked by monitoring wells EMW-5, MW-14 and EMW-3. However, TCE and cis-1,2-DCE are dense non-aqueous phase liquids (DNAPLs) and tend to concentrate in the deeper portions of aquifers due to their specific gravity being greater than the specific gravity of water. Therefore, the appearance of a TCE plume that originates in the vicinity of MW-10 may be misleading until compared with data from the lower portion of the water table aquifer.

During the previous investigation conducted by Law, TCE was detected in the same wells. The results from MW-10 was the only well which differed substantially from the concentrations detected during the RI. TCE was detected at a concentration of 170 µg/L in a groundwater sample collected from MW-10S during Law's investigation where as a concentration of 3.8 µg/L was detected during this RI (see Table 4.4 in Law's Report in Appendix B). Cis-1,2-DCE was not a requested parameter during the Law investigation.

TCE and cis-1,2-DCE contamination was detected in monitoring wells EMW-7 and MW-19 located north of the former Vehicle Maintenance Garage (presently warehouse TC474). TCE contamination exceeded the Federal MCL and the NCWQS in both wells and the detected level of cis-1,2-DCE in well EMW-7 was above the Federal MCL and the NCWQS. Monitoring well EMW-7 was installed by ESE and MW-19 was constructed by Law during their investigations. The samples collected by ESE from EMW-7 (Two rounds) contained TCE at relatively low levels. Law sampled the same well during their investigation and obtained higher levels than previously obtained by ESE. Baker's results are slightly higher than both of the previous consultant's results. Unlike the previous plume described above, the contamination in this area of the site appears to originate from the former Vehicle Maintenance Garage and may have resulted in improper disposal or mishandling of TCE based solvents used in degreasing operations.

Monitoring well 35MW-35A contained TCE contamination which exceeded the Federal MCL and NCWQS. The well is located east of a chemical storage area located between warehouse TC470 and TC572. Given the direction of groundwater flow, it is likely that the contamination may be attributed to the storage of chemicals within this area. However, not enough data exists at this time to determine the true origin of this contamination.

Well 35MW-32A exhibited elevated concentrations of TCE and cis-1,2-DCE exceeding the Federal MCL and the NCWQS. The well is located east of warehouse TC462. Enough data has not been gathered to determine the source area for these contaminants.

Semivolatiles

Semivolatile compounds were detected in monitoring wells MW-21, EMW-05, MW-29A, MW-16, and MW-22 as illustrated on Figure 4-4. These compounds appear to be related to petroleum contamination and correlate with the previously identified plumes. The particular semivolatiles for each well are listed in Table 4-7.

Pesticide/PCBs

The only pesticide detected in the shallow groundwater which exceeded the NCWQS was heptachlor. It was detected in MW-29A with no apparent source for the contaminant. The concentration is low enough to indicate that it may have originated from the application of pest controls to the surface soils.

Inorganics

Inorganic contamination was detected within the upper portion of the water table aquifer throughout the site. Figures 4-4 and 4-5 identifies the selected metals which were detected at concentrations above the Federal MCLs and/or NCWQS. Since the distribution of the contaminants does not reflect a particular trend or pattern, it is difficult to assess the entire extent of metals contamination and identify specific source areas. The data suggests that the elevated total metals are due to suspended particulates in the sample.

4.3.2.2 Lower Portion of Surficial Aquifer

Organics

Volatiles

Halogenated and nonhalogenated hydrocarbons were detected in lower portion of the water table aquifer at the site. As illustrated on Figure 4-7, detections of compound concentrations that exceed the Federal MCLs or the NCWQS were highlighted with color indicating that the compound was detected at levels exceeding one or both of the standards.

Nonhalogenated hydrocarbon contamination (e.g., BTEX) was detected at low levels in the lower portion of the water table aquifer in nearly every intermediate well location. However, the concentrations of the contaminants detected were much lower than the concentrations detected in the upper portion of the aquifer. This trend complies with the properties of the compounds (i.e., specific gravity). The only exception to the trend is MTBE. The concentration of MTBE increased in the lower portion of the aquifer rather than decrease. A reason for this exception cannot be determined at this time and may require more information to formulate an explanation.

The primary nonhalogenated hydrocarbon compounds that were detected at levels exceeding the Federal MCL and/or NCWQS were benzene, ethylbenzene and MTBE. Two primary plumes of nonhalogenated compounds were identified within the study area. The first to be discussed is located in the western, southwestern and southern portions of the site. The highest concentrations were centered around MW-10D. Benzene was not detected in this well but ethylbenzene and MTBE were detected at concentrations which exceeded the NCWQS. The surrounding wells (MW-09D, 35MW-31B, 35MW-32B, 35MW-30B, 35MW-29B and 35MW-37B) contained benzene at concentrations which exceeded the NCWQS. Three of the wells possessed concentrations which exceeded the federal MCL. During the previous Law investigation, MTBE was not detected in any of the intermediate wells; however, MW-09 and MW-10 did contain elevated levels of benzene. These results do indicate that contamination within the water table aquifer is present just above the semiconfining unit separating this aquifer and the Castle Hayne Aquifer.

The second plume is located in the eastern portion of the study area. Monitoring wells MW-19D, MW-22D and 35MW-33B contain concentrations of benzene, ethylbenzene and MTBE in excess of Federal and state groundwater standards. During Law's investigation of the site, samples were collected from monitoring well MW-19D and MW-22D. Results from the samples indicate that greater concentrations of total BTEX resided within monitoring well MW-22D than was detected by Baker and no BTEX compounds were detected in MW-19D. This information lends credibility to the theory that dissolved nonhalogenated contamination in this area of the study area is migrating with the direction of groundwater flow toward Brinson Creek.

In addition to nonhalogenated compounds, halogenated organics such as TCE, cis-1,2-DCE and trans-1,2-DCE were detected in 10 intermediate wells within the study area. The concentrations of the halogenated hydrocarbon contamination is greater in the lower portion of the aquifer than the upper portion of the aquifer. This trend is typical when halogenated organics, such as those listed previously are identified within an aquifer system. Due to the compounds specific gravity, it is common for higher concentrations of the compound to reside within the deeper portions of the aquifer.

As illustrated on Figure 4-7, two plumes of halogenated organics have been identified at the site. The first of the two plumes is located in the area of the former Vehicle Maintenance Garage (warehouse TC474) in the eastern portion of the study area. The highest concentrations of TCE were detected in wells MW-19D and 35MW-33B. TCE, cis-1,2-DCE and trans-1,2-DCE concentrations exceeded the federal MCL and NCWQS. These concentrations correlate well to the corresponding shallow wells. The concentrations detected in MW-19D are similar to the concentrations detected by Law in their previous investigation. Based on the concentrations detected in the shallow and intermediate wells, the former Vehicle Maintenance Garage is the suspected source for the halogenated hydrocarbon contamination is this portion of the study area.

A larger plume of halogenated hydrocarbons originates on the southern edge of the study area trending northeast toward Brinson Creek. Elevated TCE concentrations exceeding the Federal MCL and the NCWQS were detected in monitoring wells 35MW-30B, 35MW-32B, 35MW-29B, MW-10D, MW-09D, MW-14D and MW-21D. The highest TCE concentration was detected in MW-10D, however this does not appear to be the source area for the contamination. The southern and northeastern edge of the plume is not defined and it is Baker's belief that the contamination source is located outside of the boundaries of the study area. Monitoring wells MW-10D, MW-09D, MW-14D and MW-21D were installed by Law during their investigation of the Fuel Farm. Results from the samples collected during this investigation are similar to Baker's results.

Semivolatiles

No semivolatiles were detected in the lower portion of the shallow aquifer. The SVOCs are only present in a limited number of shallow wells which monitor the upper portion (i.e., water table) of the shallow aquifer.

Pesticides/PCBs

Heptachlor was detected in monitoring well 35MW-33B at a concentration that exceeded the NCWQS. The source of this contamination is unknown. Subsurface soil samples collected from this well boring did not exhibit pesticide contamination.

Inorganics

As illustrated on Figures 4-8 and 4-9, inorganic contamination was detected within the lower portion of the water table aquifer. In comparison to the upper portion of the aquifer, inorganic concentrations were generally lower in the lower portion of the aquifer. Since the distribution of the contaminants do not reflect a particular trend or pattern, it is difficult to assess the entire extent of metals contamination and identify specific source areas. The data suggests that suspended solids in the sample may be contributing to elevated total metals.

4.3.2.3 Upper Portion of the Castle Hayne Aquifer

No significant organic or inorganic contamination was detected in the samples collected from the deep wells (Figure 4-10). The absence of TCE in the Castle Hayne Aquifer indicates that the unit identified as a semi-confining unit must be prohibiting the vertical migration of the contaminates. Although the unit possesses very little clay and is not the "typical" semi-confining unit, the high permeability of the soils above and below the unit as well as the groundwater gradient exhibited at the site provide for the surficial aquifer waters to flow along the top of the unit instead of passing through the unit. Vertical migration may be occurring at the site but at a very slow rate such that the contamination has not been detected in the upper portion of the Castle Hayne Aquifer.

4.3.3 Surface Water and Sediment

Surface water and sediments were sampled at ten stations within Brinson Creek. The following sections discuss the detected contamination for each media.

4.3.3.1 Organics

Volatiles

No VOCs were detected in surface water samples. Toluene was the only volatile organic compound detected in the sediments obtained from station 35-SW/SD03 within Brinson Creek (Figure 4-11). Although many VOCs were not detected, heavy sheens and hydrocarbon odors were noted during sampling. During sample validation, it was noted that an unusually high number of Tentatively Identified Compounds (TICs) were identified in the samples. TICs are compounds not found on the Target Compound List (TCL), but are detected during the analysis of SVOCs and VOCs. The laboratory attempts to identify the 30 highest peaks using computerized searches of a library containing mass spectra. When the match is made, the compound is named and in most cases with high uncertainty. High concentrations of TICs may result in the sample being analyzed at a dilution which causes target compounds to be reported as not detected at an elevated level of detection. The presence of the TICs is likely indicative of the sediment samples containing elevated levels of organic compounds that could not be reported because they could not be identified. This is consistent with the observations of the Baker field team who commented that sediment samples adjacent to Site 35 appeared to contain elevated levels of fuel-related contaminants.

Semivolatiles

Although no SVOCs were detected in the surface water samples, a number of SVOCs were detected in the sediment sample collected from Brinson Creek. The SVOCs were detected in greater frequency in the samples collected from 6 to 12 inches. SVOCs were detected both upgradient and downgradient of Site 35. However, the highest levels of SVOCs were detected in samples obtained adjacent to Site 35. Due to the limitations on the figures, only the total number of SVOC positive detections at each sample location are listed. For a list of SVOCs detected at each location, reference Table 4-10.

Pesticides/PCBs

Pesticides were detected in all 10 sediment sample locations; however, no pesticides were observed in the surface water samples. The application of pest control to the surfaces in areas like Camp Geiger leads to pesticide detections in the sediments of surface water bodies like Brinson Creek. The pesticides are carried from the surface soil to the creek via surface runoff and natural erosion. This statement can be further supported by the large number of pesticides detected in the surface soils at the site. PCBs were not detected in any of the surfaced water or sediment samples collected from Brinson Creek.

4.3.3.2 Inorganics

Figures 4-12 and 4-13 illustrate the positive detections of inorganics from surface water and sediment samples, respectively, obtained under the RI. Inorganics above the Federal Screening Values (WQSVs and NOAA standards) and/or NCWQS are present in one surface water and seven sediment locations. The only compound to exceed the NOAA standards in sediments was lead. The greatest concentration was detected in sample number 36-SD06-06 collected from the 0 to 6 inch interval. The detected lead is prevalent adjacent to and downstream of Site 35 and could be related to past site activities. Mercury, lead and zinc were detected at levels exceeding the Federal and North Carolina Standards in surface water samples 35-SW01, 35-SW04 and 35-SW07. The mercury was detected in two samples (35-SW01 and 35-SW04) located upstream of Site 35 which indicates contamination may originate from an upgradient location. The concentrations of lead and zinc detected in sample 35-SW07 may be attributed to past practices at Site 35 due to its geographic location with respect to Site measurements of groundwater. Groundwater beneath site 35 indicate that flow is in the general direction of Brinson Creek and specifically in the area where 35-SW07 was collected.

SECTION 4.0 REFERENCES

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SECTION 4.0 TABLES

TABLE 4-1
POSITIVE DETECTION SUMMARY
SURFACE SOILS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER -0232

Client Sample ID:		35-SS01-00	35-SS02-00	35-SS03-00	35-SS04-00	35-SS05-00	35-SS07-00	35-SS09-00
Lab Sample ID:		5617-17	5617-19	5617-9	5617-10	4585-22	5617-8	5617-16
Date Sampled:		17-MAY-1994	17-MAY-1994	18-MAY-1994	10-MAY-1994	29-APR-1994	18-MAY-1994	18-MAY-1994
	<u>UNITS</u>							
VOLATILES								
Carbon Disulfide	UG/KG	ND	ND	36 R	ND	ND	33	37 R
1,1-Dichloroethene	UG/KG	ND	ND	ND	ND	ND	33 R	ND
Toluene	UG/KG	ND	ND	ND	ND	19 J	ND	ND
Xylene (total)	UG/KG	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES								
Phenol	UG/KG	ND	ND	ND	ND	ND	ND	3071
Acenaphthene	UG/KG	ND	ND	ND	ND	196 J	ND	ND
Phenanthrene	UG/KG	ND	ND	ND	ND	1186	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND	183 J	ND	ND
Fluoranthene	UG/KG	ND	ND	ND	ND	1567	ND	ND
Pyrene	UG/KG	ND	ND	ND	ND	1173	ND	ND
Butylbenzylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	UG/KG	ND	ND	ND	ND	566	ND	ND
Chrysene	UG/KG	ND	ND	ND	ND	683	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	UG/KG	ND	ND	ND	ND	1186	ND	ND
Benzo(a)pyrene	UG/KG	ND	ND	ND	ND	625	ND	ND
Indeno(1,2,3-cd)pyrene	UG/KG	ND	ND	ND	ND	381	ND	ND
Dibenz(a,h)anthracene	UG/KG	ND	ND	ND	ND	184 J	ND	ND
Benzo(g,h,i)perylene	UG/KG	ND	ND	ND	208 J	366	ND	ND

J - Value is estimated
NA - Not analyzed
ND - Not detected
R - Rejected positive value

TABLE 4-1 (continued)
POSITIVE DETECTION SUMMARY
SURFACE SOILS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER -0232

Client Sample ID:		35-SS01-00	35-SS02-00	35-SS03-00	35-SS04-00	35-SS05-00	35-SS07-00	35-SS09-00
Lab Sample ID:		5617-17	5617-19	5617-9	5617-10	4585-22	5617-8	5617-16
Date Sampled:		17-MAY-1994	17-MAY-1994	18-MAY-1994	10-MAY-1994	29-APR-1994	18-MAY-1994	18-MAY-1994
	UNITS							
PESTICIDE/PCBs								
beta-BHC	UG/KG	ND	ND	ND	0.53 J	NA	ND	ND
Dieldrin	UG/KG	ND	ND	0.35 J	2.9 J	NA	11	ND
4,4'-DDE	UG/KG	12	1.6 J	20	8.7	NA	14	261
Endrin	UG/KG	ND	ND	ND	7.9	NA	0.68 J	2 J
Endosulfan II	UG/KG	ND	ND	ND	2.9 J	NA	0.42 J	ND
4,4'-DDD	UG/KG	1.2 J	0.56 J	0.86 J	11	NA	2.5	7.3 J
4,4'-DDT	UG/KG	19	1.6 J	8.9	48	NA	3.2 J	262
Endrin ketone	UG/KG	ND	ND	ND	1.2 J	NA	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	1.6 J	NA	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	4.1	NA	ND	ND
gamma-Chlordane	UG/KG	ND	ND	ND	ND	NA	ND	ND

J - Value is estimated
NA - Not analyzed
ND - Not detected
R - R[illegible] positive value

TABLE 4-1 (continued)
POSITIVE DETECTION SUMMARY
SURFACE SOILS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER -0232

Client Sample ID:		35-SS10-00	35-SS11-00	35-SS12-00	35-SS13-00
Lab Sample ID:		5617-18	5617-6	5617-5	5617-20
Date Sampled:		17-MAY-1994	18-MAY-1994	18-MAY-1994	18-MAY-1994
	UNITS				
VOLATILES					
Carbon Disulfide	UG/KG	ND	ND	39 R	ND
1,1-Dichloroethene	UG/KG	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	ND	ND
Xylene (total)	UG/KG	ND	ND	ND	43
SEMIVOLATILES					
Phenol	UG/KG	ND	ND	ND	ND
Acenaphthene	UG/KG	ND	ND	ND	ND
Phenanthrene	UG/KG	ND	191 J	ND	ND
Carbazole	UG/KG	ND	ND	ND	ND
Fluoranthene	UG/KG	ND	423	ND	ND
Pyrene	UG/KG	ND	295 J	ND	ND
Butylbenzylphthalate	UG/KG	ND	ND	ND	ND
Benzo(a)anthracene	UG/KG	ND	ND	ND	ND
Chrysene	UG/KG	ND	204 J	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND
Benzo(b)fluoranthene	UG/KG	ND	337 J	ND	ND
Benzo(a)pyrene	UG/KG	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	UG/KG	ND	ND	ND	ND
Dibenz(a,h)anthracene	UG/KG	ND	ND	ND	ND
Benzo(g,h,i)perylene	UG/KG	ND	ND	ND	ND

J - Value is estimated
NA - Not analyzed
ND - Not detected
R - Rejected positive value

TABLE 4-1 (continued)
POSITIVE DETECTION SUMMARY
SURFACE SOILS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER -0232

Client Sample ID:		35-SS10-00	35-SS11-00	35-SS12-00	35-SS13-00
Lab Sample ID:		5617-18	5617-6	5617-5	5617-20
Date Sampled:		17-MAY-1994	18-MAY-1994	18-MAY-1994	18-MAY-1994
	UNITS				
PESTICIDE/PCBs					
beta-BHC	UG/KG	ND	1.6 J	ND	ND
Dieldrin	UG/KG	ND	ND	ND	212
4,4'-DDE	UG/KG	204	125	127	1570
Endrin	UG/KG	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND
4,4'-DDD	UG/KG	18	3.5 J	ND	3240
4,4'-DDT	UG/KG	76	113	67	154
Endrin ketone	UG/KG	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	36	ND	ND
gamma-Chlordane	UG/KG	ND	27	ND	ND

J - Value is estimated
NA - Not analyzed
N[illegible]ot detected
R - R[illegible]positive value

TABLE 4-2
POSITIVE DETECTION SUMMARY
SURFACE SOILS
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-SS01-00	35-SS02-00	35-SS03-00	35-SS04-00	35-SS05-00	35-SS06-00	35-SS07-00	35-SS08-00
Lab Sample ID:		5617-17	5617-19	5617-9	5617-10	4585-22	4585-21	5617-8	4585-20
Date Sampled:		17-MAY-1994	17-MAY-1994	18-MAY-1994	10-MAY-1994	29-APR-1994	29-APR-1994	18-MAY-1994	29-APR-1994
	UNITS								
Aluminum	MG/KG	2220	2420	2390	2330	3550	6510	7870	3600
Antimony	MG/KG	ND	ND	ND	8 J	7.5 R	10.5 R	7.4 J	10.2 R
Arsenic	MG/KG	ND	0.44 J	0.32 J	ND	0.74 J	0.89 J	0.5 J	66.1 J
Barium	MG/KG	15.6	6.2	7.9	79.5	13.5	13.6	15.4	20
Beryllium	MG/KG	ND	ND	ND	ND	ND	0.12 R	0.22	ND
Cadmium	MG/KG	0.04 J	0.06 J	0.14 J	15 J	0.52 R	0.53 R	0.16 J	1.1 R
Calcium	MG/KG	605 J	604 J	5420 J	27700 J	3030 J	1330 J	4680 J	621 J
Chromium	MG/KG	1.9	1.9	2.9	98.1	ND	8.6 J	13	ND
Cobalt	MG/KG	ND	ND	1.9	4.3	ND	ND	ND	ND
Copper	MG/KG	3.9	2	2.6	43	4.1	ND	3.2 J	4
Iron	MG/KG	1250	1670	2890	4400	1950 J	3470 J	10000 J	29900 J
Lead	MG/KG	7.2 J	7.3 J	10.7 J	71 J	67.6 J	13.2 J	17.1 J	36.1 J
Magnesium	MG/KG	71.6	58.7	212	675	241	255	346	194
Manganese	MG/KG	5.5	4.1	17.8	35.6	13.1 J	6.7 J	6.6	32.9 J
Mercury	MG/KG	0.13 R	0.11 R	0.24 R	0.23 R	0.05 R	0.05 R	0.13 R	0.11 R
Nickel	MG/KG	1.3	1.9	1.6	6.8	ND	ND	2.4	ND
Selenium	MG/KG	ND	ND	ND	ND	ND	ND	ND	0.94 J
Thallium	MG/KG	0.06	0.08	0.07 J	ND	0.12	0.14	0.2	0.53 J
Vanadium	MG/KG	3.6	3.6	5.3	14.2	6.1 J	12.5 J	18.8	15 J
Zinc	MG/KG	14.8 R	12.9 R	16.7 R	430	15.6 R	12.5 R	18.4 R	24.9 R

J - Value is estimated
ND - Not detected
R - Rejected positive value

TABLE 4-2 (continued)
POSITIVE DETECTION SUMMARY
SURFACE SOILS
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-SS09-00	35-SS10-00	35-SS11-00	35-SS12-00	35-SS13-00
Lab Sample ID:		5617-16	5617-18	5617-6	5617-5	5617-20
Date Sampled:		18-MAY-1994	17-MAY-1994	18-MAY-1994	18-MAY-1994	18-MAY-1994
	UNITS					
Aluminum	MG/KG	2570	3230	2400	2020	5160
Antimony	MG/KG	ND	ND	ND	ND	ND
Arsenic	MG/KG	0.29 J	0.78 J	0.55 J	0.39 J	0.79 J
Barium	MG/KG	8.9	17.8	9.8	8.7	86
Beryllium	MG/KG	ND	ND	ND	ND	ND
Cadmium	MG/KG	0.79 J	0.18 J	0.4 J	0.26 J	0.77 J
Calcium	MG/KG	13500 J	49500 J	5650 J	24000 J	7360 J
Chromium	MG/KG	5.1	5.8	3.1	3.6	9.7
Cobalt	MG/KG	ND	ND	1.3	ND	ND
Copper	MG/KG	4.5	3.3	3.8	4.8	58.3
Iron	MG/KG	2200	2010	1740	1720	8280
Lead	MG/KG	35.8 J	16.2 J	30.9 J	26.1 J	43.2 J
Magnesium	MG/KG	399	951	184	545	883
Manganese	MG/KG	12.5	11.1	11.3	13.9	66.7
Mercury	MG/KG	0.17 R	0.14 R	0.26 R	0.18 R	0.7 R
Nickel	MG/KG	2.8	2.2	1.5	2	17.2
Selenium	MG/KG	ND	ND	ND	ND	1.2 J
Thallium	MG/KG	0.07	0.08	0.1 J	ND	0.48
Vanadium	MG/KG	6.1	7.1	5.1	4	20.7
Zinc	MG/KG	138	12.5 R	24.5 R	16.2 R	67.5 R

J - Value is estimated
ND - Not detected
R - Rej[illegible]ositive value

TABLE 4-3
POSITIVE DETECTION SUMMARY
SUBSURFACE SOILS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-GWDS2-03	35-GWDS4-02	35-MW30BS-04	35-MW31-03	35-MW32BS-03	35-MW33BS-05	35-MW34B-03
Lab Sample ID:		5617-4	5617-1	5057-21	4585-25	5057-24	5057-22	5057-14
Date Sampled:		16-MAY-1994	16-MAY-1994	11-MAY-1994	30-APR-1994	14-MAY-1994	11-MAY-1994	10-MAY-1994
	UNITS							
VOLATILES								
Methylene Chloride	UG/KG	7 J	ND	7 J	ND	ND	7	ND
Acetone	UG/KG	ND	67 J	ND	11 J	ND	ND	144 J
Tetrachloroethene	UG/KG	ND	ND	60	ND	10	8	ND
SEMIVOLATILES								
Pyrene	UG/KG	ND	ND	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	UG/KG	ND	ND	NA	NA	NA	NA	NA

J- Value is estimated
NA - Not analyzed
ND - Not detected

TABLE 4-3
POSITIVE DETECTION SUMMARY
SUBSURFACE SOILS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW35B-01	35-MW35-02	35-MW36B-03	35-MW37BS-03	35-MW38BS-03
Lab Sample ID:		5057-18	4585-26	5057-1	5057-26	5057-25
Date Sampled:		10-MAY-1994	30-APR-1994	4-MAY-1994	15-MAY-1994	16-MAY-1994
	UNITS					
VOLATILES						
Methylene Chloride	UG/KG	ND	ND	ND	7 J	7 J
Acetone	UG/KG	ND	31	119 J	ND	ND
Tetrachloroethene	UG/KG	ND	ND	ND	23 J	ND
SEMIVOLATILES						
Pyrene	UG/KG	283 J	NA	NA	NA	NA
Benzo(b)fluoranthene	UG/KG	425	NA	NA	NA	NA

J- Value is estimated
NA - Not analyzed
ND - Not detected

TABLE 4-4
POSITIVE DETECTION SUMMARY
SUBSURFACE SOILS
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-GWDS01-03	35-GWDS2-03	35-GWDS3-03	35-GWDS4-02	35-GWDS05-03	35-MW29B-01	35-MW30B-01	35-MW35B-01
Lab Sample ID:		4585-15	5617-4	5617-2	5617-1	4585-17	5057-19	5057-17	5057-18
Date Sampled:		26-APR-1994	16-MAY-1994	16-MAY-1994	16-MAY-1994	28-APR-1994	10-MAY-1994	10-MAY-1994	10-MAY-1994
	UNITS								
Aluminum	MG/KG	2910	6190	3070	5650	6210	2860 J	3510 J	1870 J
Antimony	MG/KG	5.5 R	ND	ND	ND	6.7 R	ND	ND	ND
Arsenic	MG/KG	ND	0.19 J	0.39	1.2 J	2.7 J	0.68 J	0.82 J	0.4 J
Barium	MG/KG	5.5	10.7	4.8	25	15.8	8.6 J	12.5 J	5.4 J
Cadmium	MG/KG	0.59 R	0.49 J	0.13 J	0.03 J	0.67 R	0.07 J	0.09 J	0.04 J
Calcium	MG/KG	456 J	664 J	ND	ND	1040 J	1990 J	2420 J	361 J
Chromium	MG/KG	ND	5.9	3.1	10	14.4 J	3.6	4	3.4
Cobalt	MG/KG	ND	1.4	ND	ND	ND	ND	ND	ND
Copper	MG/KG	ND	2.7	1.9	2.3	ND	2.9	8.5	1.2
Iron	MG/KG	442 J	2560	1110	4030	10500 J	1390	1850	1170
→ Lead	MG/KG	8.1 J	15.4 J	4 J	6.5 J	16.7 J	144	11	10
Magnesium	MG/KG	63.5	149	93.3	217	403	188	200	ND
Manganese	MG/KG	5.6 J	6.4	1.5	3.2	3.8 J	7.1	7.5	3.2
Mercury	MG/KG	0.06 R	0.16 R	0.18 R	0.16 R	0.07 R	0.16 R	0.14 R	0.14 R
Nickel	MG/KG	ND	1.4	1.5	2	ND	ND	ND	1.2
Potassium	MG/KG	ND	ND	ND	ND	562	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	0.23 J	0.67 J	0.17 J	0.28 J	ND
Silver	MG/KG	0.39 J	ND	ND	ND	ND	ND	ND	ND
Thallium	MG/KG	ND	0.1	ND	2.1	0.51	ND	0.15	ND
Vanadium	MG/KG	3 J	7.6	4.4	13.2	19.9 J	5.5	5.5	4.4
Zinc	MG/KG	5.2 R	4.9 R	3.2 R	5.8 R	9 R	16.3	ND	ND

J - Value is estimated
ND - Not detected
R - Rejected positive value

TABLE 4-5
BASE BACKGROUND
SURFACE SOILS
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	6-201N-SB11-00	6-201N-SB12-00	6-201C-SB38-00	6-201C-SB39-00	78-BB-SB-00	41-BB-SB01-00	41-BB-SB02-00
Aluminum	1120	45.25	748	245	1490	528	1430
Antimony	4.7	4.8	1.4	1.3	0.33	2.07	0.865
Arsenic	0.28	0.29	0.91	0.28	0.22	0.356	0.317
Barium	2	2.05	16.5	3.5	8.6	1.525	4.06
Beryllium	0.095	0.1	0.03	0.03	0.11	0.1	0.09
Cadmium	0.285	0.295	0.58	0.175	0.55	0.392	0.349
Calcium	178	108	10700	402	941	18.3	54.6
Chromium	0.475	0.49	1.6	0.33	2.2	1.02	0.91
Cobalt	0.85	0.9	0.195	0.185	1.8	1.965	1.75
Copper	0.55	0.6	3.1	0.75	2	2	87.2
Iron	525	160	684	238	1020	83	970
Lead	2	3	62.9	25.1	20.4	2.59	10.9
Magnesium	11.65	10.1	200	26	118	8.85	39.1
Manganese	3.1	1	16	4.5	11.1	0.87	10.2
Mercury	0.01	0.01	0.05	0.06	0.05	0.0305	0.078
Nickel	1.6	1.65	0.8	0.75	2.2	3.55	3.15
Potassium	36.55	37.5	54.5	30.6	102	91.5	81.5
Selenium	0.47	0.485	0.5	0.465	0.31	0.311	0.277
Silver	0.95	1	0.195	0.185	0.33	0.1965	0.175
Sodium	19.65	15.85	14	4.7	67.5	44.1	39.3
Thallium	0.19	0.195	0.205	0.185	0.11	0.565	0.505
Vanadium	1.05	0.8	2.8	1.6	5.3	2.505	2.23
Zinc	0.55	0.8	23.1	4.6	28.3	2.66	6.11
Cyanide					0.265	1.23	1.09

Concentrations are in millograms per kilogram (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.

Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-5 (continued)
BASE BACKGROUND
SURFACE SOILS
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	41-BB-SB03-00	41-BB-SB04-00	69-BB-SB01-00	69-BB-SB02-00	69-BB-SB03-00	69-BB-SB04-00	74-BB-SB01-00
Aluminum	2100	5370	1310	4150	9570	5360	3110
Antimony	0.87	0.94	0.85	0.95	0.95	0.95	0.905
Arsenic	0.3205	0.345	0.31	0.345	0.79	0.35	0.3325
Barium	4.53	13.4	5.6	15.4	19.6	20.8	11.1
Beryllium	0.09	0.095	0.14	0.155	0.155	0.155	0.148
Cadmium	0.3525	0.38	0.26	0.285	0.29	0.29	0.2695
Calcium	79.2	46.3	28.2	43.6	282	53	181
Chromium	2.64	3.24	0.75	4	12.5	5.8	0.84
Cobalt	1.77	1.905	2.1	2.3	2.35	2.35	2.225
Copper	1.8	1.94	1.75	1.9	1.95	1.95	4.56
Iron	1120	2160	425	1430	9640	3890	1740
Lead	9.98	6.61	2.8	6	5.3	5.6	5.19
Magnesium	74	144	37.3	91.8	610	247	70
Manganese	11.6	11.8	15.1	12.7	12.3	8.3	9.44
Mercury	0.057	0.08	0.015	0.06	0.045	0.025	0.04
Nickel	3.2	3.45	2.9	1.6	1.65	1.65	1.56
Potassium	190	177	32.25	35.5	361	106	87.5
Selenium	0.2795	0.301	0.27	0.295	0.3	0.3	0.29
Silver	0.177	0.1905	0.045	0.045	4.3	0.39	0.046
Sodium	39.65	42.75	20	22	22.4	22.3	70.4
Thallium	0.51	0.55	0.495	0.55	0.55	0.55	0.53
Vanadium	2.255	2.43	1.8	1.95	13.5	5.6	5.21
Zinc	5.97	7.15	3.1	5.2	10.8	7.9	1.27
Cyanide	1.1	1.19	2.2	2.4	2.4	2.4	1.15

Concentrations are in millograms per kilogram (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-5 (continued)
BASE BACKGROUND
SURFACE SOILS
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	74-BB-SB02-00	74-BB-SB03-00	74-BB-SB04-00	1-BB-SB38-00	1-BB-SB39-00	1-GW13-00	28-BB-SB37-00	28-BB-SB38-00
Aluminum	1730	1000	2100	3920	4930	1600	2840	379
Antimony	0.925	0.855	0.96	3.6	3.15	8.0	3.55	2.9
Arsenic	0.339	0.314	0.352	0.315	0.28	0.29	0.31	0.255
Barium	1.6	3.12	16	9.6	9.3	2.8	5.1	1.8
Beryllium	0.151	0.14	0.1565	0.105	0.10	0.095	0.105	0.085
Cadmium	0.275	0.2545	0.285	0.315	0.28	0.285	0.31	0.255
Calcium	46.9	43.9	377	538	353	248	114	13.10
Chromium	2.7	0.795	1.98	3.5	4.7	4.1	2.0	0.60
Cobalt	2.27	2.1	2.355	0.42	0.375	0.38	0.415	0.34
Copper	3.92	1.755	1.965	1.6	0.6	1.9	0.6	0.50
Iron	401	787	1640	2270	1470	1000	1210	444
Lead	3.79	1.14	142	5.9	4.5	4.2	2.8	1.7
Magnesium	37.5	16.1	52.5	152	183	47.2	68.8	12.9
Manganese	3.13	7.37	4.61	10.6	4.2	5.9	2.7	3.3
Mercury	0.048	0.0305	0.05	0.03	0.025	0.03	0.025	0.025
Nickel	1.59	1.475	1.65	0.8	0.65	0.65	0.750	0.6
Potassium	89	82.5	92.5	149	153	20.650	29.75	8.35
Selenium	0.296	0.274	0.307	0.42	0.375	0.38	0.415	0.34
Silver	0.047	0.0435	0.0485	0.5	0.465	0.475	0.5	0.425
Sodium	71.8	87.6	122	11.0	17.2	7.25	28.5	18.2
Thallium	0.54	0.4985	0.56	0.42	0.38	0.38	0.415	0.34
Vanadium	1.94	1.8	4.69	7.9	6.1	3.5	3.6	2.1
Zinc	1.15	1.97	2.87	7.2	4.0	1.4	0.9	0.71
Cyanide	1.17	1.08	1.21					

Concentrations are in millograms per kilogram (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-5 (continued)
BASE BACKGROUND
SURFACE SOILS
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	28-GW09DW-00	30-BB-SB12-00	30-BB-SB13-00	30-BB-SB14-00	30-BB-SB15-00	30-BB-SB16-00	30-GW03-00	35-SS01-00
Aluminum	5460	54.6	24.9	49.2	37.5	196	17.7	2220.0
Antimony	3.35	3.2	3.2	3.3	3.5	3.650	3.9	2.45
Arsenic	1.8	0.28	0.29	0.29	0.31	0.325	0.34	0.065
Barium	11.6	1.8	0.7	0.7	0.7	3.100	0.8	15.6
Beryllium	0.10	0.095	0.10	0.10	0.10	0.110	0.12	0.11
Cadmium	0.295	0.28	0.29	0.29	0.31	0.325	0.34	0.04
Calcium	368	11.45	4.3	9.9	9.0	172	5.2	605.0
Chromium	6.0	1.6	0.7	1.9	0.7	0.75	0.8	1.9
Cobalt	0.91	0.375	0.38	0.38	0.41	0.43	0.45	0.60
Copper	2.9	0.55	0.6	0.6	0.6	0.65	0.7	3.9
Iron	2250	276	102	218	69.7	167	80.4	1250.0
Lead	11.6	3.3	0.47	2.4	0.73	4.4	0.86	3.60
Magnesium	157	6.5	2.6	2.6	2.8	37.1	3.1	71.6
Manganese	4.1	11.9	4.4	9.5	1.3	2.5	2.3	5.5
Mercury	0.025	0.06	0.02	0.03	0.05	0.03	0.03	0.065
Nickel	1.9	0.65	0.7	0.7	1.7	0.9	0.8	1.3
Potassium	158	8.25	11.1	3.8	1.0	29.6	1.2	129.5
Selenium	0.94	0.375	0.38	0.38	0.41	0.43	0.45	0.075
Silver	0.49	0.47	0.47	0.48	0.5	0.6	0.6	0.16
Sodium	15.0	14.8	26.0	4.9	5.2	18.2	5.8	126.00
Thallium	0.395	0.375	0.38	0.38	0.41	0.43	0.45	0.06
Vanadium	8.3	1.7	0.75	1.7	0.31	0.76	0.34	3.60
Zinc	6.6	0.35	0.30	0.48	1.7	2.0	1.2	7.4
Cyanide								

Concentrations are in millograms per kilogram (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-5 (continued)
BASE BACKGROUND
SURFACE SOILS
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	BB-SB02-00	BB-SB03-00	16-BB-SB01-00	80-BB-SB01-00	80-BB-SB02-00	80-BB-SB03-00	7-BB-SB01-00	7-BB-SB02-00
Aluminum	3630.0	1950.0	1710.0	2240.0	7770.0	2850.0	7180.0	3770.0
Antimony	5.00	5.55	5.05	1.35	1.40	1.40	6.05	5.50
Arsenic	1.000	1.100	1.000	0.250	3.200	0.265	1.200	1.100
Barium	7.4	7.0	4.1	9.9	13.0	11.6	12.0	10.2
Beryllium	0.10	0.11	0.23	0.020	0.10	0.06	0.26	0.11
Cadmium	0.50	0.55	0.50	0.165	0.175	0.175	0.600	0.550
Calcium	113.0	227.0	96.8	505	997.0	239.0	794.0	139.0
Chromium	3.3	2.5	1.0	1.200	10.0	2.0	8.4	3.8
Cobalt	1.00	1.10	1.00	0.205	1.30	0.45	1.20	1.10
Copper	1.0	1.1	1.0	1.3	2.2	0.92	1.20	1.10
Iron	2150.0	1610.0	1260.0	604.0	5550.0	1450.0	3050.0	2170.0
Lead	5.20	10.20	7.40	7.5	8.90	8.30	7.10	6.40
Magnesium	99.1	69.4	42.9	94.8	289.0	94.2	208.0	101.0
Manganese	7.4	5.5	6.9	66.0	30.7	12.8	6.5	6.2
Mercury	0.055	0.055	0.055	0.050	0.050	0.060	0.060	0.060
Nickel	2.0	2.25	2.00	1.4	2.70	1.40	2.40	2.20
Potassium	1.0	111.5	101.0	163.0	416.0	90.9	121.0	110.0
Selenium	0.500	0.550	0.500	0.285	0.300	0.300	0.600	0.550
Silver	0.50	0.55	0.50	0.220	0.23	0.23	0.60	0.55
Sodium	25.20	26.20	35.90	24.1	77.10	72.70	31.60	30.50
Thallium	1.00	1.10	1.00	0.435	0.46	0.465	1.200	1.100
Vanadium	5.40	3.10	4.50	2.3	14.70	4.30	9.70	5.40
Zinc	8.7	22.1	9.2	6.1	12.9	3.5	10.6	5.8
Cyanide								

Concentrations are in millograms per kilogram (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-5 (continued)
BASE BACKGROUND
SURFACE SOILS
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	7-BB-SB03-00	MIN	MAX	AVG	2Xaverage
Aluminum	5800.0	17.7	9570	2565.004	5130.008
Antimony	5.60	0.33	8	2.797	5.593
Arsenic	3.900	0.065	3.9	0.631	1.261
Barium	9.7	0.65	20.8	7.636	15.271
Beryllium	0.11	0.02	0.26	0.111	0.223
Cadmium	0.550	0.04	0.6	0.332	0.663
Calcium	615.0	4.25	10700	506.656	1013.313
Chromium	10.6	0.33	12.5	2.930	5.860
Cobalt	1.10	0.185	2.355	1.120	2.240
Copper	2.30	0.5	87.2	3.778	7.557
Iron	7510.0	69.7	9640	1617.285	3234.569
Lead	8.70	0.47	142	11.063	22.126
Magnesium	159.0	2.55	610	94.829	189.659
Manganese	3.6	0.87	66	9.152	18.304
Mercury	0.060	0.01	0.08	0.043	0.086
Nickel	2.25	0.6	3.55	1.666	3.332
Potassium	111.5	1	416	92.727	185.454
Selenium	1.300	0.075	1.3	0.410	0.819
Silver	0.55	0.0435	4.3	0.470	0.940
Sodium	34.60	4.7	126	35.432	70.864
Thallium	1.100	0.06	1.2	0.512	1.023
Vanadium	18.20	0.305	18.2	4.249	8.498
Zinc	7.6	0.3	28.3	6.002	12.005
Cyanide		0.265	2.4	1.453	2.905

Concentrations are in millograms per kilogram (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-6
BASE BACKGROUND
SUBSURFACE SOIL
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	6-201N-SB11-07	6-201N-SB12-02	6-201C-SB38-01	6-201C-SB39-04	78-BB-SB-01	2-GW09-01	1-BB-SB38-05	1-BB-SB39-04	1-BB-SB39-06
Aluminum	672	857	3620	2970	10200	8520	4580.000	6180.000	5980.000
Antimony	4.7	4.85	1.4	1.25	0.355	1.6	4.200	3.250	2.950
Arsenic	0.31	0.315	0.033	0.305	0.24	0.47	1.100	0.290	0.260
Barium	2	2.05	7.6	6.5	10.9	6.6	7.500	11.800	8.600
Beryllium	0.095	0.1	0.03	0.025	0.12	0.23	0.125	0.095	0.085
Cadmium	0.285	0.295	0.57	0.17	0.6	1.2	0.370	0.290	0.260
Calcium	5.35	5.4	4410	12.1	81.3	10.6	35.600	12.250	19.700
Chromium	1.6	1.85	6	2.2	5.7	8.7	10.500	5.500	5.300
Cobalt	0.65	0.9	0.235	0.175	0.95	1.9	0.495	0.385	0.350
Copper	0.475	0.6	1.7	0.65	0.95	0.47	6.600	0.600	0.500
Iron	257	126	456	833	822	2840	4940.000	1510.000	1210.000
Lead	1.2	1.6	11.5	2.7	6.1	4.3	5.100	3.800	3.100
Magnesium	13.1	12.7	133	86.8	188	260	222.000	189.000	217.000
Manganese	0.475	0.395	7.5	2.6	2.4	5.2	4.100	4.900	5.400
Mercury	0.01	0.01	0.04	0.015	0.045	0.11	0.025	0.025	0.020
Nickel	1.6	1.7	0.8	0.7	2.4	4.7	0.850	2.300	0.600
Potassium	48.9	40.8	84.7	187	123	184	409.000	191.000	268.000
Selenium	0.5	0.5	0.55	0.5	0.29	0.115	0.495	0.385	0.350
Silver	0.95	1	0.195	0.175	0.355	0.7	0.600	0.480	0.435
Sodium	12.7	12.15	13.25	7.25	44.9	31.5	12.850	21.600	9.200
Thallium	0.205	0.21	0.22	0.2	0.12	0.23	0.495	0.385	0.350
Vanadium	0.75	1	3	4.7	7.4	13.4	12.200	6.500	6.100
Zinc	0.475	0.395	11.6	0.9	2.1	1.4	4.700	2.900	2.400
					0.285	0.57			

Concentrations are in milligrams per kilograms (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-6 (continued)
BASE BACKGROUND
SUBSURFACE SOIL
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	1-GW13-04	1-GW13-08	28-BB-SB37-03	28-BB-SB38-04	28-GW09DW-01	30-BB-SB12-03	30-BB-SB13-01	30-BB-SB14-01	30-BB-SB15-01
Aluminum	4160.000	6600.000	5170.000	2830.000	5730.000	2970	17.1	25.7	42.6
Antimony	6.900	3.200	3.550	3.550	3.750	3.9	3.1	3.6	3.6
Arsenic	0.285	0.280	0.315	0.315	1.500	0.34	0.28	0.32	0.32
Barium	7.500	8.400	9.700	5.000	11.700	0.8	0.7	0.8	0.8
Beryllium	0.095	0.095	0.105	0.105	0.110	0.12	0.09	0.11	0.11
Cadmium	0.285	0.280	0.315	0.315	0.330	0.34	0.28	0.32	0.32
Calcium	52.400	92.600	23.450	6.850	441.000	7.0	6.9	4.8	6.3
Chromium	7.100	8.300	7.300	3.400	4.700	3.9	0.7	0.8	0.8
Cobalt	0.380	0.375	0.420	0.420	0.930	0.45	0.37	0.42	0.43
Copper	2.100	1.600	0.650	0.650	0.650	0.7	0.6	0.7	0.7
Iron	567.000	959.000	2090.000	749.000	2780.000	908	95.9	155	63.3
Lead	3.300	4.000	4.100	2.300	7.400	0.7	0.47	1.9	0.91
Magnesium	131.000	262.000	153.000	66.000	157.000	24.7	7.5	2.9	2.9
Manganese	2.000	4.500	3.200	1.500	5.300	1.7	4.3	6.7	1.1
Mercury	0.050	0.025	0.025	0.025	0.025	0.03	0.03	0.08	0.25
Nickel	0.650	0.650	0.750	0.750	1.000	0.8	0.7	0.8	2.2
Potassium	98.100	308.000	122.000	91.300	136.000	13.2	6.3	1.1	21.3
Selenium	0.380	0.375	0.420	0.420	0.440	0.45	0.37	0.42	0.43
Silver	0.475	0.470	0.500	0.550	0.550	0.6	0.46	0.6	0.6
Sodium	9.600	10.900	33.800	28.600	20.300	12.5	11.1	19.3	5.4
Thallium	0.380	0.375	0.420	0.420	0.440	0.45	0.37	0.42	0.43
Vanadium	3.500	10.100	6.400	2.800	8.500	6.2	0.73	1.0	0.84
Zinc	1.000	2.700	1.900	0.970	4.200	0.35	0.32	0.39	1.2

Concentrations are in milligrams per kilograms (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-6 (continued)
BASE BACKGROUND
SUBSURFACE SOIL
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	30-BB-SB16-02	30-GW03-01	35-GWDS01-03	BB-SB02-07	BB-SB03-05	80-BB-SB02-06	80-SS-SB01-03	80-BB-SB02-03	80-BB-SB02-06	80-BB-SB03-03
Aluminum	777	16.9	2910.0	888.0	2330.0	11000.0	2520.0	5950.0	9600.0	9500.0
Antimony	3.4	3.9	2.750	5.000	5.600	6.200	1.300	1.350	1.650	3.500
Arsenic	0.30	0.34	0.12	1.00	1.10	15.40	0.245	1.60	4.70	1.80
Barium	3.5	0.8	5.5	1.6	3.8	22.3	4.5	9.9	13.5	10.9
Beryllium	0.10	0.12	0.06	0.10	0.11	0.31	0.01	0.04	0.20	0.09
Cadmium	0.30	0.34	0.30	0.50	0.55	0.205	0.16	0.165	0.205	0.16
Calcium	116	6.6	456.0	74.2	290.0	257.0	105.0	323.0	210.0	142.0
Chromium	0.7	0.8	2.2	2.4	4.2	66.4	2.1	10.0	22.0	12.0
Cobalt	0.40	0.46	0.65	1.00	1.10	7.00	0.42	0.71	1.40	0.75
Copper	0.6	0.7	0.550	1.000	1.100	9.500	0.670	1.600	4.400	2.200
Iron	514	74.5	442.0	1220.0	1870.0	90500.0	795.0	2920.0	12800.0	3350.0
Lead	3.2	0.59	8.10	2.40	3.80	21.40	2.90	5.00	11.70	7.80
Magnesium	30.2	3.1	63.5	35.7	115.0	852.0	76.0	282.0	455.0	357.0
Manganese	3.7	1.7	5.6	2.7	2.4	14.9	1.8	19.9	7.4	6.2
Mercury	0.03	0.68	0.03	0.055	0.06	0.07	0.045	0.055	0.07	0.045
Nickel	1.7	0.8	1.050	2.000	2.250	0.600	0.455	1.400	0.600	2.200
Potassium	21.9	1.2	145.0	100.5	228.0	1250.0	161.0	297.0	1020.0	458.0
Selenium	0.40	0.46	0.085	0.500	0.550	2.400	0.275	0.285	0.355	0.275
Silver	0.50	0.6	0.39	0.50	0.55	0.275	0.21	0.22	0.275	0.21
Sodium	14.4	5.8	141.0	20.6	28.2	124.0	63.4	25.5	47.1	73.2
Thallium	0.40	0.46	0.06	1.00	1.10	2.70	0.425	0.44	0.55	0.42
Vanadium	1.6	0.34	3.00	3.90	4.90	69.40	2.30	10.80	18.40	13.50
Zinc	1.7	1.3	2.6	8.7	4.9	26.6	2.0	3.5	8.1	4.8

Concentrations are in milligrams per kilograms (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-6 (continued)
BASE BACKGROUND
SUBSURFACE SOIL
TAL INORGANICS
MCB CAMP LEJEUNE, NORTH CAROLINA

	80-BB-SB03-06	7-BB-SB01-05	7-BB-SB02-05	7-BB-SB03-09	MIN	MAX	AVG	2Xaverage
Aluminum	1060.0	1400.0	1700.0	581.0	16.900	11000.000	3792.416	7584.831
Antimony	1.300	5.150	5.150	5.750	0.355	6.900	3.488	6.975
Arsenic	0.24	1.05	1.05	1.15	0.033	15.400	1.167	2.335
Barium	4.3	16.1	22.6	10.8	0.650	22.600	7.466	14.931
Beryllium	0.01	0.105	0.105	0.115	0.010	0.310	0.103	0.206
Cadmium	0.155	0.50	0.50	0.550	0.155	1.200	0.356	0.712
Calcium	34.2	77.9	83.1	64.3	4.750	4410.000	233.522	467.044
Chromium	2.9	3.4	6.2	3.9	0.650	66.400	6.981	13.963
Cobalt	0.20	1.05	1.05	1.15	0.175	7.000	0.861	1.723
Copper	0.630	1.05	1.05	1.15	0.470	9.500	1.467	2.934
Iron	557.0	571.0	709.0	1620.0	63.300	90500.000	4353.241	8706.481
Lead	5.40	3.00	1.80	1.10	0.465	21.400	4.458	8.917
Magnesium	50.7	61.2	88.2	24.5	2.850	852.000	144.455	288.909
Manganese	5.4	3.9	5.3	4.2	0.395	19.900	4.637	9.273
Mercury	0.045	0.055	0.050	0.060	0.010	0.680	0.068	0.136
Nickel	0.450	2.050	2.050	2.300	0.450	4.700	1.367	2.735
Potassium	130.0	103.0	102.5	114.5	1.050	1250.000	202.067	404.134
Selenium	0.275	0.50	0.50	0.55	0.085	2.400	0.462	0.924
Silver	0.21	0.50	0.50	0.55	0.175	1.000	0.468	0.936
Sodium	18.3	33.7	27.2	31.3	5.400	141.000	30.331	60.663
Thallium	0.42	1.05	1.05	1.15	0.060	2.700	0.542	1.083
Vanadium	2.40	2.30	3.10	2.50	0.340	69.400	7.299	14.598
Zinc	1.7	6.2	4.2	6.3	0.320	26.600	3.825	7.650

Concentrations are in milligrams per kilograms (mg/kg).
Qualifiers have been removed per Baker's standards.
Qualifiers R, U, and UJ have been given one-half the detection value.
Qualifiers J, NJ, and B have been removed with no detection value change.

TABLE 4-7
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

		Surficial/upper 1	2	3	Castle Hayne	2	3	4
Client Sample ID:		**35-EMW03-03**	**35-EMW05-03**	**35-EMW7-03**	35-GWDW1-01	35-GWDW2-01	35-GWDW3-01	35-GWDW4-01
Lab Sample ID:		**D94-5361-5**	**D94-5361-1**	**D94-5361-10**	D94-5361-6	D94-5529-1	D94-5529-2	D94-5361-14
Date Sampled:		**14-MAY-1994**	**14-MAY-1994**	**14-MAY-1994**	14-MAY-1994	14-MAY-1994	15-MAY-1994	15-MAY-1994
	UNITS							
VOLATILES								
1,1,2,2-Tetrachloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Chloroform	UG/L	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/L	23.4	13.8	137	ND	ND	ND	ND
cis-1,2-Dichloroethene	UG/L	90.5	35.4	353	ND	ND	ND	ND
trans-1,2-Dichloroethene	UG/L	6.4	3.4	44	ND	ND	ND	ND
Benzene	UG/L	0.3	0.6	16	ND	0.7	0.7	ND
Ethyl benzene	UG/L	0.4	0.7	11	0.9	1.4	2	0.7
Methyl Tertiary Butyl Ether	UG/L	12.7	ND	86.8	ND	ND	ND	ND
Toluene	UG/L	0.4	0.5	9	ND	0.9	1	1
Xylenes	UG/L	1.5	1.9	40	2.1	4.5	4.7	1.8
SEMIVOLATILES								
Phenol	UG/L	ND	ND	ND	NA	NA	NA	NA
2-Methylphenol	UG/L	ND	ND	ND	NA	NA	NA	NA
4-Methylphenol	UG/L	ND	ND	ND	NA	NA	NA	NA
2,4-Dimethylphenol	UG/L	ND	ND	ND	NA	NA	NA	NA
Naphthalene	UG/L	ND	7 J	ND	NA	NA	NA	NA
2-Methylnaphthalene	UG/L	ND	ND	ND	NA	NA	NA	NA
Dibenzofuran	UG/L	ND	ND	ND	NA	NA	NA	NA

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer. 22 total

(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer. 18 total

(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer. 5 total

(4) J - Value is estimated.

(5) NA - Not analyzed.

(6) ND - Not detected.

(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-EMW03-03	35-EMW05-03	35-EMW7-03	35-GWDW1-01	35-GWDW2-01	35-GWDW3-01	35-GWDW4-01
Lab Sample ID:		D94-5361-5	D94-5361-1	D94-5361-10	D94-5361-6	D94-5529-1	D94-5529-2	D94-5361-14
Date Sampled:		14-MAY-1994	14-MAY-1994	14-MAY-1994	14-MAY-1994	14-MAY-1994	15-MAY-1994	15-MAY-1994
	UNITS							
SEMIVOLATILES (continued)								
Fluorene	UG/L	ND	ND	ND	NA	NA	NA	NA
Phenanthrene	UG/L	ND	ND	ND	NA	NA	NA	NA
Anthracene	UG/L	ND	ND	ND	NA	NA	NA	NA
Carbazole	UG/L	ND	ND	ND	NA	NA	NA	NA
PESTICIDE/PCBs								
beta-BHC	UG/L	NA	NA	NA	NA	NA	NA	NA
delta-BHC	UG/L	NA	NA	NA	NA	NA	NA	NA
Heptachlor	UG/L	NA	NA	NA	NA	NA	NA	NA
Aldrin	UG/L	NA	NA	NA	NA	NA	NA	NA
4,4'-DDD	UG/L	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	UG/L	NA	NA	NA	NA	NA	NA	NA

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

		Castle Hayne 5	Surficial/upper 4		6	7	Surficial/lower 1	8
Client Sample ID:		35-GWDW5-01	35-MW02S-02	35-MW04S-02	35-MW06S-02	35-MW09S-02	35-MW09D-02	35-MW10S-02
Lab Sample ID:		D94-5361-13	D94-4917-3	D94-4917-5	D94-4917-1	D94-5296-5	D94-5296-6	D94-5296-13
Date Sampled:		15-MAY-1994	26-APR-1994	26-APR-1994	26-APR-1994	10-MAY-1994	11-MAY-1994	12-MAY-1994
	UNITS							
VOLATILES								
1,1,2,2-Tetrachloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Chloroform	UG/L	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/L	ND	ND	ND	ND	ND	6.1	3.8
cis-1,2-Dichloroethene	UG/L	ND	ND	ND	ND	ND	3.3	32
trans-1,2-Dichloroethene	UG/L	ND	ND	ND	ND	ND	ND	2.6
Benzene	UG/L	ND	6	0.2	ND	ND	1.2	3.4
Ethyl benzene	UG/L	1	44	ND	ND	0.7	1.6	0.9
Methyl Tertiary Butyl Ether	UG/L	ND	ND	ND	ND	ND	ND	6.6 J
Toluene	UG/L	0.8	12	0.4	ND	0.3	1.2	0.6
Xylenes	UG/L	1.6	50	0.6	1	2	3.3	2.3
SEMIVOLATILES								
Phenol	UG/L	ND	NA	NA	NA	ND	ND	ND
2-Methylphenol	UG/L	ND	NA	NA	NA	ND	ND	ND
4-Methylphenol	UG/L	ND	NA	NA	NA	ND	ND	ND
2,4-Dimethylphenol	UG/L	ND	NA	NA	NA	ND	ND	ND
Naphthalene	UG/L	ND	NA	NA	NA	ND	ND	ND
2-Methylnaphthalene	UG/L	ND	NA	NA	NA	ND	ND	ND
Dibenzofuran	UG/L	ND	NA	NA	NA	ND	ND	ND

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-GWDW5-01	**35-MW02S-02**	**35-MW04S-02**	**35-MW06S-02**	**35-MW09S-02**	35-MW09D-02	**35-MW10S-02**
Lab Sample ID:		D94-5361-13	**D94-4917-3**	**D94-4917-5**	**D94-4917-1**	**D94-5296-5**	D94-5296-6	**D94-5296-13**
Date Sampled:		15-MAY-1994	**26-APR-1994**	**26-APR-1994**	**26-APR-1994**	**10-MAY-1994**	11-MAY-1994	**12-MAY-1994**
	UNITS							
SEMIVOLATILES (continued)								
Fluorene	UG/L	ND	NA	NA	NA	ND	ND	ND
Phenanthrene	UG/L	ND	NA	NA	NA	ND	ND	ND
Anthracene	UG/L	ND	NA	NA	NA	ND	ND	ND
Carbazole	UG/L	ND	NA	NA	NA	ND	ND	ND
PESTICIDE/PCBs								
beta-BHC	UG/L	ND	NA	NA	NA	NA	NA	NA
delta-BHC	UG/L	ND	NA	NA	NA	NA	NA	NA
Heptachlor	UG/L	ND	NA	NA	NA	NA	NA	NA
Aldrin	UG/L	ND	NA	NA	NA	NA	NA	NA
4,4'-DDD	UG/L	ND	NA	NA	NA	NA	NA	NA
4,4'-DDT	UG/L	ND	NA	NA	NA	NA	NA	NA

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

		Surf/lower	Surficial/upper					
		2	9	3	10	4	11	5
Client Sample ID:		35-MW10D-02	35-MW14S-02	35-MW14D-02	35-MW16S-02	35-MW16D-02	35-MW19S-02	35-MW19D-02
Lab Sample ID:		D94-5296-8	D94-5296-10	D94-5296-11	D94-5296-16	D94-5296-12	D94-5296-17	D94-5296-22
Date Sampled:		11-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994
	UNITS							
VOLATILES								
1,1,2,2-Tetrachloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Chloroform	UG/L	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/L	649	299	180	ND	ND	26.8	900
cis-1,2-Dichloroethene	UG/L	973	682	185	ND	ND	26	664
trans-1,2-Dichloroethene	UG/L	102	47	18	ND	ND	6	176
Benzene	UG/L	ND	ND	ND	698	0.5	ND	ND
Ethyl benzene	UG/L	36	18	6	420	1.1	0.8	29
Methyl Tertiary Butyl Ether	UG/L	241	92.5	43.9	34.1	ND	ND	319
Toluene	UG/L	59	17	12	984	1	0.6	12
Xylenes	UG/L	135	54	19	1700	2.5	1.8	50
SEMIVOLATILES								
Phenol	UG/L	ND	ND	ND	11	ND	ND	ND
2-Methylphenol	UG/L	ND	ND	ND	ND	ND	ND	ND
4-Methylphenol	UG/L	ND	ND	ND	6 J	ND	ND	ND
2,4-Dimethylphenol	UG/L	ND	ND	ND	ND	ND	ND	ND
Naphthalene	UG/L	ND	ND	ND	75	ND	ND	ND
2-Methylnaphthalene	UG/L	ND	ND	ND	70	ND	ND	ND
Dibenzofuran	UG/L	ND	ND	ND	ND	ND	ND	ND

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW10D-02	35-MW14S-02	35-MW14D-02	35-MW16S-02	35-MW16D-02	35-MW19S-02	35-MW19D-02
Lab Sample ID:		D94-5296-8	D94-5296-10	D94-5296-11	D94-5296-16	D94-5296-12	D94-5296-17	D94-5296-22
Date Sampled:		11-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994
	UNITS							
SEMIVOLATILES (continued)								
Fluorene	UG/L	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	UG/L	ND	ND	ND	ND	ND	ND	ND
Anthracene	UG/L	ND	ND	ND	ND	ND	ND	ND
Carbazole	UG/L	ND	ND	ND	ND	ND	ND	ND
PESTICIDE/PCBs								
beta-BHC	UG/L	NA	NA	NA	NA	NA	NA	NA
delta-BHC	UG/L	NA	NA	NA	NA	NA	NA	NA
Heptachlor	UG/L	NA	NA	NA	NA	NA	NA	NA
Aldrin	UG/L	NA	NA	NA	NA	NA	NA	NA
4,4'-DDD	UG/L	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	UG/L	NA	NA	NA	NA	NA	NA	NA

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

		Surficial / upper	Surf/lower					
		12	6	13	7	14	8	25
Client Sample ID:		35-MW21S-02	35-MW21D-02	35-MW22S-02	35-MW22D-02	35-MW25S-02	35-MW25D-02	35-MW26AW-02
Lab Sample ID:		D94-5296-23	D94-5296-24	D94-5361-17	D94-5361-2	D94-5361-4	D94-5361-18	D94-5529-8
Date Sampled:		13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	17-MAY-1994
	UNITS							
VOLATILES								
1,1,2,2-Tetrachloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	UG/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Chloroform	UG/L	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/L	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/L	ND	8.3	ND	0.4	ND	ND	ND
cis-1,2-Dichloroethene	UG/L	ND	13.9	ND	38.3	ND	ND	ND
trans-1,2-Dichloroethene	UG/L	ND	1.5	ND	ND	ND	ND	ND
Benzene	UG/L	210	ND	1660	1.7	25	0.3	0.7
Ethyl benzene	UG/L	824	0.7	96	0.5	259	0.6	1.8
Methyl Tertiary Butyl Ether	UG/L	ND	ND	13.4	ND	ND	ND	ND
Toluene	UG/L	45	0.6	86	0.5	122	0.7	1.3
Xylenes	UG/L	1320	2.1	100	1.4	561	1.6	3.7
SEMIVOLATILES								
Phenol	UG/L	ND	ND	23	ND	ND	ND	NA
2-Methylphenol	UG/L	ND	ND	ND	ND	ND	ND	NA
4-Methylphenol	UG/L	ND	ND	ND	ND	ND	ND	NA
2,4-Dimethylphenol	UG/L	ND	ND	ND	ND	ND	ND	NA
Naphthalene	UG/L	499	ND	118	ND	123	ND	NA
2-Methylnaphthalene	UG/L	668	ND	152	ND	131	ND	NA
Dibenzofuran	UG/L	23	ND	14	ND	8 J	ND	NA

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW21S-02	35-MW21D-02	35-MW22S-02	35-MW22D-02	35-MW25S-02	35-MW25D-02	35-MW26AW-02
Lab Sample ID:		D94-5296-23	D94-5296-24	D94-5361-17	D94-5361-2	D94-5361-4	D94-5361-18	D94-5529-8
Date Sampled:		13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	17-MAY-1994
	UNITS							
SEMIVOLATILES (continued)								
Fluorene	UG/L	22	ND	21	ND	8 J	ND	NA
Phenanthrene	UG/L	52	ND	31	ND	10 J	ND	NA
Anthracene	UG/L	7 J	ND	ND	ND	ND	ND	NA
Carbazole	UG/L	12	ND	13	ND	ND	ND	NA
PESTICIDE/PCBs								
beta-BHC	UG/L	0.023 J	ND	NA	NA	NA	NA	NA
delta-BHC	UG/L	ND	ND	NA	NA	NA	NA	NA
Heptachlor	UG/L	ND	ND	NA	NA	NA	NA	NA
Aldrin	UG/L	0.013 J	ND	NA	NA	NA	NA	NA
4,4'-DDD	UG/L	ND	ND	NA	NA	NA	NA	NA
4,4'-DDT	UG/L	ND	ND	NA	NA	NA	NA	NA

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

		surf/lower	surficial/upper				
		9	10	10	11	11	12
Client Sample ID:		35-MW26BW-01	35-MW29A-01	35-MW29BW-01	35-MW30AW-01	35-MW30BW-01	35-MW31BW-01
Lab Sample ID:		D94-5529-17	D94-5296-1	D94-5296-4	D94-5529-4	D94-5361-11	D94-5361-15
Date Sampled:		20-MAY-1994	10-MAY-1994	10-MAY-1994	16-MAY-1994	15-MAY-1994	14-MAY-1994
	UNITS						
VOLATILES							
1,1,2,2-Tetrachloroethane	UG/L	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/L	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	UG/L	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	UG/L	ND	ND	ND	ND	ND	ND
Chloroform	UG/L	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/L	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/L	ND	ND	255	ND	217	ND
cis-1,2-Dichloroethene	UG/L	260	ND	53	ND	485	234
trans-1,2-Dichloroethene	UG/L	ND	ND	6	ND	115	26
Benzene	UG/L	ND	4.1	2.5	ND	16	15
Ethyl benzene	UG/L	ND	2.4	0.9	0.9	11	21
Methyl Tertiary Butyl Ether	UG/L	ND	ND	22.3	ND	223	76.3
Toluene	UG/L	ND	2.2	1.6	1.3	15	14
Xylenes	UG/L	ND	6.6	1.9	1.7	40	66
SEMIVOLATILES							
Phenol	UG/L	NA	ND	ND	NA	NA	NA
2-Methylphenol	UG/L	NA	17	ND	NA	NA	NA
4-Methylphenol	UG/L	NA	ND	ND	NA	NA	NA
2,4-Dimethylphenol	UG/L	NA	74	ND	NA	NA	NA
Naphthalene	UG/L	NA	71	ND	NA	NA	NA
2-Methylnaphthalene	UG/L	NA	81 J	ND	NA	NA	NA
Dibenzofuran	UG/L	NA	ND	ND	NA	NA	NA

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW26BW-01	35-MW29A-01	35-MW29BW-01	35-MW30AW-01	35-MW30BW-01	35-MW31BW-01
Lab Sample ID:		D94-5529-17	D94-5296-1	D94-5296-4	D94-5529-4	D94-5361-11	D94-5361-15
Date Sampled:		20-MAY-1994	10-MAY-1994	10-MAY-1994	16-MAY-1994	15-MAY-1994	14-MAY-1994
	UNITS						
SEMIVOLATILES (continued)							
Fluorene	UG/L	NA	ND	ND	NA	NA	NA
Phenanthrene	UG/L	NA	ND	ND	NA	NA	NA
Anthracene	UG/L	NA	ND	ND	NA	NA	NA
Carbazole	UG/L	NA	ND	ND	NA	NA	NA
PESTICIDE/PCBs							
beta-BHC	UG/L	NA	0.022 J	ND	NA	NA	NA
delta-BHC	UG/L	NA	ND	0.05 J	NA	NA	NA
Heptachlor	UG/L	NA	0.011 J	ND	NA	NA	NA
Aldrin	UG/L	NA	0.017 J	ND	NA	NA	NA
4,4'-DDD	UG/L	NA	ND	0.21 J	NA	NA	NA
4,4'-DDT	UG/L	NA	ND	ND	NA	NA	NA

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

		Surficial/upper	Surf/lower				
		18	13	19	14	20	15
Client Sample ID:		35-MW32AW-01	35-MW32BW-01	35-MW33AW-01	35-MW33BW-01	35-MW34AW-01	35-MW34BW-01
Lab Sample ID:		D94-5529-15	D94-5715-6	D94-5529-14	D94-5529-7	D94-5361-8	D94-5361-7
Date Sampled:		19-MAY-1994	19-MAY-1994	19-MAY-1994	17-MAY-1994	16-MAY-1994	16-MAY-1994
	<u>UNITS</u>						
VOLATILES							
1,1,2,2-Tetrachloroethane	UG/L	20.5	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/L	1.9	ND	ND	ND	ND	ND
1,1-Dichloroethane	UG/L	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	UG/L	ND	ND	ND	ND	ND	ND
Chloroform	UG/L	ND	ND	ND	ND	ND	ND
Tetrachloroethene	UG/L	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/L	25.8	197	ND	574	ND	0.6
cis-1,2-Dichloroethene	UG/L	96.2	594	ND	788	ND	11.6
trans-1,2-Dichloroethene	UG/L	39.8	102	ND	130	ND	ND
Benzene	UG/L	1	3 J	ND	22	ND	0.4
Ethyl benzene	UG/L	1.3	3 J	1.1	41	ND	0.6
Methyl Tertiary Butyl Ether	UG/L	72.9	172	ND	265	ND	ND
Toluene	UG/L	1.1	3 J	1.7	30	ND	0.4
Xylenes	UG/L	4.2	9	3.9	95	1.7	1.8
SEMIVOLATILES							
Phenol	UG/L	NA	NA	ND	ND	NA	NA
2-Methylphenol	UG/L	NA	NA	ND	ND	NA	NA
4-Methylphenol	UG/L	NA	NA	ND	ND	NA	NA
2,4-Dimethylphenol	UG/L	NA	NA	ND	ND	NA	NA
Naphthalene	UG/L	NA	NA	ND	ND	NA	NA
2-Methylnaphthalene	UG/L	NA	NA	ND	ND	NA	NA
Dibenzofuran	UG/L	NA	NA	ND	ND	NA	NA

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW32AW-01	35-MW32BW-01	35-MW33AW-01	35-MW33BW-01	35-MW34AW-01	35-MW34BW-01
Lab Sample ID:		D94-5529-15	D94-5715-6	D94-5529-14	D94-5529-7	D94-5361-8	D94-5361-7
Date Sampled:		19-MAY-1994	19-MAY-1994	19-MAY-1994	17-MAY-1994	16-MAY-1994	16-MAY-1994
	UNITS						
SEMIVOLATILES (continued)							
Fluorene	UG/L	NA	NA	ND	ND	NA	NA
Phenanthrene	UG/L	NA	NA	ND	ND	NA	NA
Anthracene	UG/L	NA	NA	ND	ND	NA	NA
Carbazole	UG/L	NA	NA	ND	ND	NA	NA
PESTICIDE/PCBs							
beta-BHC	UG/L	NA	NA	ND	0.022 J	NA	NA
delta-BHC	UG/L	NA	NA	ND	ND	NA	NA
Heptachlor	UG/L	NA	NA	ND	0.013 J	NA	NA
Aldrin	UG/L	NA	NA	ND	ND	NA	NA
4,4'-DDD	UG/L	NA	NA	ND	ND	NA	NA
4,4'-DDT	UG/L	NA	NA	ND	0.014 J	NA	NA

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Surf/lower

		20	16	21	17	18
Client Sample ID:		35-MW35AW-01	35-MW35BW-01	35-MW36AW-01	35-MW36BW-01	35-MW37BW-01
Lab Sample ID:		D94-5529-3	D94-5361-16	D94-5361-19	D94-5361-3	D94-5715-4
Date Sampled:		14-MAY-1994	15-MAY-1994	15-MAY-1994	15-MAY-1994	19-MAY-1994
	<u>UNITS</u>					
VOLATILES						
1,1,2,2-Tetrachloroethane	UG/L	64.7	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/L	1	ND	ND	ND	ND
1,1-Dichloroethane	UG/L	ND	3.4	2.5	7.6	ND
1,1-Dichloroethene	UG/L	0.8	5.7	2.1	6.9	ND
Chloroform	UG/L	0.6	ND	ND	ND	ND
Tetrachloroethene	UG/L	1.9	ND	ND	ND	ND
Trichloroethene	UG/L	79	0.6	ND	ND	ND
cis-1,2-Dichloroethene	UG/L	14.8	3.2	ND	ND	ND
trans-1,2-Dichloroethene	UG/L	3.7	0.4	ND	ND	ND
Benzene	UG/L	0.4	ND	1.7	0.5	5.3
Ethyl benzene	UG/L	0.7	0.8	0.8	0.6	0.3
Methyl Tertiary Butyl Ether	UG/L	ND	ND	ND	ND	ND
Toluene	UG/L	1.1	0.5	0.8	0.7	2.2
Xylenes	UG/L	1.7	1.9	3	1.9	0.6
SEMIVOLATILES						
Phenol	UG/L	NA	NA	NA	NA	NA
2-Methylphenol	UG/L	NA	NA	NA	NA	NA
4-Methylphenol	UG/L	NA	NA	NA	NA	NA
2,4-Dimethylphenol	UG/L	NA	NA	NA	NA	NA
Naphthalene	UG/L	NA	NA	NA	NA	NA
2-Methylnaphthalene	UG/L	NA	NA	NA	NA	NA
Dibenzofuran	UG/L	NA	NA	NA	NA	NA

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-7 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW35AW-01	35-MW35BW-01	35-MW36AW-01	35-MW36BW-01	35-MW37BW-01
Lab Sample ID:		D94-5529-3	D94-5361-16	D94-5361-19	D94-5361-3	D94-5715-4
Date Sampled:		14-MAY-1994	15-MAY-1994	15-MAY-1994	15-MAY-1994	19-MAY-1994
	UNITS					
SEMIVOLATILES (continued)						
Fluorene	UG/L	NA	NA	NA	NA	NA
Phenanthrene	UG/L	NA	NA	NA	NA	NA
Anthracene	UG/L	NA	NA	NA	NA	NA
Carbazole	UG/L	NA	NA	NA	NA	NA
PESTICIDE/PCBs						
beta-BHC	UG/L	NA	NA	NA	NA	NA
delta-BHC	UG/L	NA	NA	NA	NA	NA
Heptachlor	UG/L	NA	NA	NA	NA	NA
Aldrin	UG/L	NA	NA	NA	NA	NA
4,4'-DDD	UG/L	NA	NA	NA	NA	NA
4,4'-DDT	UG/L	NA	NA	NA	NA	NA

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-8
POSITIVE DETECTION SUMMARY
GROUNDWATER
TOTAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-EMW03-03	35-EMW05-03	35-EMW7-03	35-GWDW5-01	35-MW09S-02	35-MW09D-02	35-MW10S-02	35-MW10D-02
Lab Sample ID:		5361-5	5361-1	5361-10	5361-13	5296-5	5296-6	5296-13	5296-8
Date Sampled:		14-MAY-1994	14-MAY-1994	14-MAY-1994	15-MAY-1994	10-MAY-1994	11-MAY-1994	12-MAY-1994	11-MAY-1994
	UNITS								
Aluminum	UG/L	4960	43800	81000	215	93000	10800	218000	24600
Antimony	UG/L	ND	ND	ND	ND	46 R	46 R	46 R	46 R
Arsenic	UG/L	3.5	23.4	10.7	2.6	86.5 J	7.8 J	165 J	20.3 J
Barium	UG/L	60.4 J	114	1410	20.7	706	132	2230	271
Beryllium	UG/L	1.5	2.5	16.7	ND	14	3	40	6
Cadmium	UG/L	1.6	1.8	4.7	ND	4.4 J	1.3 J	19.7 R	3.6 J
Calcium	UG/L	215000	47400	834000	49300	256000	202000	2050000	443000
Chromium	UG/L	25.6	91.4	283	ND	451	96	1120	206
Cobalt	UG/L	26	ND	67.9	ND	19	ND	60	ND
Copper	UG/L	5	20.4	32.8	2.7	41	15	140	25
Iron	UG/L	10400	36500	81000	310	55300	10200	111000	20900
Lead	UG/L	2.7	35.6 R	22.3 R	1.6	35.7	10.7 J	57.6	9.7 J
Magnesium	UG/L	4880	5990	20500	2560	13200	5180	42600	9690
Manganese	UG/L	45.7	75.8	281	13.3	273	49	462	83
Mercury	UG/L	ND	ND	0.17 J	0.46 J	ND	ND	ND	ND
Nickel	UG/L	28.8	18.8	104	ND	62	18	221	29
Potassium	UG/L	ND	4540	7370	5730	9140	ND	12800	4670
Selenium	UG/L	ND	ND	ND	ND	2.1 J	1.7	7 R	7 R
Silver	UG/L	ND	ND	ND	ND	ND	ND	20	ND
Sodium	UG/L	6930	12300	7750	33900	68200	9450	45400	9070
Thallium	UG/L	ND	2 J	1.3	ND	2.3	ND	4.8 J	1.1
Vanadium	UG/L	35.5	92.6	185	ND	246	37	537	90
Zinc	UG/L	81.1	148	383	ND	867	91 R	947	147 R

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-8
POSITIVE DETECTION SUMMARY
GROUNDWATER
TOTAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW14S-02	35-MW14D-02	35-MW16S-02	35-MW16D-02	35-MW19S-02	35-MW19D-02	35-MW21S-02	35-MW21D-02
Lab Sample ID:		5296-10	5296-11	5296-16	5296-12	5296-17	5296-22	5296-23	5296-24
Date Sampled:		12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	13-MAY-1994	13-MAY-1994
	UNITS								
Aluminum	UG/L	114000	5110	158000	8870	101000	23000	119000	4350
Antimony	UG/L	46 R	46 R	46 R	46 R	46 R	46 R	46 R	46 R
Arsenic	UG/L	30.2 J	2.9 J	6 J	1.2 R	6.3 J	4.5 J	103 J	1.9 J
Barium	UG/L	2210	118	870	82	287	99	1400	77
Beryllium	UG/L	30	1	34	4	11	12	29	1
Cadmium	UG/L	6.8 J	1.1 J	8.2 J	1.3 J	10.2 J	15	11.1	1 J
Calcium	UG/L	896000	164000	886000	131000	104000	210000	1200000	330000
Chromium	UG/L	743	64	735	81	301	201	1050	81
Cobalt	UG/L	17	ND	33	ND	168	118	32	ND
Copper	UG/L	78	12	70	16	38	21	83	11
Iron	UG/L	77700	5530	137000	31300	139000	63300	255000	9730
Lead	UG/L	23.6	4.4 J	29.9	5.3 J	64	13.1	31	3.2 J
Magnesium	UG/L	25300	3970	27200	5390	9650	10200	33300	8590
Manganese	UG/L	195	32	408	344	684	1420	121	65
Mercury	UG/L	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	UG/L	85	ND	127	30	174	148	138	ND
Potassium	UG/L	5590	3090	8300	ND	10900	ND	9000	ND
Selenium	UG/L	13.5 J	2 J	7 R	1.4 R	1.4 J	7 R	7 J	7 R
Silver	UG/L	4	ND	4	ND	ND	ND	ND	ND
Sodium	UG/L	10500	8450	4470	7540	14600	ND	10900	23100
Thallium	UG/L	3.3	ND	2.5	1	2.8	1.6	4.5	ND
Vanadium	UG/L	302	26	466	48	228	99	447	33
Zinc	UG/L	493 R	151 R	689	138 R	714	707	622	42 R

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-8
POSITIVE DETECTION SUMMARY
GROUNDWATER
TOTAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW22S-02	35-MW22D-02	35-MW25S-02	35-MW25D-02	35-MW29A-01	35-MW29BW-01	35-MW33AW-01	35-MW33BW-01
Lab Sample ID:		5361-17	5361-2	5361-4	5361-18	5296-1	5296-4	5529-14	5529-7
Date Sampled:		13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	10-MAY-1994	10-MAY-1994	19-MAY-1994	17-MAY-1994
	UNITS								
Aluminum	UG/L	380000	34100	7810	8880	113822	1880	78200	ND
Antimony	UG/L	ND	ND	ND	ND	10.2 J	3.8 J	83.5 R	49 R
Arsenic	UG/L	26.2	2.6 J	6.1	3.7 J	14.9 J	2.9 J	ND	ND
Barium	UG/L	2280	300	150	205	3440	93	898	43.9
Beryllium	UG/L	63.5	11.8	2.3	3.9	3.8 J	0.14 J	3.5	ND
Cadmium	UG/L	340	6.1	0.56	0.96	11	0.31	0.31 J	0.49 J
Calcium	UG/L	787000	825000	138000 J	262000 J	18900	132000	13510	92100
Chromium	UG/L	1540	268	40.1 J	74.2 J	292	4.6	194	ND
Cobalt	UG/L	281	56.1	ND	ND	168 J	12 J	ND	ND
Copper	UG/L	94.7	26.4	2	7.7	38 J	4 J	13.4	ND
Iron	UG/L	239000	57500	65900 J	9820 J	117000	2260	70100	67.7
Lead	UG/L	6.9	14.9 R	2.2	2	4.2 J	3.9 J	18.2 J	1.2 J
Magnesium	UG/L	35400	16700	6220	4960	10700	3210	8260	2650
Manganese	UG/L	497	299	735 J	55 J	662	52 J	58.8	23.3
Mercury	UG/L	0.15 J	0.84 J	0.44 J	ND	ND	ND	ND	ND
Nickel	UG/L	524	119	ND	13.4	294	28 J	34.1	ND
Potassium	UG/L	22300	7150	ND	4050	8880	ND	5690	2740
Selenium	UG/L	11.5 J	ND	ND	ND	1.4 R	1.4 R	1.8 J	ND
Silver	UG/L	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	UG/L	5030	7960	10700	7140	14200	8450	8070	10800
Thallium	UG/L	2.7	ND	1.5 J	ND	5	ND	0.9	ND
Vanadium	UG/L	886	141	25.1	32.4	425	8 J	176	ND
Zinc	UG/L	1850	424	43.6	41.9	415	42 J	65.8	ND

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-9
POSITIVE DETECTION SUMMARY
GROUNDWATER
DISSOLVED INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-EMW03D-03	35-EMW05D-03	35-EMW7D-03	35-GWDW5D-01	35-MW09SD-02	35-MW09DD-02	35-MW10SD-02
Lab Sample ID:		D94-5361-5	D94-5361-1	D94-5361-10	D94-5361-13	D94-5296-5	D94-5296-6	D94-5296-13
Date Sampled:		14-MAY-1994	14-MAY-1994	14-MAY-1994	15-MAY-1994	10-MAY-1994	11-MAY-1994	12-MAY-1994
	UNITS							
Aluminum	UG/L	ND	ND	ND	ND	ND	ND	ND
Arsenic	UG/L	ND	16	ND	ND	6	ND	22
Barium	UG/L	ND	ND	20	ND	46	20	44
Cadmium	UG/L	ND	ND	ND	ND	ND	ND	ND
Calcium	UG/L	95000	46100	93900	53200	94700	91600	117000
Chromium	UG/L	ND	ND	ND	ND	ND	ND	ND
Iron	UG/L	ND	16400	ND	ND	ND	278	2600
Lead	UG/L	ND	ND	ND	ND	ND	ND	ND
Magnesium	UG/L	2210	3240	3850	2450	3720	2300	3180
Manganese	UG/L	19	47	19	11	42	24	47
Mercury	UG/L	0.7	0.5	0.6	0.8	2.9	1.4	ND
Nickel	UG/L	ND	ND	ND	ND	ND	ND	ND
Sodium	UG/L	6710	12500	6200	36100	72200	8460	39700
Vanadium	UG/L	ND	ND	ND	ND	ND	ND	12
Zinc	UG/L	ND	ND	6	ND	ND	ND	ND

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.

(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.

(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.

(4) J - Value is estimated.

(5) NA - Not analyzed.

(6) ND - Not detected.

(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
DISSOLVED INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

			6		7		8	
Client Sample ID:		35-MW10DD-02	35-MW14SD-02	35-MW14DD-02	35-MW16SD-02	35-MW16DD-02	35-MW19SD-02	35-MW19DD-02
Lab Sample ID:		D94-5296-8	D94-5296-10	D94-5296-11	D94-5296-16	D94-5296-12	D94-5296-17	D94-5296-22
Date Sampled:		11-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994	12-MAY-1994
	UNITS							
Aluminum	UG/L	ND	ND	ND	ND	ND	372	ND
Arsenic	UG/L	ND	10	ND	7	ND	ND	ND
Barium	UG/L	ND	38	34	29	ND	23	ND
Cadmium	UG/L	ND	ND	ND	ND	ND	ND	ND
Calcium	UG/L	109000	154000	113000	113000	85700	44400	107000
Chromium	UG/L	ND	ND	ND	ND	ND	ND	ND
Iron	UG/L	306	4330	5830	10300	222	254	ND
Lead	UG/L	ND	ND	ND	ND	ND	2	ND
Magnesium	UG/L	2380	5970	2400	3750	3300	2140	4710
Manganese	UG/L	17	73	22	89	244	157	34
Mercury	UG/L	ND	0.7	5.2	ND	0.3	1.6	0.2
Nickel	UG/L	ND	ND	ND	ND	ND	ND	ND
Sodium	UG/L	7170	7830	7550	2570	7000	13800	9770
Vanadium	UG/L	ND	ND	ND	ND	ND	ND	ND
Zinc	UG/L	ND	ND	ND	ND	ND	ND	ND

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
DISSOLVED INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW21SD-02	35-MW21DD-02	35-MW22SD-02	35-MW22DD-02	35-MW25SD-02	35-MW25DD-02	35-MW29AD-01
Lab Sample ID:		D94-5296-23	D94-5296-24	D94-5361-17	D94-5361-2	D94-5361-4	D94-5361-18	D94-5296-1
Date Sampled:		13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	13-MAY-1994	10-MAY-1994
	UNITS							
Aluminum	UG/L	ND	ND	444	5850	ND	ND	288
Arsenic	UG/L	64	ND	ND	13	ND	ND	17
Barium	UG/L	ND	26	71	53	ND	21	145
Cadmium	UG/L	ND	ND	3	ND	ND	ND	ND
Calcium	UG/L	100000	132000	674000	122000	107000	77900	7160
Chromium	UG/L	ND	ND	ND	24	ND	ND	ND
Iron	UG/L	90600	1730	1530	17400	35000	ND	4330
Lead	UG/L	ND	ND	ND	2	ND	3	ND
Magnesium	UG/L	4260	4380	8520	3450	5040	1640	2120
Manganese	UG/L	36	44	186	87	733	22	56
Mercury	UG/L	0.2	0.3	0.8	0.7	0.5	0.5	5.6
Nickel	UG/L	ND	ND	ND	10	ND	ND	28
Sodium	UG/L	8220	21900	8150	3620	11100	6720	14200
Vanadium	UG/L	ND	ND	ND	19	ND	ND	11
Zinc	UG/L	10	ND	36	42	ND	ND	8

NOTES:

(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-9 (continued)
POSITIVE DETECTION SUMMARY
GROUNDWATER
DISSOLVED INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-MW29BWD-01	35-MW33AWD-01	35-MW33BWD-01
Lab Sample ID:		D94-5296-4	D94-5529-14	D94-5529-7
Date Sampled:		10-MAY-1994	19-MAY-1994	17-MAY-1994
	UNITS			
Aluminum	UG/L	ND	117	ND
Arsenic	UG/L	ND	ND	ND
Barium	UG/L	79	77	44
Cadmium	UG/L	ND	ND	ND
Calcium	UG/L	82900	10600	93300
Chromium	UG/L	ND	ND	ND
Iron	UG/L	102	ND	ND
Lead	UG/L	ND	ND	2
Magnesium	UG/L	2670	4330	2630
Manganese	UG/L	42	25	24
Mercury	UG/L	6	2.2	3.7
Nickel	UG/L	ND	ND	ND
Sodium	UG/L	8760	7960	11200
Vanadium	UG/L	ND	ND	ND
Zinc	UG/L	ND	10	ND

NOTES:
(1) Blue indicates samples collected from wells screened in the upper-portion of the Surficial Aquifer.
(2) Red indicates samples collected from wells screened in the lower-portion of the Surficial Aquifer.
(3) Green indicates samples collected from wells screened in the upper-portion of the Castle Hayne Aquifer.
(4) J - Value is estimated.
(5) NA - Not analyzed.
(6) ND - Not detected.
(7) Only samples with positive detections were included on this table. For complete results refer to Appendix V.

TABLE 4-10
POSITIVE DETECTION SUMMARY
SEDIMENTS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-SD01-06	35-SD01-612	35-SD02-06	35-SD02-612	35-SD03-06	35-SD03-612	35-SD04-06
Lab Sample ID:		4585-4	4585-5	4585-6	4585-8	5608-1	5608-2	4585-1
Date Sampled:		20-APR-1994	20-APR-1994	20-APR-1994	20-APR-1994	17-MAY-1994	17-MAY-1994	20-APR-1994
	UNITS							
VOLATILES								
Acetone	UG/KG	ND	128 J	ND	ND	ND	ND	ND
Carbon Disulfide	UG/KG	ND	ND	ND	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	ND	ND	8 J	ND	ND
SEMIVOLATILES								
Diethylphthalate	UG/KG	ND	ND	ND	ND	352 J	896	ND
Di-n-butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
PESTICIDE/PCBs								
beta-BHC	UG/KG	ND	ND	ND	ND	ND	ND	ND
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND	ND
Heptachlor	UG/KG	ND	ND	ND	ND	2.3 J	ND	ND
Heptachlor epoxide	UG/KG	0.74 J	ND	0.43 J	1.2 J	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	1.7 J	ND	ND	1.6 J
4,4'-DDE	UG/KG	ND	1 J	1.8 J	38	ND	ND	31 J
Endrin	UG/KG	ND	ND	ND	0.44 J	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	1.4 J	ND	ND	1.3 J
4,4'-DDD	UG/KG	ND	1.1 J	2.3 J	40	ND	ND	43
4,4'-DDT	UG/KG	ND	0.73 J	0.66 J	1.6 J	ND	ND	4.9 J
Methoxychlor	UG/KG	2.7 J	0.65 J	0.49 J	2.2 J	ND	ND	0.86 J
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	0.51 J	6	ND	ND	4
gamma-Chlordane	UG/KG	ND	ND	ND	6.7	ND	ND	3.6

J - Value is estimated
ND - Not detected
R - Rejected positive value

TABLE 4-10 (continued)
POSITIVE DETECTION SUMMARY
SEDIMENTS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-SD04-612	35-SD05-06	35-SD05-612	35-SD06-06	35-SD06-612	35-SD07-06	35-SD07-612
Lab Sample ID:		4585-3	5608-3	5608-4	5608-5	5608-6	4585-9	4585-10
Date Sampled:		20-APR-1994	17-MAY-1994	17-MAY-1994	17-MAY-1994	17-MAY-1994	20-APR-1994	20-APR-1994
	UNITS							
VOLATILES								
Acetone	UG/KG	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	UG/KG	ND	ND	ND	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	ND	ND	ND	ND	ND
SEMIVOLATILES								
Diethylphthalate	UG/KG	ND	ND	ND	ND	398 J	ND	ND
Di-n-butylphthalate	UG/KG	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	625 J	704 J	469 J	ND	ND	ND	ND
PESTICIDE/PCBs								
beta-BHC	UG/KG	ND	ND	ND	ND	ND	0.59 J	ND
delta-BHC	UG/KG	ND	ND	ND	1 J	ND	ND	0.92 J
Heptachlor	UG/KG	ND	ND	ND	ND	ND	0.91 J	ND
Heptachlor epoxide	UG/KG	1.2 J	ND	0.72 J	ND	ND	0.78 J	1.4 J
Dieldrin	UG/KG	3.1 J	ND	ND	ND	ND	1.4 J	2.6 J
4,4'-DDE	UG/KG	82	80	46	115	7.7	34	57
Endrin	UG/KG	0.59 J	ND	0.85 J	0.77 J	ND	ND	0.7 J
Endosulfan II	UG/KG	3.5 J	1.6 J	0.84 J	2.2 J	ND	1.3 J	0.88 J
4,4'-DDD	UG/KG	111	43	28	39	5.9	40	60
4,4'-DDT	UG/KG	5.2	3.7 J	1.3 J	1.7 J	ND	2.3 J	2.1 J
Methoxychlor	UG/KG	ND	ND	ND	ND	ND	ND	3.4 J
Endrin ketone	UG/KG	2.8 J	3.1 J	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	1.5 J	1.1 J	2.2 J	1 J	ND	ND
alpha-Chlordane	UG/KG	5.6	9.3	4.8	ND	ND	7	8.5
gamma-Chlordane	UG/KG	7.6	ND	5	ND	ND	6.1	9.7

J - Value is estimated
ND [illegible] detected
R - Rej[illegible]ositive value

TABLE 4-10 (continued)
POSITIVE DETECTION SUMMARY
SEDIMENTS
TCL ORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-SD05-06	36-SD05-612	36-SD06-06	36-SD06-612	36-SD07-06	36-SD07-612
Lab Sample ID:		5608-13	5608-18	5608-19	5608-20	5608-21	5608-22
Date Sampled:		18-MAY-1994	18-MAY-1994	18-MAY-1994	18-MAY-1994	18-MAY-1994	18-MAY-1994
	UNITS						
VOLATILES							
Acetone	UG/KG	ND	ND	ND	ND	ND	ND
Carbon Disulfide	UG/KG	146 R	ND	35 R	ND	ND	156 R
Toluene	UG/KG	ND	ND	ND	ND	ND	ND
SEMIVOLATILES							
Diethylphthalate	UG/KG	2135 J	ND	ND	ND	ND	ND
Di-n-butylphthalate	UG/KG	ND	ND	ND	218 J	ND	ND
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND	ND
PESTICIDE/PCBs							
beta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
delta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
Heptachlor	UG/KG	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	52	ND	ND	14 J
4,4'-DDE	UG/KG	242 J	1200	249	179	51	32 J
Endrin	UG/KG	ND	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	223 J	1140	221	159	74	41
4,4'-DDT	UG/KG	31 J	46 J	14 J	8 J	ND	5.7 J
Methoxychlor	UG/KG	ND	ND	ND	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	7.6 J	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	ND	ND	ND	13 J	6.5 J
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND

J - Value is estimated
ND - Not detected
R - Rejected positive value

TABLE 4-11
POSITIVE DETECTION SUMMARY
SEDIMENTS
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-SD01-06	35-SD01-612	35-SD02-06	35-SD02-612	35-SD03-06	35-SD03-612	35-SD04-06	35-SD04-612
Lab Sample ID:		4585-4	4585-5	4585-6	4585-8	5608-1	5608-2	4585-1	4585-3
Date Sampled:		20-APR-1994	20-APR-1994	20-APR-1994	20-APR-1994	17-MAY-1994	17-MAY-1994	20-APR-1994	20-APR-1994
	UNITS								
Aluminum	MG/KG	37300	19200	484	903	1160	2010	1950 J	4240
Antimony	MG/KG	8.9 R	6.8 R	5.9 R	5.7 R	ND	ND	8.1 R	10.3 R
Arsenic	MG/KG	2.3 J	ND	0.46 J	0.34 J	0.27 R	0.69 R	0.97 J	1 J
Barium	MG/KG	129	58.8	3.8	6.5	7.8	10.9	10	30.1
Beryllium	MG/KG	1.6 R	1 R	0.18 R	ND	ND	ND	ND	0.16 R
Cadmium	MG/KG	0.97 R	0.74 R	0.64 R	0.61 R	ND	ND	0.88 R	0.78 R
Calcium	MG/KG	5040 J	3160 J	3831 J	4970 J	795 J	1360	4940 J	4110 J
Chromium	MG/KG	28.4 J	17 J	ND	ND	2.5	3.7	ND	14.8 J
Cobalt	MG/KG	6.6	3.2	1.8	ND	ND	ND	ND	ND
Copper	MG/KG	4.1	ND	ND	24.8	ND	ND	4.2	8.4
Iron	MG/KG	10400 J	6210 J	1050 J	1970 J	1130	2530	3560 J	7110 J
Lead 35	MG/KG	21.1 J	12.4 J	4.7 J	26.3 J	5.2	77.9	32 J	34.4 J
Magnesium	MG/KG	685	480	88.1	145	148	334	260	405
Manganese	MG/KG	29.7 J	13.1 J	3.2 J	5.2 J	4.1	6.6	11 J	15.9 J
Mercury	MG/KG	0.1 R	0.07 R	0.07 J	0.06 R	0.24 R	0.25 R	0.09 R	0.08 R
Nickel	MG/KG	ND	ND	ND	ND	2.2	2.1 B	ND	ND
Potassium	MG/KG	498	ND	ND	ND	ND	ND	ND	ND
Selenium	MG/KG	1.6 J	ND	0.23 J	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND	518	461
Thallium	MG/KG	0.66 J	0.43 J	ND	ND	0.15	ND	ND	0.22 J
Vanadium	MG/KG	24.2 J	14.5 J	0.94 J	1.9 J	2.1	3	4.8 J	8.8 J
Zinc	MG/KG	21.3 R	14.2 R	17.3 R	17.7 R	21 R	31.3 R	45 R	101 J

B - Reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL).
J - Value is estimated
ND - Not detected
R - Rejected positive value

TABLE 4-11 (continued)
POSITIVE DETECTION SUMMARY
SEDIMENTS
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-SD05-06	35-SD05-612	35-SD06-06	35-SD06-612	35-SD07-06	35-SD07-612	36-SD05-06	36-SD05-612
Lab Sample ID:		5608-3	5608-4	5608-5	5608-6	4585-9	4585-10	5608-13	5608-18
Date Sampled:		17-MAY-1994	17-MAY-1994	17-MAY-1994	17-MAY-1994	20-APR-1994	20-APR-1994	18-MAY-1994	18-MAY-1994
	UNITS								
Aluminum	MG/KG	11300	2580	16000	8430	3960	8820	11100	17200
Antimony	MG/KG	ND	ND	ND	ND	7.2 R	8.4 R	ND	ND
Arsenic	MG/KG	2.3 J	0.91 J	3.7 J	0.33 R	1.2 J	2.3 J	9 R	2.8 J
Barium	MG/KG	43.7	15.8	36.7	19.2	19.5	48.6	25.7	31.6
Beryllium	MG/KG	0.4	ND	0.59	0.27	0.2 R	0.4 R	ND	ND
Cadmium	MG/KG	ND	ND	ND	ND	0.79 R	4.3 R	ND	ND
Calcium	MG/KG	6490 J	5780 J	4500 J	4100 J	2530 J	3800 J	5670 J	8340 J
Chromium	MG/KG	16.3	4.3	20.9	9.1	7.1 J	20 J	19.4	14.6
Cobalt	MG/KG	3.2	ND	2.9	4	7.8	3.2	ND	ND
Copper	MG/KG	18.1	5.2	21.2	4.6	9.4	10.6	24.4	6.8
Iron	MG/KG	13400	3910	10900	8350	5340 J	7220 J	14900	15900
Lead	MG/KG	92	54.2	82.6	19.8 R	42 J	79 J	115	15.9 R
Magnesium	MG/KG	1070	446	1140	715	227	359	2750	2940
Manganese	MG/KG	25.2	10.9	24.3	23.4	28.8 J	37 J	36.8	62.8
Mercury	MG/KG	0.53 R	0.31 R	1.2 R	0.4 R	0.08 R	0.08 R	1.4 R	1.2 R
Nickel	MG/KG	5.5	2.2	6.4	2.6	ND	ND	13.6 B	7.8
Potassium	MG/KG	ND	ND	812	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	0.25 J	0.28 J	ND	ND
Sodium	MG/KG	729	ND	706	712	ND	ND	4980	1860
Thallium	MG/KG	0.63	0.2	0.47	0.35	0.22 J	0.38	0.89	0.59
Vanadium	MG/KG	21.2	4.7	23.9	10.9	8.7 J	15.9 J	39.3	19.6
Zinc	MG/KG	124 R	48.2 R	139 R	35 R	60.4 J	104 J	145 R	32.9 R

B - Reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL).
J - Value is estimated
ND - Not detected
R - Re[illegible]ositive value

TABLE 4-11 (continued)
POSITIVE DETECTION SUMMARY
SEDIMENTS
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-SD06-06	36-SD06-612	36-SD07-06	36-SD07-612
Lab Sample ID:		5608-19	5608-20	5608-21	5608-22
Date Sampled:		18-MAY-1994	18-MAY-1994	18-MAY-1994	18-MAY-1994
	UNITS				
Aluminum	MG/KG	2150	1560	31500	10800
Antimony	MG/KG	ND	ND	ND	ND
Arsenic	MG/KG	0.67 J	0.7 J	2 J	1.7 J
Barium	MG/KG	3.4	2.4	60.9	19.9
Beryllium	MG/KG	ND	ND	1.1	ND
Cadmium	MG/KG	ND	ND	ND	ND
Calcium	MG/KG	301 J	ND	17500 J	8610 J
Chromium	MG/KG	3.1	2.4	28.6	10.4
Cobalt	MG/KG	1.4	ND	ND	ND
Copper	MG/KG	4.4	3.4	14.4	5.1
Iron	MG/KG	1860	1090	13100	9710
Lead	MG/KG	15100	7.1	44.9	17
Magnesium	MG/KG	305	201	3830	1830
Manganese	MG/KG	5.6	4.9	29.2	15.3
Mercury	MG/KG	0.41 R	0.45 R	8 R	3.9 R
Nickel	MG/KG	2.1	2.6	10	7.3
Potassium	MG/KG	ND	ND	2610	ND
Selenium	MG/KG	ND	ND	ND	ND
Sodium	MG/KG	548	514	4320	1180
Thallium	MG/KG	ND	ND	0.96	0.54
Vanadium	MG/KG	4.6	3.2	28.6	12.4
Zinc	MG/KG	25.9 R	16.6 R	50.9 R	29.2 R

B - Reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL).
J - Value is estimated
ND - Not detected
R - Rejected positive value

TABLE 4-12
POSITIVE DETECTION SUMMARY
SURFACE WATER
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:			35-SW01	35-SW02	35-SW03	35-SW04	35-SW05	35-SW06	35-SW07	36-SW05
Lab Sample ID:			4120-12	4120-13	4120-1	4120-2	4120-3	4120-4	4581-1	4375-9
Date Sampled:			12-APR-1994	12-APR-1994	12-APR-1994	12-APR-1994	12-APR-1994	12-APR-1994	20-APR-1994	18-APR-1994
		UNITS								
Aluminum		UG/L	ND	ND	ND	ND	ND	ND	6580	1.3
Antimony		UG/L	ND	ND	1.8	1.5	ND	ND	ND	3.9
Arsenic		UG/L	ND	ND	ND	ND	ND	ND	2.7 J	ND
Barium		UG/L	16.9	16.7	19.5	19	18.2	23.3	48.5 J	ND
Calcium		UG/L	58000	58100	59500	59300	58800	63900	58500	41700
Chromium		UG/L	ND	ND	1 J	ND	ND	1.2 J	ND	ND
Cobalt		UG/L	ND	ND	9.5 J	11.7 J	16.8 J	ND	9 J	ND
Iron		UG/L	764 J	850 J	1060 J	1230 J	842 J	1750 J	9500	967 J
Lead	8.5	UG/L	ND	1.4	2.1	2.1	ND	2.4	97 J	ND
Magnesium		UG/L	2380	2390	3120	3140	3470	5180	4610 J	17900
Manganese		UG/L	30.1	29.1	36.9	44.9	38.7	77.4	113	31.9
Mercury	0.025	UG/L	3 J	ND	ND	3.2 J	ND	ND	ND	ND
Potassium		UG/L	2460	2170	3210	2760	2810	3840	4780 J	8210
Selenium		UG/L	ND	ND	ND	1.3 J	ND	ND	ND	ND
Sodium		UG/L	47000	42600	57000	59100	57300	68800	59800	192000
Thallium		UG/L	ND	ND	ND	ND	ND	ND	1 J	ND
Vanadium		UG/L	ND	ND	ND	ND	ND	ND	14.8 J	11.2
Zinc	86	UG/L	18.3 R	17.9 R	19.8 R	14 R	19.1 R	ND	129 J	ND

J - Value is estimated
ND - Not detected
R - Rejected positive value

TABLE 4-12 (continued)
POSITIVE DETECTION SUMMARY
SURFACE WATER
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-SW06		36-SW07	
Lab Sample ID:		4375-11		4375-10	
Date Sampled:		18-APR-1994		18-APR-1994	
	UNITS				
Aluminum	UG/L	1.2	J	1	
Antimony	UG/L	ND		2.4	J
Arsenic	UG/L	ND		ND	
Barium	UG/L	ND		ND	
Calcium	UG/L	44000		48800	
Chromium	UG/L	ND		ND	
Cobalt	UG/L	ND		ND	
Iron	UG/L	1070	J	1380	J
Lead	UG/L	ND		ND	
Magnesium	UG/L	13200		9300	
Manganese	UG/L	29.5		24.5	
Mercury	UG/L	ND		ND	
Potassium	UG/L	7490		5920	
Selenium	UG/L	ND		ND	
Sodium	UG/L	136000		103000	
Thallium	UG/L	ND		ND	
Vanadium	UG/L	9		4.5	
Zinc	UG/L	ND		ND	

J - Value is estimated
ND - Not detected
R - Re[illegible] positive value

TABLE 4-13

SUMMARY OF BIOTA SAMPLES SENT TO LABORATORY FOR TISSUE ANALYSIS
SITE 35
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER 0232

Station Location	Sample Identification	Number of Organisms	Species	Whole Body or Fillet
Site 35 - Brinson Creek Station FS01	35-FS01-AE-WB01	5	American Eel	Whole Body
Station FS02	35-FS02-AE-WB01	4	American Eel	Whole Body
	35-FS02-PS-WB01	2	Pumpkin Seed	Whole Body
	35-FS02-LG-F01	1	Long-nosed Gar	Fillet
	35-FS02-MC-F01	2	Mud Catfish	Fillet
	35-FS02-CF-WB01	10	Crayfish	Whole Body
Station FS03	35-FS03-AE-WB01	1	American Eel	Whole Body
	35-FS03-PS-WB01	2	Pumpkin Seed	Whole Body
	35-FS03-PS-WB02	5	Pumpkin Seed	Whole Body
	35-FS03-LG-F01	3	Long-nosed Gar	Fillet
	35-FS03-LG-F02	3	Long-nosed Gar	Fillet
	35-FS03-LG-WB01	3	Long-nosed Gar	Whole Body
	35-FS03-MC-F01	4	Mud Catfish	Fillet
	35-FS03-MC-WB01	4	Mud Catfish	Whole Body
	35-FS03-WM-F01	2	Warmouth	Fillet
	35-FS03-SM-F01	4	Striped Mullet	Fillet
	35-FS03-BG-F01	4	Blue Gill	Fillet
Brinson Creek (Downstream of Site 35) Station FS01	36-FS01-SM-WB01	4	Striped Mullet	Whole Body
	36-FS01-SM-F01	4	Striped Mullet	Fillet
	36-FS01-WC-F01	3	White Catfish	Fillet
Station FS02	36-FS02-SM-F01	4	Striped Mullet	Fillet
	36-FS02-WC-F01	3	White Catfish	Fillet
	36-FS02-WC-WB01	3	White Catfish	Whole Body
	36-FS02-WC-WB02	3	White Catfish	Whole Body
	36-FS02-LMB-F01	2	Largemouth Bass	Fillet
	36-FS02-BC01	6	Blue Crab	Edible Portion
Station FS03	36-FS03-SM-F01	4	Striped Mullet	Fillet
	35-FS03-WC-F01	3	White Catfish	Fillet
	35-FS03-WC-F02	3	White Catfish	Fillet
	35-FS03-WC-WB01	3	White Catfish	Whole Body
	35-FS03-LMB-F01	1	Largemouth Bass	Fillet
	35-FS03-WM-F01	1	Warmouth	Fillet
	35-FS03-LG-F01	2	Long-nosed Gar	Fillet
	35-FS03-BC01	5	Blue Crab	Edible Portion
	35-FS03-BC02	5	Blue Crab	Edible Portion

TABLE 4-14
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
VOLATILE ORGANIC COMPOUNDS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-FSO2-MC-FO1	35-FS03-MC-F01	35-FSO3-SM-FO1	36-FS01-SM-F01	35-FSO2-LG-FO1	35-FSO3-LG-FO2	36-FS02-BC01
Lab Sample ID:		4970-11	4970-12	4970-16	4970-19	4970-7	4970-9	5896-1
Date Sampled:		03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	26-MAY-1994
	UNITS							
Methylene Chloride	UG/KG	ND	ND	ND	ND	26 J	ND	6549
Acetone	UG/KG	ND	ND	ND	ND	263 J	ND	54320 J
Carbon Disulfide	UG/KG	850 J	196 J	1328	1006 J	502 J	424 J	ND
2-Butanone	UG/KG	ND	ND	ND	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	24 J	ND	ND	ND	ND

J - Value is estimated
ND - Not detected

TABLE 4-14
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
VOLATILE ORGANIC COMPOUNDS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-FS03-BC01	36-FS03-BC02	36-FS03-SM-F01	36-FS03-LMB-F01	36-FS03-WM-F01	36-FS03-LG-F01	36-FS01-WC-F01
Lab Sample ID:		5896-2	5896-3	4971-1	4971-10DL	4971-12	4971-12	4971-2
Date Sampled:		26-MAY-1994	26-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS							
Methylene Chloride	UG/KG	7192	16317	ND	ND	ND	ND	28 J
Acetone	UG/KG	95199	372323	ND	2788 J	ND	58 J	312 J
Carbon Disulfide	UG/KG	ND	ND	579 J	752 J	796 J	752 J	875 J
2-Butanone	UG/KG	ND	ND	ND	5108 J	ND	63 J	ND
Toluene	UG/KG	ND	ND	ND	ND	ND	ND	ND

J - Value is estimated
ND [illegible] detected

TABLE 4-14
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
VOLATILE ORGANIC COMPOUNDS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-FS02-WC-F01	36-FS03-WC-F01	36-FS03-WC-F02	36-FS02-LMB-F01
Lab Sample ID:		4971-3	4971-6	4971-7	4971-9
Date Sampled:		3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS				
Methylene Chloride	UG/KG	ND	50 J	ND	ND
Acetone	UG/KG	198 J	413 J	255	1550 J
Carbon Disulfide	UG/KG	456 J	348 J	278 J	1145 J
2-Butanone	UG/KG	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	ND	ND

J - Value is estimated
ND - Not detected

TABLE 4-15
POSITIVE DETECTION SUMMARY
FISH WHOLE BODY TISSUE
VOLATILE ORGANIC COMPOUNDS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-FS03-LG-WB01	35-FSO3-MC-WBO1	35-FSO3-PS-WB01	35-FSO2-PS-WBO2	36-FS02-WC-WB01	36-FS02-WC-WB02	36-FS03-WC-WB01
Lab Sample ID:		4970-10	4970-13	4970-5	4970-6	4971-4	4971-5	4971-8
Date Sampled:		03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994
	<u>UNITS</u>							
1,1-Dichloroethane	UG/KG	ND	37 J	ND	ND	ND	ND	ND
Acetone	UG/KG	137 J	24684 J	39 J	ND	1794 J	938 J	2360 J
Carbon Disulfide	UG/KG	469 J	1064 J	467 J	835 J	402 J	1367 J	348 J
Methylene Chloride	UG/KG	ND	ND	17 J	ND	35 J	42 J	28 J
Toluene	UG/KG	ND	ND	ND	ND	ND	ND	33 J
Xylene (total)	UG/KG	ND	ND	ND	ND	ND	ND	58 J

J - Value is estimated
ND - Not detected

TABLE 4-16
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
PESTICIDES AND PCBs
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-FS02-MC-F01	35-FS03-MC-F01	35-FS03-WM-F01	35-FS03-SM-F01	35-FS03-BG-F01	36-FS01-SM-F01	36-FS02-SM-F01
Lab Sample ID:		4970-11	4970-12	4970-15	4970-16	4970-17	4970-19	4970-20
Date Sampled:		03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994
	UNITS							
beta-BHC	UG/KG	ND	ND	ND	ND	ND	ND	ND
gamma-BHC (Lindane)	UG/KG	ND	ND	2.5 J	ND	3.9 J	5.5 J	ND
Heptachlor	UG/KG	ND	ND	ND	ND	4.3 J	2.8 J	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	12 J	22 J	31 J	12 J	4.3 J	36 J	17 J
4,4'-DDE	UG/KG	78 J	189 J	254 J	111 J	184 J	270 J	137 J
Endrin	UG/KG	3.6 J	ND	ND	4 J	10 J	2.5 J	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	47 J	146 J	56 J	61 J	40 J	196 J	100 J
4,4'-DDT	UG/KG	5.6 J	5 J	15 J	6 J	8.3 J	12 J	6.3 J
Endrin ketone	UG/KG	ND	ND	3.8 J	3.6 J	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	2.8 J	ND	ND	4 J
alpha-Chlordane	UG/KG	12 J	ND	17 J	ND	8.4 J	28 J	18 J

J - Value is estimated
ND - Not detected

TABLE 4-16
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
PESTICIDES AND PCBs
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-FS02-LG-F01	35-FS03-LG-F01	35-FS03-LG-F02	36-FS02-BC01	36-FS03-BC01	36-FS03-BC02	36-FS03-SM-F01	36-FS03-LMB-F01
Lab Sample ID:		4970-7	4970-8	4970-9	5896-1	5896-2	5896-3	4971-1	4971-10
Date Sampled:		03-MAY-1994	03-MAY-1994	03-MAY-1994	26-MAY-1994	26-MAY-1994	26-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS								
beta-BHC	UG/KG	ND	ND	5.9 J	8.9 J	8.4 J	6.8 J	ND	ND
gamma-BHC (Lindane)	UG/KG	ND	ND	ND	3.6 J	2.1 J	ND	ND	ND
Heptachlor	UG/KG	ND	ND	ND	2.6 J	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	2.3 J	ND	6.6 J	ND
Heptachlor epoxide	UG/KG	ND	3.9 J	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	ND	ND	9.4 J	6 J	8.8 J	48 J	5.2 J
4,4'-DDE	UG/KG	343 J	297 J	572 J	101 J	42 J	48 J	444 J	39 J
Endrin	UG/KG	ND	26 J	52 J	ND	ND	ND	17 J	ND
Endosulfan II	UG/KG	4.6 J	3.6 J	9.6 J	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	62 J	54 J	103 J	49 J	19 J	33 J	256 J	22 J
4,4'-DDT	UG/KG	2.5 J	4.5 J	5.1 J	2.5 J	ND	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	13 J	ND
alpha-Chlordane	UG/KG	11 J	ND	38 J	3.7 J	3.6 J	ND	46 J	3.5 J

J - Value is estimated
N t detected

TABLE 4-16
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
PESTICIDES AND PCBs
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-FS03-WM-F01	36-FS03-LG-F01	36-FS01-WC-F01	36-FS02-WC-F01	36-FS03-WC-F01	36-FS03-WC-F02	36-FS02-LMB-F01
Lab Sample ID:		4971-11	4971-12	4971-2	4971-3	4971-6	4971-7	4971-9
Date Sampled:		3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS							
beta-BHC	UG/KG	11 J	ND	9.6 J	4.2 J	ND	ND	ND
gamma-BHC (Lindane)	UG/KG	4.9 J	ND	ND	ND	ND	ND	ND
Heptachlor	UG/KG	ND	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	5.7 J	ND
Heptachlor epoxide	UG/KG	ND	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	40 J	ND	7.8 J	10 J	13 J	11 J	8 J
4,4'-DDE	UG/KG	394 J	186 J	148 J	72 J	110 J	80 J	45 J
Endrin	UG/KG	4.6 J	ND	8.8 J	ND	ND	ND	ND
Endosulfan II	UG/KG	4.5 J	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	133 J	47 J	40 J	22 J	70 J	22 J	50 J
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	ND	ND	ND	ND	ND
Endrin aldehyde	UG/KG	ND	ND	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	27 J	14 J	22 J	12 J	10 J	14 J	ND

J - Value is estimated
ND - Not detected

TABLE 4-17
POSITIVE DETECTION SUMMARY
FISH WHOLE BODY TISSUE
PESTICIDES AND PCBs
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

SAMPLE LOCATION		35-FS03-LG-WB01	35-FS03-MC-WB01	35-FS02-CF-WB01	36-FS01-SM-WB01	35-FS02-AE-WB01	35-FS03-AE-WB01
SAMPLE No.		4970-10	4970-13	4970-14	4970-18	4970-2	4970-3
DATE COLLECTED		03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994
	UNITS						
beta-BHC	UG/KG	ND	ND	ND	ND	ND	ND
gamma-BHC (Lindane)	UG/KG	ND	ND	ND	8 J	ND	ND
Heptachlor	UG/KG	ND	ND	ND	7.8 J	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	ND
Dieldrin	UG/KG	ND	13 J	ND	55 J	59 J	14 J
4,4'-DDE	UG/KG	249 J	95 J	27 J	400 J	434 J	55 J
Endrin	UG/KG	21 J	ND	ND	27 J	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	3.4 J	ND	ND
4,4'-DDD	UG/KG	52 J	53 J	5.2 J	99 J	319 J	27 J
4,4'-DDT	UG/KG	5.8 J	6.4 J	ND	17 J	58 J	6.5 J
Endrin ketone	UG/KG	ND	ND	ND	ND	14 J	ND
Endrin aldehyde	UG/KG	6.5 J	ND	ND	ND	ND	ND
alpha-Chlordane	UG/KG	23 J	20 J	ND	60 J	32 J	3.5 J
gamma-Chlordane	UG/KG	ND	12 J	ND	22 J	ND	ND

J - Value is estimated
ND - Not detected

TABLE 4-17
POSITIVE DETECTION SUMMARY
FISH WHOLE BODY TISSUE
PESTICIDES AND PCBs
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

SAMPLE LOCATION		35-FS02-PS-WB01	35-FS03-PS-WB01	35-FS02-PS-WB02	36-FS02-WC-WB01	36-FS02-WC-WB02	36-FS03-WC-WB01
SAMPLE No.		4970-4	4970-5	4970-6	4971-4	4971-5	4971-8
DATE COLLECTED		03-MAY-1994	03-MAY-1994	03-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS						
beta-BHC	UG/KG	ND	5.3 J	ND	4.8 J	8.3 J	ND
gamma-BHC (Lindane)	UG/KG	ND	ND	ND	ND	ND	ND
Heptachlor	UG/KG	ND	ND	ND	ND	ND	ND
Aldrin	UG/KG	ND	ND	ND	ND	ND	2.6 J
Dieldrin	UG/KG	11 J	16 J	5 J	10 J	31 J	3.2 J
4,4'-DDE	UG/KG	81 J	152 J	53 J	239 J	208 J	39 J
Endrin	UG/KG	5.3 J	8.7 J	3 J	23 J	12 J	ND
Endosulfan II	UG/KG	ND	ND	ND	3.4 J	ND	ND
4,4'-DDD	UG/KG	38 J	82 J	20 J	74 J	138 J	18 J
4,4'-DDT	UG/KG	ND	19 J	7.7 J	ND	ND	ND
Endrin ketone	UG/KG	ND	ND	3.1 J	ND	ND	ND
Endrin aldehyde	UG/KG	ND	3.3 J	ND	ND	ND	ND
alpha-Chlordane	UG/KG	ND	9.6 J	2.9 J	42 J	30 J	5 J
gamma-Chlordane	UG/KG	ND	ND	ND	ND	ND	ND

J - Value is estimated
ND [illegible] detected

TABLE 4-18

POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		35-FS02-MC-F01	35-FS03-MC-F01	35-FS03-WM-F01	35-FS03-SM-F01	35-FS03-BG-F01	36-FS01-SM-F01
Lab Sample ID:		4970-11	4970-12	4970-15	4970-16	4970-17	4970-19
Date Sampled:		03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994
	UNITS						
Aluminum	MG/KG	ND	25.9	ND	27.3	20	ND
Arsenic	MG/KG	ND	ND	ND	ND	ND	ND
Barium	MG/KG	ND	0.54	0.43	0.76	0.64	0.41
Cadmium	MG/KG	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	ND	925 J	13300 J	1140 J	13200 J	839 J
Chromium	MG/KG	ND	ND	ND	ND	ND	ND
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND
Copper	MG/KG	3.9	4.5	2.3	5.6	2.8	3.3
Iron	MG/KG	38.2	48	ND	39.1	ND	40.6
Lead	MG/KG	ND	ND	ND	NA	ND	ND
Magnesium	MG/KG	1190	1420	1000	833	1260	929
Manganese	MG/KG	3.1	1.1	1.5	ND	2.1	1
Mercury	MG/KG	0.24 R	0.25 R	0.33 J	0.18 R	0.2 R	0.18 R
Potassium	MG/KG	16400	19000	9180	12500	13500	12400
Selenium	MG/KG	ND	ND	ND	ND	ND	ND
Silver	MG/KG	1.3 R	ND	0.75 R	ND	ND	ND
Sodium	MG/KG	2770	2920	1970	21900	5720	2160
Vanadium	MG/KG	ND	ND	ND	ND	ND	ND
Zinc	MG/KG	27.5 R	33.2 R	30.2 R	28.7 R	40.5	32 R

J - Value is estimated
NA - Not analyzed
ND - Not detected
R - Rejected

TABLE 4-18
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-FS02-SM-F01	35-FSO2-LG-FO1	35-FS03-LG-F01	35-FSO3-LG-FO2	36-FS02-BC01	36-FS03-BC01	36-FS03-BC02
Lab Sample ID:		4970-20	4970-7	4970-8	4970-9	5896-1	5896-2	5896-3
Date Sampled:		03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	26-MAY-1994	26-MAY-1994	26-MAY-1994
	UNITS							
Aluminum	MG/KG	24.7	25.8	ND	ND	19.3	ND	ND
Arsenic	MG/KG	ND	ND	ND	ND	ND	1.4 J	ND
Barium	MG/KG	2.2	0.52	0.53	ND	ND	ND	ND
Cadmium	MG/KG	ND	0.35	0.5	0.33	0.8	0.16	ND
Calcium	MG/KG	7070 J	878 J	995 J	676 J	1970 J	2170 J	1740 J
Chromium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Cobalt	MG/KG	ND	ND	ND	ND	6.9	ND	ND
Copper	MG/KG	3.5	3.3	3.1	2.7	26.3	27.5	22.3
Iron	MG/KG	41.7	ND	ND	ND	39.9	40.2	20.4
Lead	MG/KG	ND	ND	ND	ND	0.61 J	0.58 J	0.51 J
Magnesium	MG/KG	1070	1330	1230	1160	1550 J	1500 J	1500 J
Manganese	MG/KG	1.1	1.9	1.6	1.5	ND	ND	1.7
Mercury	MG/KG	0.18 R	0.98 J	0.49 J	0.3 J	1.3 R	0.9 R	0.9 R
Potassium	MG/KG	12300	14200	13900	12200	13500	13000	14400
Selenium	MG/KG	ND	ND	ND	ND	0.8 J	0.72 J	ND
Silver	MG/KG	1.1 R	2.9 R	ND	ND	ND	ND	ND
Sodium	MG/KG	2480	2550	2900	2660	15300	14200	14900
Vanadium	MG/KG	ND	ND	ND	ND	ND	ND	ND
Zinc	MG/KG	38	32.7 R	31.7 R	18.9 R	104	130	93.8

J - Value is estimated
NA - Not analyzed
ND - Not detected
R [illegible]ected

TABLE 4-18
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

Client Sample ID:		36-FS03-SM-F01	36-FS03-LMB-F01	36-FS03-WM-F01	36-FS03-LG-F01	36-FS01-WC-F01	36-FS02-WC-F01
Lab Sample ID:		4971-1	4971-10	4971-11	4971-12	4971-2	4971-3
Date Sampled:		3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS						
Aluminum	MG/KG	ND	ND	ND	ND	ND	ND
Arsenic	MG/KG	ND	ND	ND	ND	ND	1.8
Barium	MG/KG	1.2	0.65	0.62	0.52	1	ND
Cadmium	MG/KG	ND	ND	ND	ND	ND	ND
Calcium	MG/KG	1570	1440	7060	678	ND	ND
Chromium	MG/KG	3	ND	ND	ND	ND	ND
Cobalt	MG/KG	ND	ND	ND	ND	ND	ND
Copper	MG/KG	ND	ND	ND	ND	ND	ND
Iron	MG/KG	41.7	40.2	34.6	28	52	45
Lead	MG/KG	ND	ND	0.51 R	0.56 R	ND	ND
Magnesium	MG/KG	994	1470	981	1210	1250	1310
Manganese	MG/KG	0.86	ND	2	1.7	2.5	2.1
Mercury	MG/KG	ND	1.3 J	ND	0.29 J	0.33 J	ND
Potassium	MG/KG	14000	20200	11800	12100	18900	16000
Selenium	MG/KG	ND	5.8 J	ND	0.6 J	0.99 J	ND
Silver	MG/KG	ND	ND	1	1.3	ND	ND
Sodium	MG/KG	ND	ND	ND	ND	ND	ND
Vanadium	MG/KG	ND	ND	1.7	ND	ND	ND
Zinc	MG/KG	28.8	22.9	33.1	18.2	58.3	34.9

J - Value is estimated
NA - Not analyzed
ND - Not detected
R - Rejected

TABLE 4-18
POSITIVE DETECTION SUMMARY
FISH FILLET TISSUE
TAL INORGANICS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

	Client Sample ID:	36-FS03-WC-F01	36-FS03-WC-F02	36-FS02-LMB-F01
	Lab Sample ID:	4971-6	4971-7	4971-9
	Date Sampled:	3-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS			
Aluminum	MG/KG	ND	ND	ND
Arsenic	MG/KG	ND	ND	ND
Barium	MG/KG	0.86	0.79	0.6
Cadmium	MG/KG	ND	ND	ND
Calcium	MG/KG	1090	1590	6750
Chromium	MG/KG	ND	ND	4
Cobalt	MG/KG	ND	ND	ND
Copper	MG/KG	ND	ND	ND
Iron	MG/KG	39.8	53.6	43.3
Lead	MG/KG	ND	0.63 R	ND
Magnesium	MG/KG	1220	1380	1400
Manganese	MG/KG	2.3	1.8	1.3
Mercury	MG/KG	ND	ND	1.2 J
Potassium	MG/KG	17600	17900	15000
Selenium	MG/KG	ND	ND	ND
Silver	MG/KG	3.3	2.2	1.4
Sodium	MG/KG	ND	ND	ND
Vanadium	MG/KG	ND	ND	ND
Zinc	MG/KG	35.2	39	26.8

J - Value is estimated
NA - Not analyzed
ND [illegible] detected
[illegible] ected

TABLE 4-19
POSITIVE DETECTION SUMMARY
FISH WHOLE BODY TISSUE
TAL METALS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

SAMPLE LOCATION		35-FS03-LG-WB01	35-FS3-MC-WB01	35-FS02-CF-WB01	36-FS01-SM-WB01	35-FS02-AE-WB01	35-FS02-PS-WB01
SAMPLE No.		4970-10	4970-13	4970-14	4970-18	4970-2	4970-4
DATE COLLECTED		03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994	03-MAY-1994
	UNITS						
Aluminum	MG/KG	ND	35.5	53.2	45.8	23.7	24.4
Barium	MG/KG	ND	1.1	3.3	5	0.89	1.6
Cadmium	MG/KG	ND	ND	ND	ND	0.88	ND
Calcium	MG/KG	1910 J	20400 J	17800 J	11000 J	21600 J	35200 J
Chromium	MG/KG	ND	ND	ND	2.7	ND	2.3
Copper	MG/KG	3.9	4.8	70.3	10.9	6.6	3.3
Iron	MG/KG	392	160	244	145	113	99.5
Lead	MG/KG	ND	ND	NA	ND	2.5	ND
Magnesium	MG/KG	1130	1250	705	832	1100	1270
Manganese	MG/KG	1.6	7.3	11.2	3.6	2.4	4.3
Mercury	MG/KG	0.2 R	0.68 J	0.7 J	0.15 R	0.19 R	0.18 R
Potassium	MG/KG	11000	11600	9970	8970	10100	9630
Selenium	MG/KG	ND	ND	ND	ND	ND	ND
Silver	MG/KG	1.2 R	ND	ND	2.3 R	ND	ND
Sodium	MG/KG	3730	4260	7090	2710	17200	3150
Zinc	MG/KG	42.3	58.3	102	54	83.8	86.7

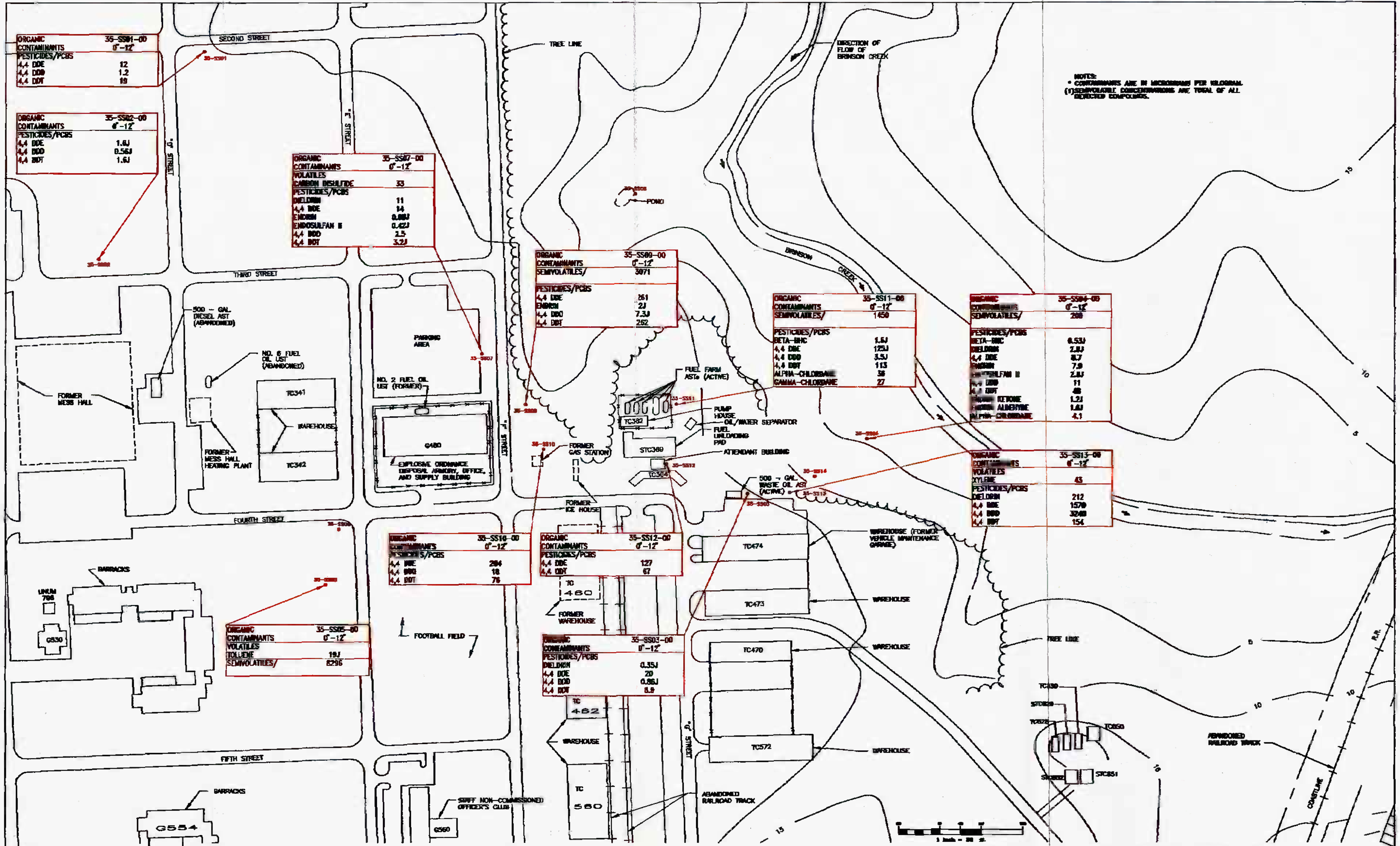
J - Value is estimated
NA - Not analyzed
ND - Not detected
R - Rejected

TABLE 4-19
POSITIVE DETECTION SUMMARY
FISH WHOLE BODY TISSUE
TAL METALS
SITE 35, CAMP GEIGER AREA FUEL FARM
MCB CAMP LEJEUNE, NORTH CAROLINA
CONTRACT TASK ORDER - 0232

SAMPLE LOCATION		35-FSO3-PS-WB01	35-FSO2-PS-WBO2	36-FS02-WC-WB01	36-FS02-WC-WB02	36-FS03-WC-WB01
SAMPLE No.		4970-5	4970-6	4971-4	4971-5	4971-8
DATE COLLECTED		03-MAY-1994	03-MAY-1994	3-MAY-1994	3-MAY-1994	3-MAY-1994
	UNITS					
Aluminum	MG/KG	ND	ND	ND	ND	ND
Barium	MG/KG	1	1	1.3	1.2	0.94
Cadmium	MG/KG	ND	0.25	ND	ND	ND
Calcium	MG/KG	50800 J	49700 J	8070	23100	9100
Chromium	MG/KG	2.6	2.3	ND	3.6	2.5
Copper	MG/KG	3.2	3.8	ND	ND	ND
Iron	MG/KG	72	60.9	106	96.5	80.3
Lead	MG/KG	ND	ND	0.43 R	0.41 R	ND
Magnesium	MG/KG	1540	1370	1100	1270	983
Manganese	MG/KG	3.4	4.5	9.6	10.3	5.8
Mercury	MG/KG	0.16 R	0.17 R	ND	ND	ND
Potassium	MG/KG	8970	9310	10400	12100	9480
Selenium	MG/KG	0.43 J	ND	0.63 J	1 J	0.91 J
Silver	MG/KG	0.87 R	ND	2.1	1.2	1
Sodium	MG/KG	3600	3460	ND	ND	ND
Zinc	MG/KG	77.9	87.1	62.1	56.5	51.4

J - Value is estimated
NA - Not analyzed
ND - Not detected
Rejected

SECTION 4.0 FIGURES



LEGEND

- FENCE LINE
- CONTOUR LINES DEPICTING SURFICAL RELIEF
- SURFACE SOIL SAMPLE LOCATION

DATE	OCT. 1994
SCALE	1"= 80'
DRAWN	WJM
REVIEWED	JSC
B.O.#	62470-232-0000-07080
CADD#	23291148

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

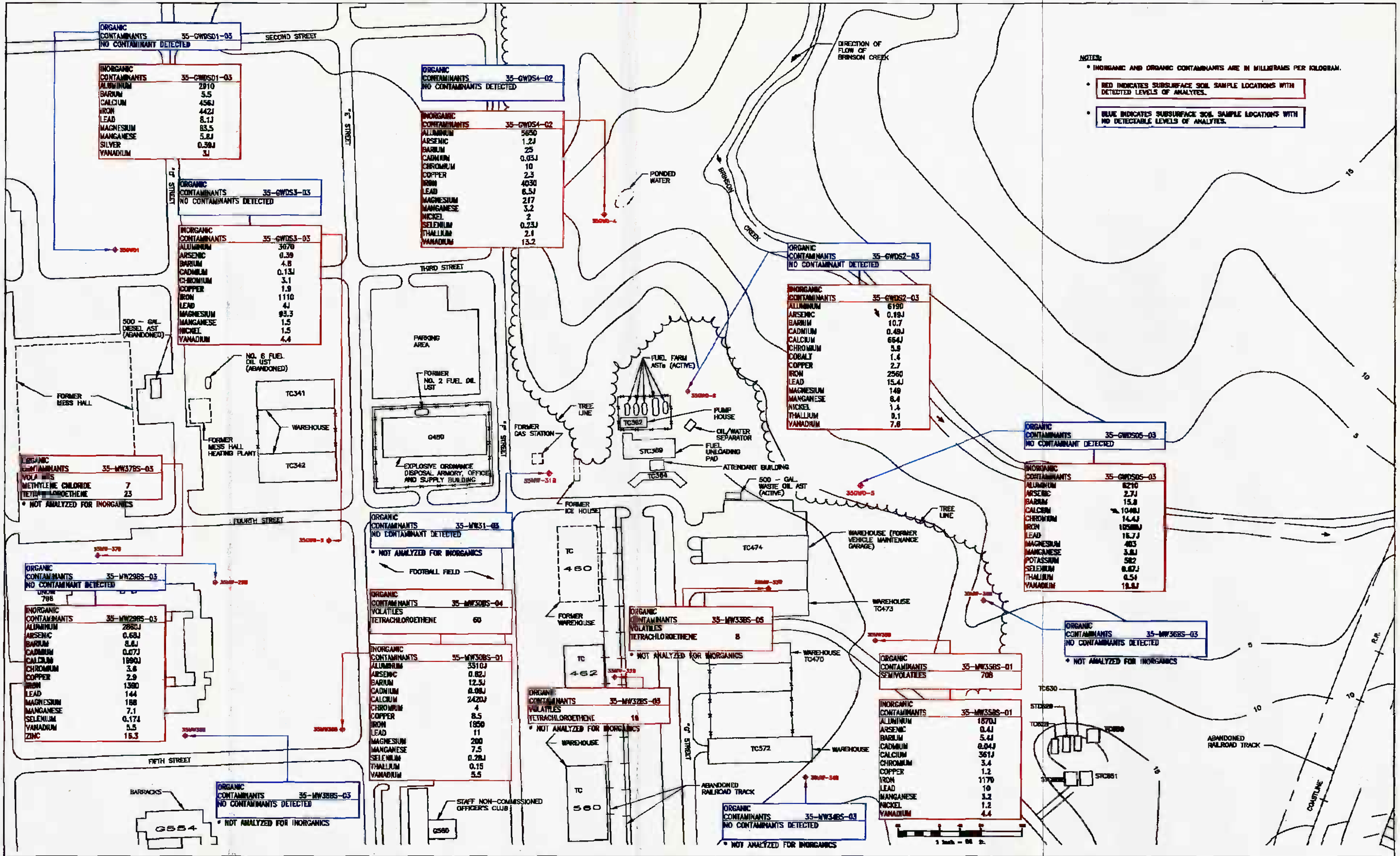
Baker
Baker Environmental, Inc.

DETECTED ORGANICS IN SURFACE SOIL
CONTRACT TASK ORDER - 0232

SCALE 1"= 80'
DATE OCT. 1994

FIGURE No.
4-1

01539UB6Y



NOTES:

- INORGANIC AND ORGANIC CONTAMINANTS ARE IN MILLIGRAMS PER KILOGRAM.
- RED INDICATES SUBSURFACE SOIL SAMPLE LOCATIONS WITH DETECTED LEVELS OF ANALYTES.
- BLUE INDICATES SUBSURFACE SOIL SAMPLE LOCATIONS WITH NO DETECTABLE LEVELS OF ANALYTES.

ORGANIC CONTAMINANTS	35-GWDS01-03
NO CONTAMINANT DETECTED	

INORGANIC CONTAMINANTS	35-GWDS01-03
ALUMINUM	2910
BARIUM	5.5
CALCIUM	456J
IRON	442J
LEAD	8.1J
MAGNESIUM	83.5
MANGANESE	5.8J
SILVER	0.39J
VANADIUM	3J

ORGANIC CONTAMINANTS	35-GWDS3-03
NO CONTAMINANTS DETECTED	

INORGANIC CONTAMINANTS	35-GWDS3-03
ALUMINUM	3070
ARSENIC	0.39
BARIUM	4.8
CADMIUM	0.13J
CHROMIUM	3.1
COPPER	1.9
IRON	1110
LEAD	4J
MAGNESIUM	93.3
MANGANESE	1.5
NICKEL	1.5
VANADIUM	4.4

ORGANIC CONTAMINANTS	35-GWDS4-02
NO CONTAMINANTS DETECTED	

INORGANIC CONTAMINANTS	35-GWDS4-02
ALUMINUM	5650
ARSENIC	1.2J
BARIUM	25
CADMIUM	0.03J
CHROMIUM	10
COPPER	2.3
IRON	4030
LEAD	6.5J
MAGNESIUM	217
MANGANESE	3.2
NICKEL	2
SELENIUM	0.23J
THALLIUM	2.1
VANADIUM	13.2

ORGANIC CONTAMINANTS	35-GWDS2-03
NO CONTAMINANT DETECTED	

INORGANIC CONTAMINANTS	35-GWDS2-03
ALUMINUM	6190
ARSENIC	0.19J
BARIUM	10.7
CADMIUM	0.49J
CALCIUM	664J
CHROMIUM	5.9
COBALT	1.4
COPPER	2.7
IRON	2560
LEAD	15.4J
MAGNESIUM	149
MANGANESE	6.4
NICKEL	1.4
THALLIUM	0.1
VANADIUM	7.6

ORGANIC CONTAMINANTS	35-GWDS05-03
NO CONTAMINANT DETECTED	

INORGANIC CONTAMINANTS	35-GWDS05-03
ALUMINUM	8210
ARSENIC	2.7J
BARIUM	15.8
CALCIUM	1040J
CHROMIUM	14.4J
IRON	10500J
LEAD	15.7J
MAGNESIUM	403
MANGANESE	3.8J
POTASSIUM	582
SELENIUM	0.67J
THALLIUM	0.54
VANADIUM	19.8J

ORGANIC CONTAMINANTS	35-MW37BS-03
VOLATILES	
METHYLENE CHLORIDE	7
TETRACHLOROETHENE	23

* NOT ANALYZED FOR INORGANICS

ORGANIC CONTAMINANTS	35-MW29BS-03
NO CONTAMINANT DETECTED	

INORGANIC CONTAMINANTS	35-MW29BS-03
ALUMINUM	2860J
ARSENIC	0.68J
BARIUM	8.6J
CADMIUM	0.07J
CALCIUM	1890J
CHROMIUM	3.6
COPPER	2.9
IRON	1380
LEAD	144
MAGNESIUM	188
MANGANESE	7.1
SELENIUM	0.17J
VANADIUM	5.5
ZINC	15.3

ORGANIC CONTAMINANTS	35-MW31-03
NO CONTAMINANT DETECTED	

* NOT ANALYZED FOR INORGANICS

ORGANIC CONTAMINANTS	35-MW30BS-04
VOLATILES	
TETRACHLOROETHENE	60

INORGANIC CONTAMINANTS	35-MW30BS-01
ALUMINUM	3510J
ARSENIC	0.82J
BARIUM	12.5J
CADMIUM	0.08J
CALCIUM	2420J
CHROMIUM	4
COPPER	8.5
IRON	1850
LEAD	11
MAGNESIUM	200
MANGANESE	7.5
SELENIUM	0.28J
THALLIUM	0.15
VANADIUM	5.5

ORGANIC CONTAMINANTS	35-MW33BS-05
VOLATILES	
TETRACHLOROETHENE	8

* NOT ANALYZED FOR INORGANICS

ORGANIC CONTAMINANTS	35-MW32BS-03
VOLATILES	
TETRACHLOROETHENE	16

* NOT ANALYZED FOR INORGANICS

ORGANIC CONTAMINANTS	35-MW36BS-03
NO CONTAMINANTS DETECTED	

* NOT ANALYZED FOR INORGANICS

ORGANIC CONTAMINANTS	35-MW35BS-01
SEMIVOLATILES	708

INORGANIC CONTAMINANTS	35-MW35BS-01
ALUMINUM	1570J
ARSENIC	0.4J
BARIUM	5.4J
CADMIUM	0.04J
CALCIUM	361J
CHROMIUM	3.4
COPPER	1.2
IRON	1170
LEAD	10
MANGANESE	3.2
NICKEL	1.2
VANADIUM	4.4

ORGANIC CONTAMINANTS	35-MW38BS-03
NO CONTAMINANTS DETECTED	

* NOT ANALYZED FOR INORGANICS

ORGANIC CONTAMINANTS	35-MW34BS-03
NO CONTAMINANTS DETECTED	

* NOT ANALYZED FOR INORGANICS

LEGEND

-x-x- – FENCE LINE
—15— – CONTOUR LINES DEPICTING SURFICIAL RELIEF
35GWD1 ◆ – SUBSURFACE SOIL SAMPLE LOCATION/MONITORING WELL INSTALLATION UNDER BAKER III (1994).

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJB
REVIEWED	JSC
E.O.#	62470-232-0000-07000
CARD#	23291538

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

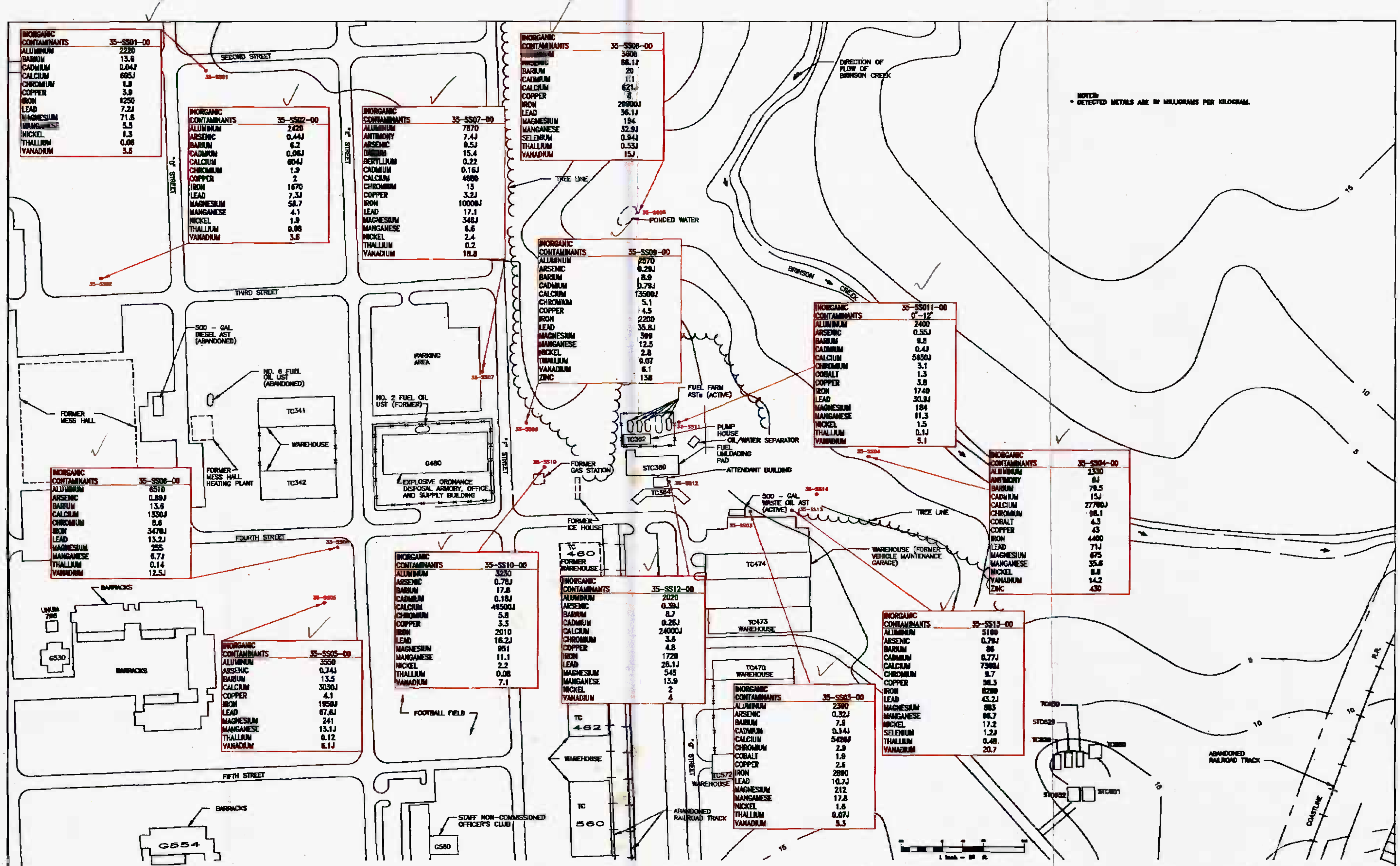
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED INORGANICS AND ORGANICS
IN SUBSURFACE SOIL
CONTRACT TASK ORDER – 0232

SCALE 1" = 80'
DATE OCT. 1994

FIGURE No.
4-2



NOTE:
• DETECTED METALS ARE IN MILLIGRAMS PER KILOGRAM.

INORGANIC CONTAMINANTS	35-SS01-00
ALUMINUM	2220
BARIUM	13.6
CADMIUM	0.04J
CALCIUM	605J
CHROMIUM	1.8
COPPER	3.9
IRON	1250
LEAD	7.2J
MAGNESIUM	71.6
MANGANESE	5.5
NICKEL	1.3
THALLIUM	0.06
VANADIUM	3.6

INORGANIC CONTAMINANTS	35-SS02-00
ALUMINUM	2420
ARSENIC	0.44J
BARIUM	6.2
CADMIUM	0.06J
CALCIUM	604J
CHROMIUM	1.9
COPPER	2
IRON	1670
LEAD	7.3J
MAGNESIUM	58.7
MANGANESE	4.1
NICKEL	1.9
THALLIUM	0.08
VANADIUM	3.6

INORGANIC CONTAMINANTS	35-SS07-00
ALUMINUM	7870
ANTIMONY	7.4J
ARSENIC	0.5J
BARIUM	15.4
BERYLLIUM	0.22
CADMIUM	0.16J
CALCIUM	4680
CHROMIUM	13
COPPER	3.2J
IRON	10000J
LEAD	17.1
MAGNESIUM	346J
MANGANESE	6.6
NICKEL	2.4
THALLIUM	0.2
VANADIUM	18.8

INORGANIC CONTAMINANTS	35-SS08-00
ALUMINUM	3600
ARSENIC	86.1J
BARIUM	20
CADMIUM	1.1
CALCIUM	621J
COPPER	8
IRON	29900J
LEAD	36.1J
MAGNESIUM	194
MANGANESE	32.9J
SELENIUM	0.94J
THALLIUM	0.53J
VANADIUM	15J

INORGANIC CONTAMINANTS	35-SS09-00
ALUMINUM	2570
ARSENIC	0.29J
BARIUM	8.9
CADMIUM	0.79J
CALCIUM	13500J
CHROMIUM	5.1
COPPER	4.5
IRON	2200
LEAD	35.8J
MAGNESIUM	399
MANGANESE	12.5
NICKEL	2.8
THALLIUM	0.07
VANADIUM	6.1
ZINC	138

INORGANIC CONTAMINANTS	35-SS011-00 0"-12"
ALUMINUM	2400
ARSENIC	0.55J
BARIUM	9.8
CADMIUM	0.4J
CALCIUM	5850J
CHROMIUM	3.1
COBALT	1.3
COPPER	3.8
IRON	1740
LEAD	30.9J
MAGNESIUM	184
MANGANESE	11.3
NICKEL	1.5
THALLIUM	0.1J
VANADIUM	5.1

INORGANIC CONTAMINANTS	35-SS04-00
ALUMINUM	2330
ANTIMONY	8J
BARIUM	79.5
CADMIUM	15J
CALCIUM	27700J
CHROMIUM	98.1
COBALT	4.3
COPPER	43
IRON	4400
LEAD	71J
MAGNESIUM	675
MANGANESE	35.6
NICKEL	8.8
VANADIUM	14.2
ZINC	430

INORGANIC CONTAMINANTS	35-SS06-00
ALUMINUM	6510
ARSENIC	0.89J
BARIUM	13.6
CALCIUM	1330J
CHROMIUM	8.6
IRON	3470J
LEAD	13.2J
MAGNESIUM	255
MANGANESE	6.7J
THALLIUM	0.14
VANADIUM	12.5J

INORGANIC CONTAMINANTS	35-SS10-00
ALUMINUM	3230
ARSENIC	0.78J
BARIUM	17.8
CADMIUM	0.18J
CALCIUM	49500J
CHROMIUM	5.8
COPPER	3.3
IRON	2010
LEAD	16.2J
MAGNESIUM	951
MANGANESE	11.1
NICKEL	2.2
THALLIUM	0.08
VANADIUM	7.1

INORGANIC CONTAMINANTS	35-SS12-00
ALUMINUM	2020
ARSENIC	0.39J
BARIUM	8.7
CADMIUM	0.26J
CALCIUM	24000J
CHROMIUM	3.6
COPPER	4.8
IRON	1720
LEAD	26.1J
MAGNESIUM	545
MANGANESE	13.9
NICKEL	2
VANADIUM	4

INORGANIC CONTAMINANTS	35-SS05-00
ALUMINUM	3550
ARSENIC	0.74J
BARIUM	13.5
CALCIUM	3030J
COPPER	4.1
IRON	1950J
LEAD	67.6J
MAGNESIUM	241
MANGANESE	13.1J
THALLIUM	0.12
VANADIUM	6.1J

INORGANIC CONTAMINANTS	35-SS13-00
ALUMINUM	5100
ARSENIC	0.79J
BARIUM	86
CADMIUM	0.77J
CALCIUM	7380J
CHROMIUM	9.7
COPPER	38.3
IRON	8280
LEAD	43.2J
MAGNESIUM	883
MANGANESE	88.7
NICKEL	17.2
SELENIUM	1.2J
THALLIUM	0.48J
VANADIUM	20.7

INORGANIC CONTAMINANTS	35-SS03-00
ALUMINUM	2390
ARSENIC	0.32J
BARIUM	7.9
CADMIUM	0.14J
CALCIUM	5420J
CHROMIUM	2.9
COBALT	1.9
COPPER	2.6
IRON	2890
LEAD	10.7J
MAGNESIUM	212
MANGANESE	17.8
NICKEL	1.6
THALLIUM	0.07J
VANADIUM	5.3

LEGEND

- ✕–✕– – FENCE LINE
- —15— – CONTOUR LINES DEPICTING SURFICIAL RELIEF
- ● – SURFACE SOIL SAMPLE LOCATION

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07060
CADD#	23291308

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

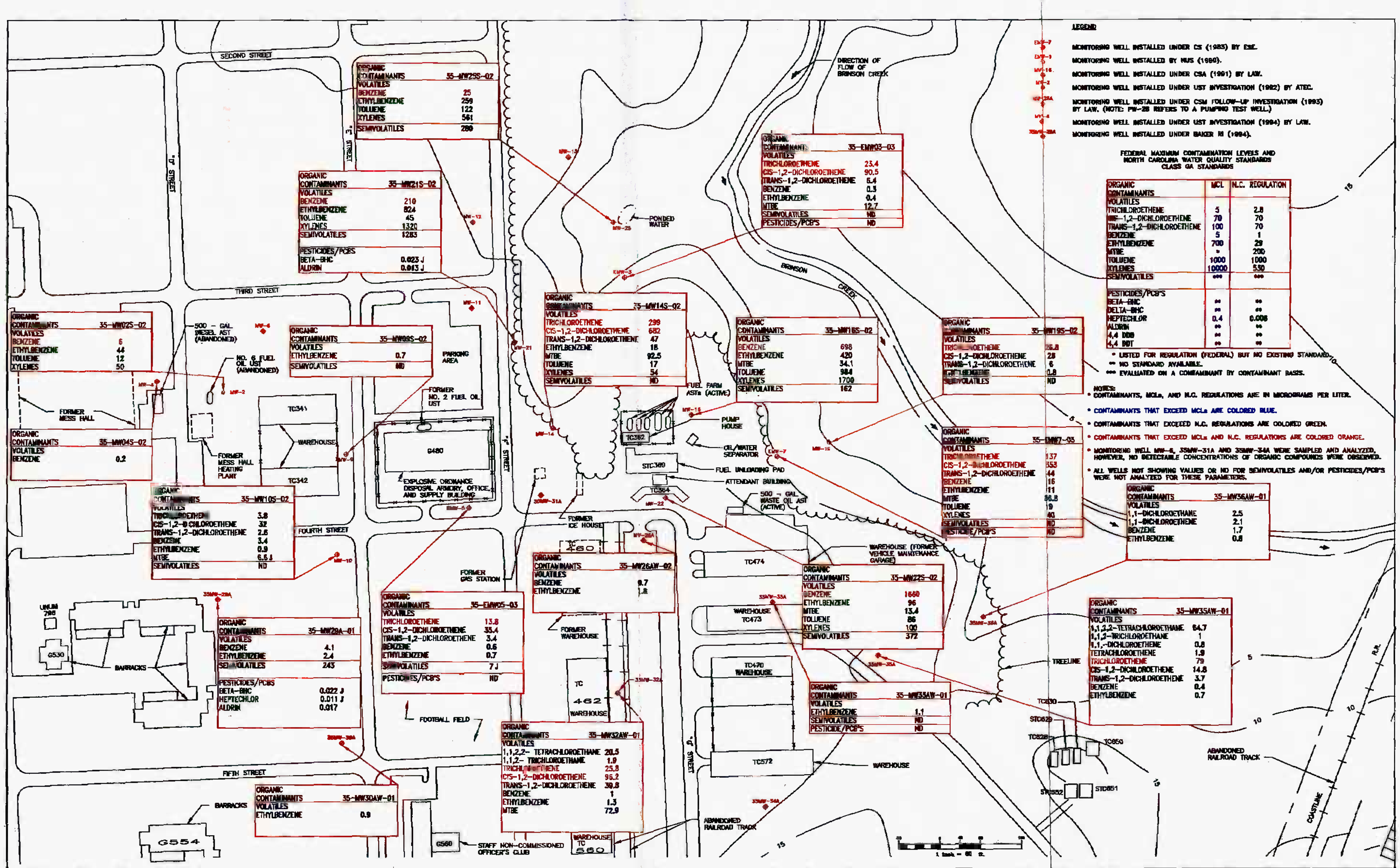
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED INORGANICS IN SURFACE SOILS
CONTRACT TASK ORDER – 0232

SCALE 1" = 80'
DATE OCT. 1994

FIGURE No.
4–3



ORGANIC CONTAMINANTS	35-MW25S-02
VOLATILES	
BENZENE	25
ETHYLBENZENE	259
TOLUENE	122
XYLENES	561
SEMIVOLATILES	280

ORGANIC CONTAMINANTS	35-MW21S-02
VOLATILES	
BENZENE	210
ETHYLBENZENE	824
TOLUENE	45
XYLENES	1320
SEMIVOLATILES	1283
PESTICIDES/PCBS	
BETA-BHC	0.023 J
ALDRIN	0.013 J

ORGANIC CONTAMINANTS	35-EMW03-03
VOLATILES	
TRICHLOROETHENE	23.4
CIS-1,2-DICHLOROETHENE	90.5
TRANS-1,2-DICHLOROETHENE	5.4
BENZENE	0.3
ETHYLBENZENE	0.4
MTBE	12.7
SEMIVOLATILES	ND
PESTICIDES/PCB'S	ND

ORGANIC CONTAMINANTS	35-MW02S-02
VOLATILES	
BENZENE	6
ETHYLBENZENE	44
TOLUENE	12
XYLENES	50

ORGANIC CONTAMINANTS	35-MW09S-02
VOLATILES	
ETHYLBENZENE	0.7
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW14S-02
VOLATILES	
TRICHLOROETHENE	299
CIS-1,2-DICHLOROETHENE	682
TRANS-1,2-DICHLOROETHENE	47
ETHYLBENZENE	18
MTBE	92.5
TOLUENE	17
XYLENES	54
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW16S-02
VOLATILES	
BENZENE	698
ETHYLBENZENE	420
MTBE	34.1
TOLUENE	984
XYLENES	1700
SEMIVOLATILES	162

ORGANIC CONTAMINANTS	35-MW19S-02
VOLATILES	
TRICHLOROETHENE	25.8
CIS-1,2-DICHLOROETHENE	28
TRANS-1,2-DICHLOROETHENE	6
ETHYLBENZENE	0.8
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW04S-02
VOLATILES	
BENZENE	0.2

ORGANIC CONTAMINANTS	35-MW10S-02
VOLATILES	
TRICHLOROETHENE	3.8
CIS-1,2-DICHLOROETHENE	32
TRANS-1,2-DICHLOROETHENE	2.6
BENZENE	3.4
ETHYLBENZENE	0.9
MTBE	6.6 J
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-EMW7-03
VOLATILES	
TRICHLOROETHENE	137
CIS-1,2-DICHLOROETHENE	353
TRANS-1,2-DICHLOROETHENE	44
BENZENE	16
ETHYLBENZENE	11
MTBE	86.8
TOLUENE	19
XYLENES	40
SEMIVOLATILES	ND
PESTICIDE/PCB'S	ND

ORGANIC CONTAMINANTS	35-MW36AW-01
VOLATILES	
1,1-DICHLOROETHANE	2.5
1,1-DICHLOROETHENE	2.1
BENZENE	1.7
ETHYLBENZENE	0.8

ORGANIC CONTAMINANTS	35-MW26AW-02
VOLATILES	
BENZENE	0.7
ETHYLBENZENE	1.8

ORGANIC CONTAMINANTS	35-MW22S-02
VOLATILES	
BENZENE	1660
ETHYLBENZENE	96
MTBE	13.4
TOLUENE	86
XYLENES	100
SEMIVOLATILES	372

ORGANIC CONTAMINANTS	35-EMW05-03
VOLATILES	
TRICHLOROETHENE	13.8
CIS-1,2-DICHLOROETHENE	35.4
TRANS-1,2-DICHLORDETHENE	3.4
BENZENE	0.6
ETHYLBENZENE	0.7
SEMIVOLATILES	7 J
PESTICIDES/PCB'S	ND

ORGANIC CONTAMINANTS	35-MW35AW-01
VOLATILES	
1,1,2,2-TETRACHLOROETHANE	64.7
1,1,2-TRICHLOROETHANE	1
1,1,-DICHLOROETHENE	0.8
TETRACHLOROETHENE	1.9
TRICHLOROETHENE	79
CIS-1,2-DICHLOROETHENE	14.8
TRANS-1,2-DICHLOROETHENE	3.7
BENZENE	0.4
ETHYLBENZENE	0.7

ORGANIC CONTAMINANTS	35-MW29A-01
VOLATILES	
BENZENE	4.1
ETHYLBENZENE	2.4
SEMIVOLATILES	243
PESTICIDES/PCBS	
BETA-BHC	0.022 J
HEPTECHLOR	0.011 J
ALDRIN	0.017

ORGANIC CONTAMINANTS	35-MW33AW-01
VOLATILES	
ETHYLBENZENE	1.1
SEMIVOLATILES	ND
PESTICIDE/PCB'S	ND

ORGANIC CONTAMINANTS	35-MW32AW-01
VOLATILES	
1,1,2,2- TETRACHLOROETHANE	20.5
1,1,2- TRICHLOROETHANE	1.9
TRICHLOROETHENE	25.8
CIS-1,2-DICHLOROETHENE	96.2
TRANS-1,2-DICHLOROETHENE	39.8
BENZENE	1
ETHYLBENZENE	1.3
MTBE	72.9

ORGANIC CONTAMINANTS	35-MW30AW-01
VOLATILES	
ETHYLBENZENE	0.9

LEGEND

- EMW-7 MONITORING WELL INSTALLED UNDER CS (1983) BY ESE.
- EMW-1 MONITORING WELL INSTALLED BY NUS (1990).
- MW-16 MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.
- MW-2 MONITORING WELL INSTALLED UNDER UST INVESTIGATION (1992) BY ATEC.
- MW-28A MONITORING WELL INSTALLED UNDER CSM FOLLOW-UP INVESTIGATION (1993) BY LAW. (NOTE: PW-28 REFERS TO A PUMPING TEST WELL.)
- MW-4 MONITORING WELL INSTALLED UNDER UST INVESTIGATION (1994) BY LAW.
- 35MW-29A MONITORING WELL INSTALLED UNDER BAKER RI (1994).

FEDERAL MAXIMUM CONTAMINATION LEVELS AND
NORTH CAROLINA WATER QUALITY STANDARDS
CLASS GA STANDARDS

ORGANIC CONTAMINANTS	MCL	N.C. REGULATION
VOLATILES		
TRICHLOROETHENE	5	2.8
CIS-1,2-DICHLOROETHENE	70	70
TRANS-1,2-DICHLOROETHENE	100	70
BENZENE	5	1
ETHYLBENZENE	700	29
MTBE	*	200
TOLUENE	1000	1000
XYLENES	10000	530
SEMIVOLATILES	***	***
PESTICIDES/PCB'S		
BETA-BHC	**	**
DELTA-BHC	**	**
HEPTECHLOR	0.4	0.008
ALDRIN	**	**
4,4 DDD	**	**
4,4 DDT	**	**

* LISTED FOR REGULATION (FEDERAL) BUT NO EXISTING STANDARD.
** NO STANDARD AVAILABLE.
*** EVALUATED ON A CONTAMINANT BY CONTAMINANT BASIS.

NOTES:
- CONTAMINANTS, MCLs, AND N.C. REGULATIONS ARE IN MICROGRAMS PER LITER.
- CONTAMINANTS THAT EXCEED MCLs ARE COLORED BLUE.
- CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.
- CONTAMINANTS THAT EXCEED MCLs AND N.C. REGULATIONS ARE COLORED ORANGE.
- MONITORING WELL MW-6, 35MW-31A AND 35MW-34A WERE SAMPLED AND ANALYZED, HOWEVER, NO DETECTABLE CONCENTRATIONS OF ORGANIC COMPOUNDS WERE OBSERVED.
- ALL WELLS NOT SHOWING VALUES OR ND FOR SEMIVOLATILES AND/OR PESTICIDES/PCB'S WERE NOT ANALYZED FOR THESE PARAMETERS.

LEGEND

- -x-x- – FENCE LINE
- —15— – CONTOUR LINES DEPICTING SURFICIAL RELIEF

LEGEND CONTINUED IN UPPER RIGHT HAND CORNER.

DATE	OCT. 1994
SCALE	1" = 60'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23290081

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

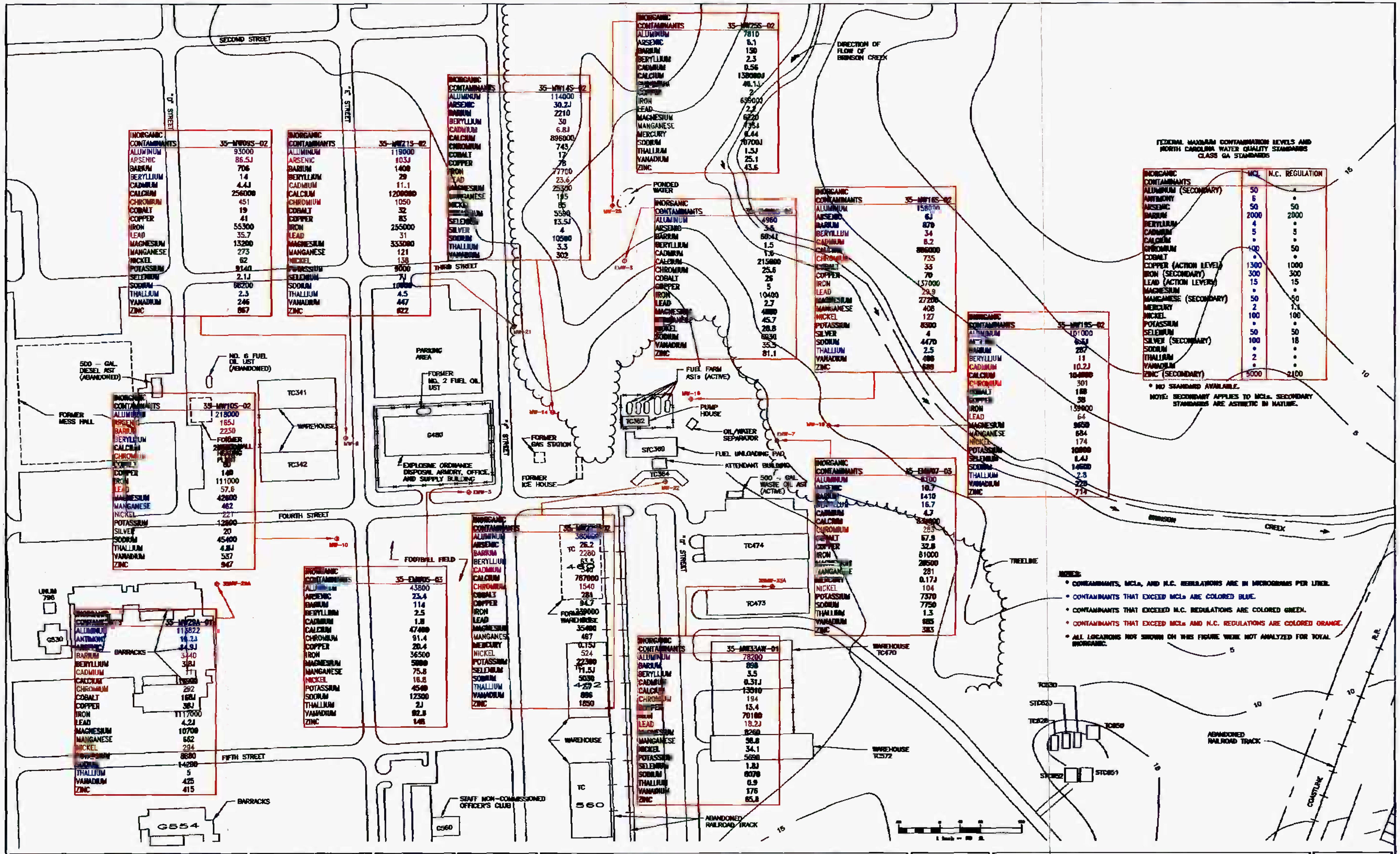
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED ORGANICS IN UPPER PORTION OF SURFICIAL AQUIFER
CONTRACT TASK ORDER – 0232

SCALE 1" = 60'
DATE OCT. 1994

FIGURE No.
4-4



INORGANIC CONTAMINANTS	35-MW09S-02
ALUMINUM	93000
ARSENIC	86.5J
BARIUM	706
BERYLLIUM	14
CADMIUM	4.4J
CALCIUM	256000
CHROMIUM	451
COBALT	19
COPPER	41
IRON	55300
LEAD	35.7
MAGNESIUM	13200
MANGANESE	273
NICKEL	62
POTASSIUM	9140
SELENIUM	2.1J
SODIUM	68200
THALLIUM	2.3
VANADIUM	246
ZINC	867

INORGANIC CONTAMINANTS	35-MW21S-02
ALUMINUM	119000
ARSENIC	103J
BARIUM	1400
BERYLLIUM	29
CADMIUM	11.1
CALCIUM	1200000
CHROMIUM	1050
COBALT	32
COPPER	83
IRON	255000
LEAD	31
MAGNESIUM	333000
MANGANESE	121
NICKEL	138
POTASSIUM	9000
SELENIUM	7J
SODIUM	10000
THALLIUM	4.5
VANADIUM	447
ZINC	822

INORGANIC CONTAMINANTS	35-MW14S-02
ALUMINUM	114000
ARSENIC	30.2J
BARIUM	2210
BERYLLIUM	30
CADMIUM	6.8J
CALCIUM	896000
CHROMIUM	743
COBALT	17
COPPER	78
IRON	77700
LEAD	23.6
MAGNESIUM	25300
MANGANESE	195
NICKEL	85
POTASSIUM	5590
SELENIUM	13.5J
SILVER	4
SODIUM	10500
THALLIUM	3.3
VANADIUM	302

INORGANIC CONTAMINANTS	35-MW25S-02
ALUMINUM	7810
ARSENIC	6.1
BARIUM	150
BERYLLIUM	2.3
CADMIUM	0.56
CALCIUM	138000J
CHROMIUM	40.1J
COPPER	2
IRON	659000
LEAD	2.2
MAGNESIUM	6220
MANGANESE	736.4
MERCURY	0.44
SODIUM	10700J
THALLIUM	1.5J
VANADIUM	25.1
ZINC	43.6

INORGANIC CONTAMINANTS	35-[illegible]-03
ALUMINUM	4960
ARSENIC	3.5
BARIUM	60.4J
BERYLLIUM	1.5
CADMIUM	1.6
CALCIUM	215000
CHROMIUM	25.6
COBALT	26
COPPER	5
IRON	10400
LEAD	2.7
MAGNESIUM	4880
MANGANESE	45.7
NICKEL	28.8
SODIUM	6930
VANADIUM	35.5
ZINC	81.1

INORGANIC CONTAMINANTS	35-MW16S-02
ALUMINUM	158000
ARSENIC	6J
BARIUM	870
BERYLLIUM	34
CADMIUM	6.2
CALCIUM	806000
CHROMIUM	735
COBALT	33
COPPER	70
IRON	157000
LEAD	29.9
MAGNESIUM	27200
MANGANESE	408
NICKEL	127
POTASSIUM	8300
SILVER	4
SODIUM	4470
THALLIUM	2.5
VANADIUM	408
ZINC	688

INORGANIC CONTAMINANTS	35-MW19S-02
ALUMINUM	101000
ARSENIC	63J
BARIUM	287
BERYLLIUM	11
CADMIUM	10.2J
CALCIUM	164000
CHROMIUM	301
COBALT	188
COPPER	38
IRON	159000
LEAD	64
MAGNESIUM	9650
MANGANESE	684
NICKEL	174
POTASSIUM	10800
SELENIUM	1.4J
SODIUM	14600
THALLIUM	2.8
VANADIUM	229
ZINC	714

FEDERAL MAXIMUM CONTAMINATION LEVELS AND NORTH CAROLINA WATER QUALITY STANDARDS CLASS GA STANDARDS

INORGANIC CONTAMINANTS	MCL	N.C. REGULATION
ALUMINUM (SECONDARY)	50	*
ANTIMONY	6	*
ARSENIC	50	50
BARIUM	2000	2000
BERYLLIUM	4	*
CADMIUM	5	5
CALCIUM	*	*
CHROMIUM	100	50
COBALT	*	*
COPPER (ACTION LEVEL)	1300	1000
IRON (SECONDARY)	300	300
LEAD (ACTION LEVEL)	15	15
MAGNESIUM	*	*
MANGANESE (SECONDARY)	50	50
MERCURY	2	1.1
NICKEL	100	100
POTASSIUM	*	*
SELENIUM	50	50
SILVER (SECONDARY)	100	18
SODIUM	*	*
THALLIUM	2	*
VANADIUM	*	*
ZINC (SECONDARY)	5000	2100

* NO STANDARD AVAILABLE.

NOTE: SECONDARY APPLIES TO MCLs. SECONDARY STANDARDS ARE ASTHETIC IN NATURE.

INORGANIC CONTAMINANTS	35-MW10S-02
ALUMINUM	218000
ARSENIC	165J
BARIUM	2250
BERYLLIUM	[illegible]
CALCIUM	[illegible]
CHROMIUM	[illegible]
COBALT	[illegible]
COPPER	149
IRON	111000
LEAD	57.6
MAGNESIUM	42600
MANGANESE	462
NICKEL	221
POTASSIUM	12800
SILVER	20
SODIUM	45400
THALLIUM	4.8J
VANADIUM	537
ZINC	947

INORGANIC CONTAMINANTS	35-EMW07-03
ALUMINUM	8100
ARSENIC	10.7
BARIUM	1410
BERYLLIUM	16.7
CADMIUM	4.7
CALCIUM	834000
CHROMIUM	263
COBALT	57.9
COPPER	32.8
IRON	81000
MAGNESIUM	28500
MANGANESE	281
MERCURY	0.17J
NICKEL	104
POTASSIUM	7370
SODIUM	7750
THALLIUM	1.3
VANADIUM	985
ZINC	383

INORGANIC CONTAMINANTS	35-MW29A-01
ALUMINUM	113822
ANTIMONY	16.2J
ARSENIC	34.9J
BARIUM	3440
BERYLLIUM	3.8J
CADMIUM	11
CALCIUM	16900
CHROMIUM	292
COBALT	168J
COPPER	38J
IRON	1117000
LEAD	4.2J
MAGNESIUM	10700
MANGANESE	662
NICKEL	294
POTASSIUM	8680
SODIUM	14200
THALLIUM	5
VANADIUM	425
ZINC	415

INORGANIC CONTAMINANTS	35-EMW05-03
ALUMINUM	43800
ARSENIC	23.4
BARIUM	114
BERYLLIUM	2.5
CADMIUM	1.8
CALCIUM	47400
CHROMIUM	91.4
COPPER	20.4
IRON	36500
MAGNESIUM	5800
MANGANESE	75.8
NICKEL	16.8
POTASSIUM	4540
SODIUM	12300
THALLIUM	2J
VANADIUM	92.8
ZINC	148

INORGANIC CONTAMINANTS	35-MW[illegible]-02
ALUMINUM	380000
ARSENIC	26.2
BARIUM	2280
BERYLLIUM	63.5
CADMIUM	[illegible]
CALCIUM	787000
CHROMIUM	1540
COBALT	281
COPPER	94.7
IRON	239000
LEAD	[illegible]
MAGNESIUM	35400
MANGANESE	487
MERCURY	0.15J
NICKEL	524
POTASSIUM	22300
SELENIUM	11.5J
SODIUM	5030
THALLIUM	[illegible]
VANADIUM	886
ZINC	1850

INORGANIC CONTAMINANTS	35-MW33AW-01
ALUMINUM	78200
BARIUM	898
BERYLLIUM	3.5
CADMIUM	0.31J
CALCIUM	13500
CHROMIUM	194
COPPER	13.4
IRON	70100
LEAD	18.2J
MAGNESIUM	8260
MANGANESE	58.6
NICKEL	34.1
POTASSIUM	5690
SELENIUM	1.8J
SODIUM	8070
THALLIUM	0.9
VANADIUM	176
ZINC	65.8

NOTES:
- CONTAMINANTS, MCLs, AND N.C. REGULATIONS ARE IN MICROGRAMS PER LITER.
- CONTAMINANTS THAT EXCEED MCLs ARE COLORED BLUE.
- CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.
- CONTAMINANTS THAT EXCEED MCLs AND N.C. REGULATIONS ARE COLORED ORANGE.
- ALL LOCATIONS NOT SHOWN ON THIS FIGURE WERE NOT ANALYZED FOR TOTAL INORGANIC.

LEGEND

- EMW-7 MONITORING WELL INSTALLED UNDER CS (1983) BY ESE.
- EMW-5 MONITORING WELL INSTALLED BY NUS (1990).
- MW-16 MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.
- 35MW-29A MONITORING WELL INSTALLED UNDER BAKER RI (1994).
- -x-x- FENCE LINE
- —15— CONTOUR LINES DEPICTING SURFICIAL RELIEF

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23290281

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

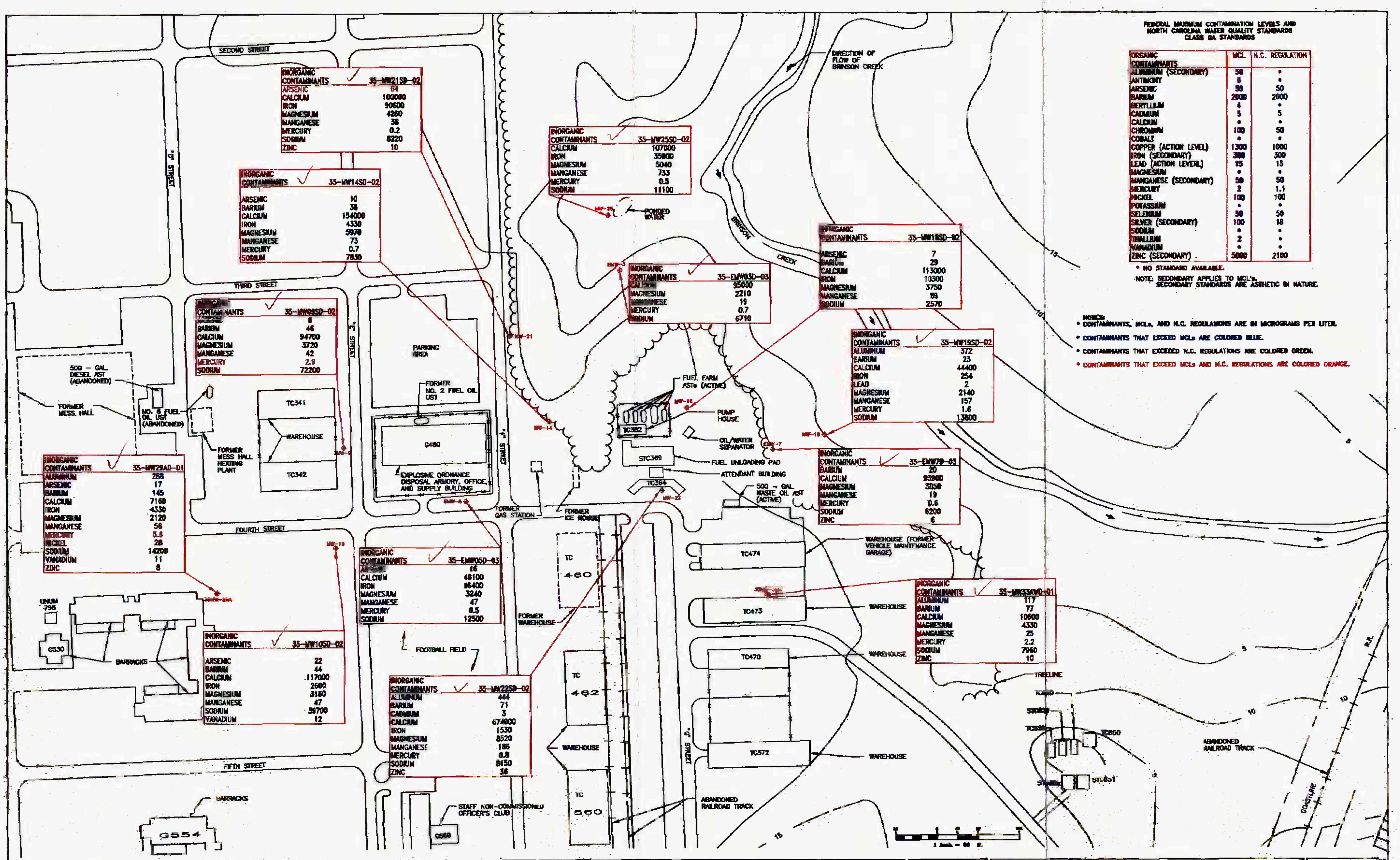
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED TOTAL INORGANICS IN
UPPER PORTION OF SURFICIAL AQUIFER
CONTRACT TASK ORDER - 0232

SCALE 1" = 80'
DATE OCT. 1994

FIGURE No.
4-5



INORGANIC CONTAMINANTS	35-MW21SD-02
ARSENIC	64
CALCIUM	100000
IRON	90600
MAGNESIUM	4260
MANGANESE	36
MERCURY	0.2
SODIUM	8220
ZINC	10

INORGANIC CONTAMINANTS	35-MW14SD-02
ARSENIC	10
BARIUM	38
CALCIUM	154000
IRON	4330
MAGNESIUM	5970
MANGANESE	73
MERCURY	0.7
SODIUM	7830

INORGANIC CONTAMINANTS	35-MW25SD-02
CALCIUM	107000
IRON	35000
MAGNESIUM	5040
MANGANESE	733
MERCURY	0.5
SODIUM	11100

INORGANIC CONTAMINANTS	35-EMW03D-03
CALCIUM	95000
MAGNESIUM	2210
MANGANESE	19
MERCURY	0.7
SODIUM	6710

INORGANIC CONTAMINANTS	35-MW18SD-02
ARSENIC	7
BARIUM	29
CALCIUM	113000
IRON	10300
MAGNESIUM	3750
MANGANESE	89
SODIUM	2570

INORGANIC CONTAMINANTS	35-MW19SD-02
ALUMINUM	372
BARIUM	23
CALCIUM	44400
IRON	254
LEAD	2
MAGNESIUM	2140
MANGANESE	157
MERCURY	1.6
SODIUM	13800

INORGANIC CONTAMINANTS	35-EMW7D-03
BARIUM	20
CALCIUM	93900
MAGNESIUM	3050
MANGANESE	19
MERCURY	0.6
SODIUM	6200
ZINC	6

INORGANIC CONTAMINANTS	35-MW33AWD-01
ALUMINUM	117
BARIUM	77
CALCIUM	10600
MAGNESIUM	4330
MANGANESE	25
MERCURY	2.2
SODIUM	7960
ZINC	10

INORGANIC CONTAMINANTS	35-MW09SD-02
ARSENIC	6
BARIUM	46
CALCIUM	94700
MAGNESIUM	3720
MANGANESE	42
MERCURY	2.9
SODIUM	72200

INORGANIC CONTAMINANTS	35-MW29AD-01
ALUMINUM	288
ARSENIC	17
BARIUM	145
CALCIUM	7160
IRON	4330
MAGNESIUM	2120
MANGANESE	56
MERCURY	5.8
NICKEL	28
SODIUM	14200
VANADIUM	11
ZINC	8

INORGANIC CONTAMINANTS	35-EMW05D-03
ARSENIC	16
CALCIUM	46100
IRON	16400
MAGNESIUM	3240
MANGANESE	47
MERCURY	0.5
SODIUM	12500

INORGANIC CONTAMINANTS	35-MW10SD-02
ARSENIC	22
BARIUM	44
CALCIUM	117000
IRON	2600
MAGNESIUM	3180
MANGANESE	47
SODIUM	39700
VANADIUM	12

INORGANIC CONTAMINANTS	35-MW22SD-02
ALUMINUM	444
BARIUM	71
CADMIUM	3
CALCIUM	674000
IRON	1530
MAGNESIUM	8520
MANGANESE	186
MERCURY	0.8
SODIUM	8150
ZINC	56

FEDERAL MAXIMUM CONTAMINATION LEVELS AND NORTH CAROLINA WATER QUALITY STANDARDS CLASS GA STANDARDS

ORGANIC CONTAMINANTS	MCL	N.C. REGULATION
ALUMINUM (SECONDARY)	50	•
ANTIMONY	6	•
ARSENIC	50	50
BARIUM	2000	2000
BERYLLIUM	4	•
CADMIUM	5	5
CALCIUM	•	•
CHROMIUM	100	50
COBALT	•	•
COPPER (ACTION LEVEL)	1300	1000
IRON (SECONDARY)	300	300
LEAD (ACTION LEVERL)	15	15
MAGNESIUM	•	•
MANGANESE (SECONDARY)	50	50
MERCURY	2	1.1
NICKEL	100	100
POTASSIUM	•	•
SELENIUM	50	50
SILVER (SECONDARY)	100	18
SODIUM	•	•
THALLIUM	2	•
VANADIUM	•	•
ZINC (SECONDARY)	5000	2100

• NO STANDARD AVAILABLE.

NOTE: SECONDARY APPLIES TO MCL's.
SECONDARY STANDARDS ARE ASTHETIC IN NATURE.

NOTES:
- CONTAMINANTS, MCLs, AND N.C. REGULATIONS ARE IN MICROGRAMS PER LITER.
- CONTAMINANTS THAT EXCEED MCLs ARE COLORED BLUE.
- CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.
- CONTAMINANTS THAT EXCEED MCLs AND N.C. REGULATIONS ARE COLORED ORANGE.

LEGEND
EMW-7 - MONITORING WELL INSTALLED UNDER CS (1993) BY ESE.
EMW-3 - MONITORING WELL INSTALLED BY [illegible] (1986).
MW-25 - MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.
35MW-29A - MONITORING WELL INSTALLED UNDER BAKER RI (1994).
- FENCE LINE
15 - CONTOUR LINES DEPICTING SURFICIAL RELIEF

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WDH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23290321

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

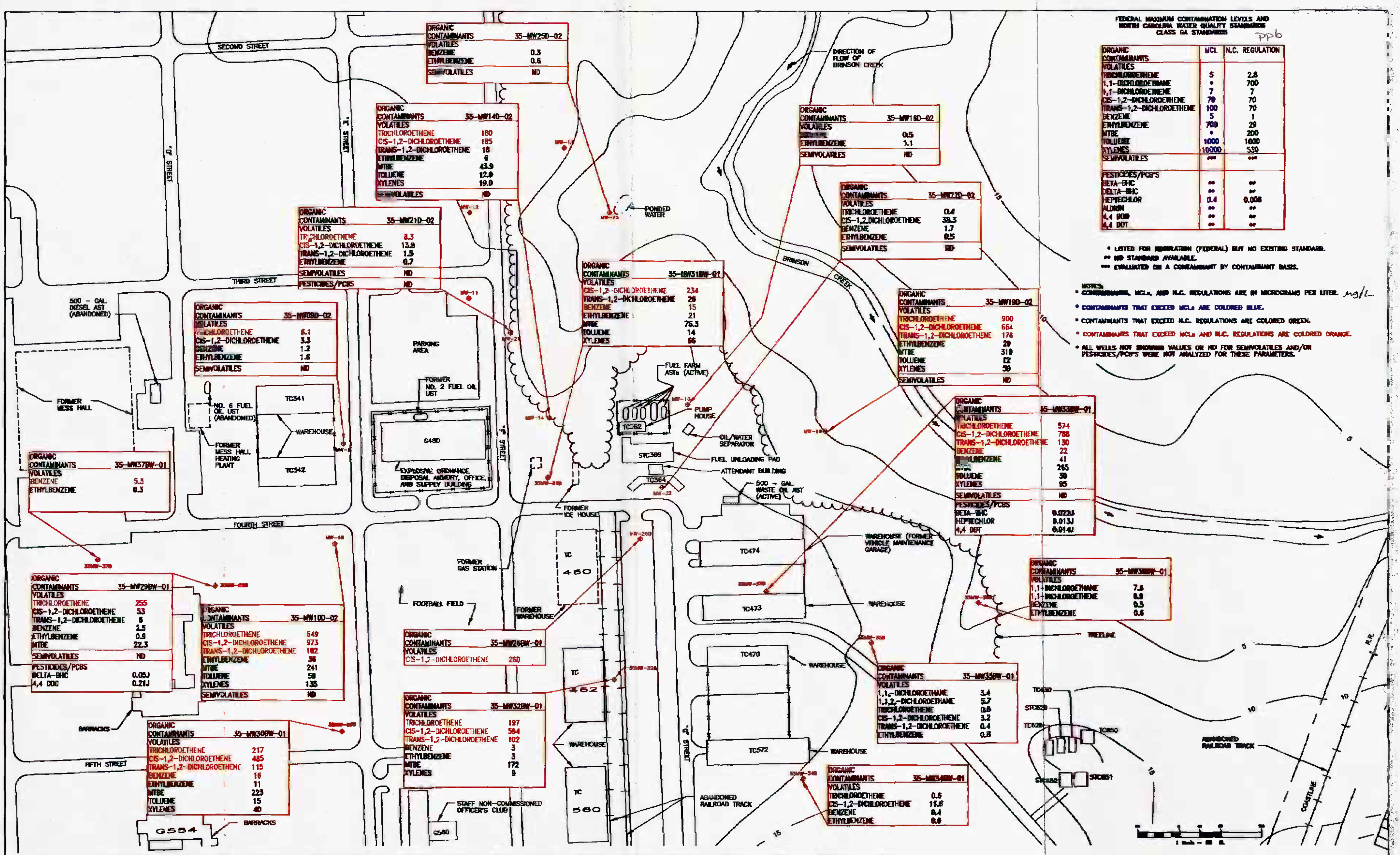
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED DISSOLVED INORGANICS IN UPPER PORTION OF SURFICIAL AQUIFER
CONTRACT TASK ORDER - 0232

SCALE 1" = 80'
DATE Oct. 1994

FIGURE No.
4-6



ORGANIC CONTAMINANTS	35-MW25D-02
VOLATILES	
BENZENE	0.3
ETHYLBENZENE	0.6
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW14D-02
VOLATILES	
TRICHLOROETHENE	180
CIS-1,2-DICHLOROETHENE	185
TRANS-1,2-DICHLOROETHENE	18
ETHYLBENZENE	6
MTBE	43.9
TOLUENE	12.0
XYLENES	19.0
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW21D-02
VOLATILES	
TRICHLOROETHENE	8.3
CIS-1,2-DICHLOROETHENE	13.9
TRANS-1,2-DICHLOROETHENE	1.5
ETHYLBENZENE	0.7
SEMIVOLATILES	ND
PESTICIDES/PCBS	ND

ORGANIC CONTAMINANTS	35-MW09D-02
VOLATILES	
TRICHLOROETHENE	6.1
CIS-1,2-DICHLOROETHENE	3.3
BENZENE	1.2
ETHYLBENZENE	1.6
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW37BW-01
VOLATILES	
BENZENE	5.3
ETHYLBENZENE	0.3

ORGANIC CONTAMINANTS	35-MW16D-02
VOLATILES	
BENZENE	0.5
ETHYLBENZENE	1.1
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW22D-02
VOLATILES	
TRICHLOROETHENE	0.4
CIS-1,2,DICHLOROETHENE	38.3
BENZENE	1.7
ETHYLBENZENE	0.5
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW31BW-01
VOLATILES	
CIS-1,2-DICHLOROETHENE	234
TRANS-1,2-DICHLOROETHENE	26
BENZENE	15
ETHYLBENZENE	21
MTBE	76.3
TOLUENE	14
XYLENES	66

ORGANIC CONTAMINANTS	35-MW19D-02
VOLATILES	
TRICHLOROETHENE	900
CIS-1,2-DICHLOROETHENE	664
TRANS-1,2-DICHLOROETHENE	176
ETHYLBENZENE	29
MTBE	319
TOLUENE	12
XYLENES	58
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW33BW-01
VOLATILES	
TRICHLOROETHENE	574
CIS-1,2-DICHLOROETHENE	788
TRANS-1,2-DICHLOROETHENE	130
BENZENE	22
ETHYLBENZENE	41
MTBE	265
TOLUENE	39
XYLENES	95
SEMIVOLATILES	ND
PESTICIDES/PCBS	
BETA-BHC	0.0223J
HEPTECHLOR	0.013J
4,4 DDT	0.014J

ORGANIC CONTAMINANTS	35-MW38BW-01
VOLATILES	
1,1-DICHLOROETHANE	7.6
1,1-DICHLOROETHENE	6.9
BENZENE	0.5
ETHYLBENZENE	0.6

ORGANIC CONTAMINANTS	35-MW29BW-01
VOLATILES	
TRICHLOROETHENE	255
CIS-1,2-DICHLOROETHENE	53
TRANS-1,2-DICHLOROETHENE	6
BENZENE	2.5
ETHYLBENZENE	0.9
MTBE	22.3
SEMIVOLATILES	ND
PESTICIDES/PCBS	
DELTA-BHC	0.05J
4,4 DDD	0.21J

ORGANIC CONTAMINANTS	35-MW10D-02
VOLATILES	
TRICHLOROETHENE	549
CIS-1,2-DICHLOROETHENE	973
TRANS-1,2-DICHLOROETHENE	102
ETHYLBENZENE	36
MTBE	241
TOLUENE	59
XYLENES	135
SEMIVOLATILES	ND

ORGANIC CONTAMINANTS	35-MW30BW-01
VOLATILES	
TRICHLOROETHENE	217
CIS-1,2-DICHLOROETHENE	485
TRANS-1,2-DICHLOROETHENE	115
BENZENE	16
ETHYLBENZENE	11
MTBE	223
TOLUENE	15
XYLENES	40

ORGANIC CONTAMINANTS	35-MW26BW-01
VOLATILES	
CIS-1,2-DICHLOROETHENE	260

ORGANIC CONTAMINANTS	35-MW32BW-01
VOLATILES	
TRICHLOROETHENE	197
CIS-1,2-DICHLOROETHENE	594
TRANS-1,2-DICHLOROETHENE	102
BENZENE	3
ETHYLBENZENE	3
MTBE	172
XYLENES	8

ORGANIC CONTAMINANTS	35-MW35BW-01
VOLATILES	
1,1,-DICHLOROETHANE	3.4
1,1,2,-DICHLOROETHANE	5.7
TRICHLOROETHENE	0.6
CIS-1,2-DICHLOROETHENE	3.2
TRANS-1,2-DICHLOROETHENE	0.4
ETHYLBENZENE	0.8

ORGANIC CONTAMINANTS	35-MW34BW-01
VOLATILES	
TRICHLOROETHENE	0.6
CIS-1,2-DICHLOROETHENE	11.6
BENZENE	0.4
ETHYLBENZENE	0.6

FEDERAL MAXIMUM CONTAMINATION LEVELS AND
NORTH CAROLINA WATER QUALITY STANDARDS
CLASS GA STANDARDS

ppb

ORGANIC CONTAMINANTS	MCL	N.C. REGULATION
VOLATILES		
TRICHLOROETHENE	5	2.8
1,1-DICHLOROETHANE	•	700
1,1-DICHLOROETHENE	7	7
CIS-1,2-DICHLOROETHENE	70	70
TRANS-1,2-DICHLOROETHENE	100	70
BENZENE	5	1
ETHYLBENZENE	700	29
MTBE	•	200
TOLUENE	1000	1000
XYLENES	10000	530
SEMIVOLATILES	***	***
PESTICIDES/PCB'S		
BETA-BHC	**	**
DELTA-BHC	**	**
HEPTECHLOR	0.4	0.008
ALDRIN	**	**
4,4 DDD	**	**
4,4 DDT	**	**

* LISTED FOR REGULATION (FEDERAL) BUT NO EXISTING STANDARD.
** NO STANDARD AVAILABLE.
*** EVALUATED ON A CONTAMINANT BY CONTAMINANT BASIS.

NOTES:
- CONTAMINANTS, MCLs, AND N.C. REGULATIONS ARE IN MICROGRAMS PER LITER. μg/L
- CONTAMINANTS THAT EXCEED MCLs ARE COLORED BLUE.
- CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.
- CONTAMINANTS THAT EXCEED MCLs AND N.C. REGULATIONS ARE COLORED ORANGE.
- ALL WELLS NOT SHOWING VALUES OR ND FOR SEMIVOLATILES AND/OR PESTICIDES/PCB'S WERE NOT ANALYZED FOR THESE PARAMETERS.

LEGEND
- 35MW-29B – MONITORING WELL INSTALLED UNDER BAKER III (1994).
- MW-10 – MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.
- – FENCE LINE
- —15— – CONTOUR LINES DEPICTING SURFICIAL RELIEF

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	W.M
REVIEWED	JBC
D.O.#	62470-232-0000-07000
CADD#	[illegible]

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

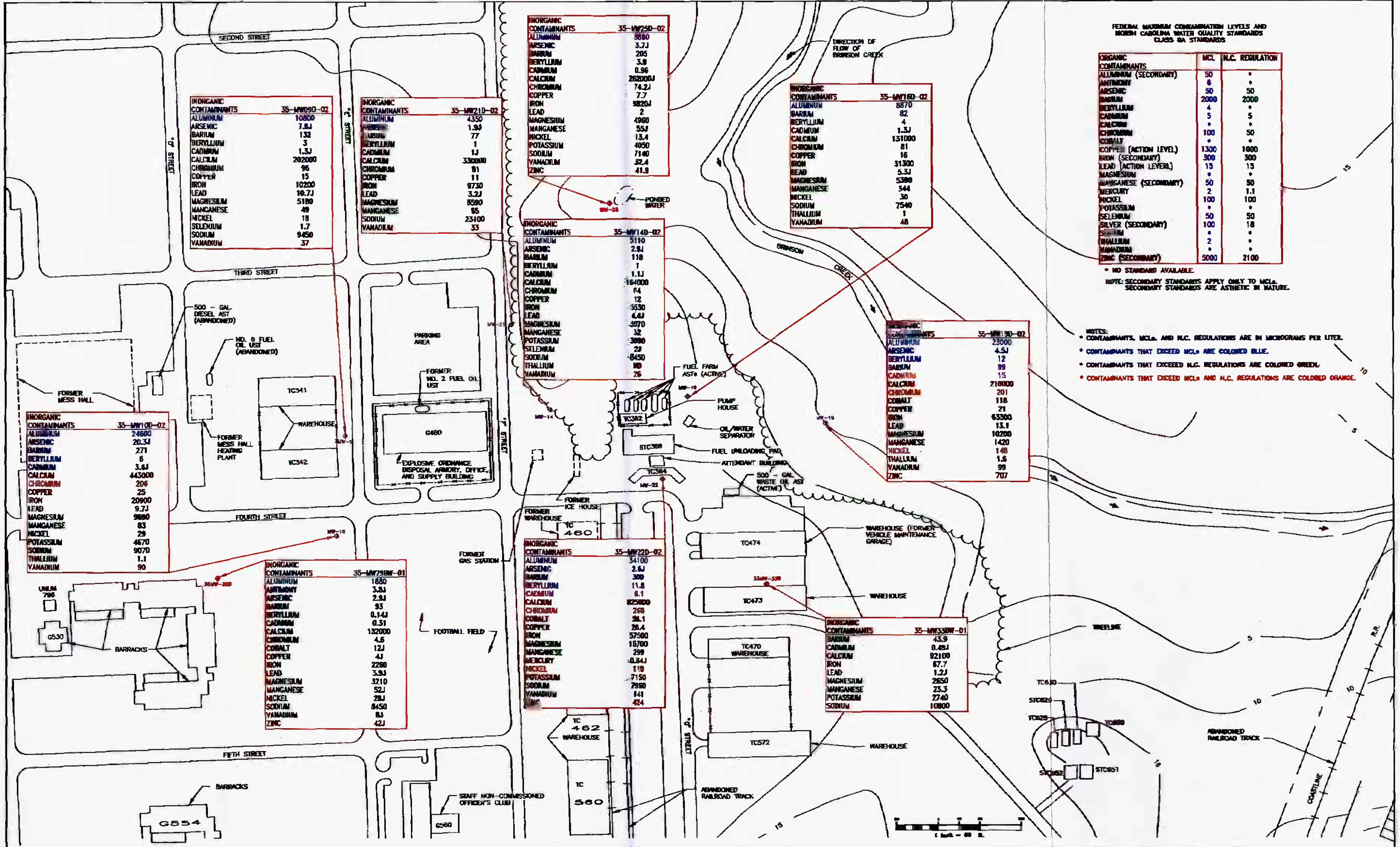
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED ORGANICS IN LOWER
PORTION OF SURFICIAL AQUIFER
CONTRACT TASK ORDER – 0232

SCALE	1" = 80'	DATE	OCT. 1994

FIGURE No.
4–7



INORGANIC CONTAMINANTS	35-MW09D-02
ALUMINUM	10800
ARSENIC	7.8J
BARIUM	132
BERYLLIUM	3
CADMIUM	1.3J
CALCIUM	202000
CHROMIUM	96
COPPER	15
IRON	10200
LEAD	10.7J
MAGNESIUM	5180
MANGANESE	49
NICKEL	18
SELENIUM	1.7
SODIUM	9450
VANADIUM	37

INORGANIC CONTAMINANTS	35-MW21D-02
ALUMINUM	4350
ARSENIC	1.9J
BARIUM	77
BERYLLIUM	1
CADMIUM	1J
CALCIUM	330000
CHROMIUM	81
COPPER	11
IRON	9730
LEAD	3.2J
MAGNESIUM	8590
MANGANESE	65
SODIUM	23100
VANADIUM	33

INORGANIC CONTAMINANTS	35-MW25D-02
ALUMINUM	8880
ARSENIC	3.7J
BARIUM	205
BERYLLIUM	3.9
CADMIUM	0.96
CALCIUM	262000J
CHROMIUM	74.2J
COPPER	7.7
IRON	9820J
LEAD	2
MAGNESIUM	4960
MANGANESE	55J
NICKEL	13.4
POTASSIUM	4050
SODIUM	7140
VANADIUM	32.4
ZINC	41.9

INORGANIC CONTAMINANTS	35-MW16D-02
ALUMINUM	8870
BARIUM	82
BERYLLIUM	4
CADMIUM	1.3J
CALCIUM	131000
CHROMIUM	81
COPPER	16
IRON	31300
LEAD	5.3J
MAGNESIUM	5390
MANGANESE	344
NICKEL	30
SODIUM	7540
THALLIUM	1
VANADIUM	48

FEDERAL MAXIMUM CONTAMINATION LEVELS AND NORTH CAROLINA WATER QUALITY STANDARDS CLASS GA STANDARDS

ORGANIC CONTAMINANTS	MCL	N.C. REGULATION
ALUMINUM (SECONDARY)	50	•
ANTIMONY	6	•
ARSENIC	50	50
BARIUM	2000	2000
BERYLLIUM	4	•
CADMIUM	5	5
CALCIUM	•	•
CHROMIUM	100	50
COBALT	•	•
COPPER (ACTION LEVEL)	1300	1000
IRON (SECONDARY)	300	300
LEAD (ACTION LEVERL)	15	15
MAGNESIUM	•	•
MANGANESE (SECONDARY)	50	50
MERCURY	2	1.1
NICKEL	100	100
POTASSIUM	•	•
SELENIUM	50	50
SILVER (SECONDARY)	100	18
SODIUM	•	•
THALLIUM	2	•
VANADIUM	•	•
ZINC (SECONDARY)	5000	2100

• NO STANDARD AVAILABLE.

NOTE: SECONDARY STANDARDS APPLY ONLY TO MCLs.
SECONDARY STANDARDS ARE ASTHETIC IN NATURE.

INORGANIC CONTAMINANTS	35-MW14D-02
ALUMINUM	5110
ARSENIC	2.9J
BARIUM	118
BERYLLIUM	1
CADMIUM	1.1J
CALCIUM	164000
CHROMIUM	64
COPPER	12
IRON	5630
LEAD	4.4J
MAGNESIUM	3970
MANGANESE	32
POTASSIUM	3080
SELENIUM	2J
SODIUM	8450
THALLIUM	ND
VANADIUM	26

INORGANIC CONTAMINANTS	35-MW19D-02
ALUMINUM	23000
ARSENIC	4.5J
BERYLLIUM	12
BARIUM	99
CADMIUM	15
CALCIUM	216000
CHROMIUM	201
COBALT	118
COPPER	21
IRON	63300
LEAD	13.1
MAGNESIUM	10200
MANGANESE	1420
NICKEL	148
THALLIUM	1.6
VANADIUM	99
ZINC	707

NOTES:
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- CONTAMINANTS THAT EXCEED MCLs AND N.C. REGULATIONS ARE COLORED ORANGE.

INORGANIC CONTAMINANTS	35-MW10D-02
ALUMINUM	24600
ARSENIC	20.3J
BARIUM	271
BERYLLIUM	6
CADMIUM	3.6J
CALCIUM	443000
CHROMIUM	206
COPPER	25
IRON	20900
LEAD	9.7J
MAGNESIUM	9690
MANGANESE	83
NICKEL	29
POTASSIUM	4670
SODIUM	9070
THALLIUM	1.1
VANADIUM	90

INORGANIC CONTAMINANTS	35-MW29BW-01
ALUMINUM	1880
ANTIMONY	3.8J
ARSENIC	2.9J
BARIUM	93
BERYLLIUM	0.14J
CADMIUM	0.31
CALCIUM	132000
CHROMIUM	4.6
COBALT	12J
COPPER	4J
IRON	2260
LEAD	3.9J
MAGNESIUM	3210
MANGANESE	52J
NICKEL	28J
SODIUM	8450
VANADIUM	8J
ZINC	42J

INORGANIC CONTAMINANTS	35-MW22D-02
ALUMINUM	34100
ARSENIC	2.6J
BARIUM	300
BERYLLIUM	11.8
CADMIUM	6.1
CALCIUM	825000
CHROMIUM	268
COBALT	36.1
COPPER	26.4
IRON	57500
MAGNESIUM	16700
MANGANESE	299
MERCURY	0.84J
NICKEL	119
POTASSIUM	7150
SODIUM	7990
VANADIUM	141
ZINC	424

INORGANIC CONTAMINANTS	35-MW33BW-01
BARIUM	43.9
CADMIUM	0.49J
CALCIUM	92100
IRON	67.7
LEAD	1.2J
MAGNESIUM	2650
MANGANESE	23.3
POTASSIUM	2740
SODIUM	10800

LEGEND
- –x–x– – FENCE LINE
- —15— – CONTOUR LINES DEPICTING SURFICIAL RELIEF
- 35MW-29B ● – MONITORING WELL INSTALLED UNDER BAKER RI (1994).
- MW-16 ● – MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.

DATE MAY 1995
SCALE 1" = 80'
DRAWN WJH
REVIEWED JSC
S.O.# 62470-232-0000-07000
CADD# 232905RI

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

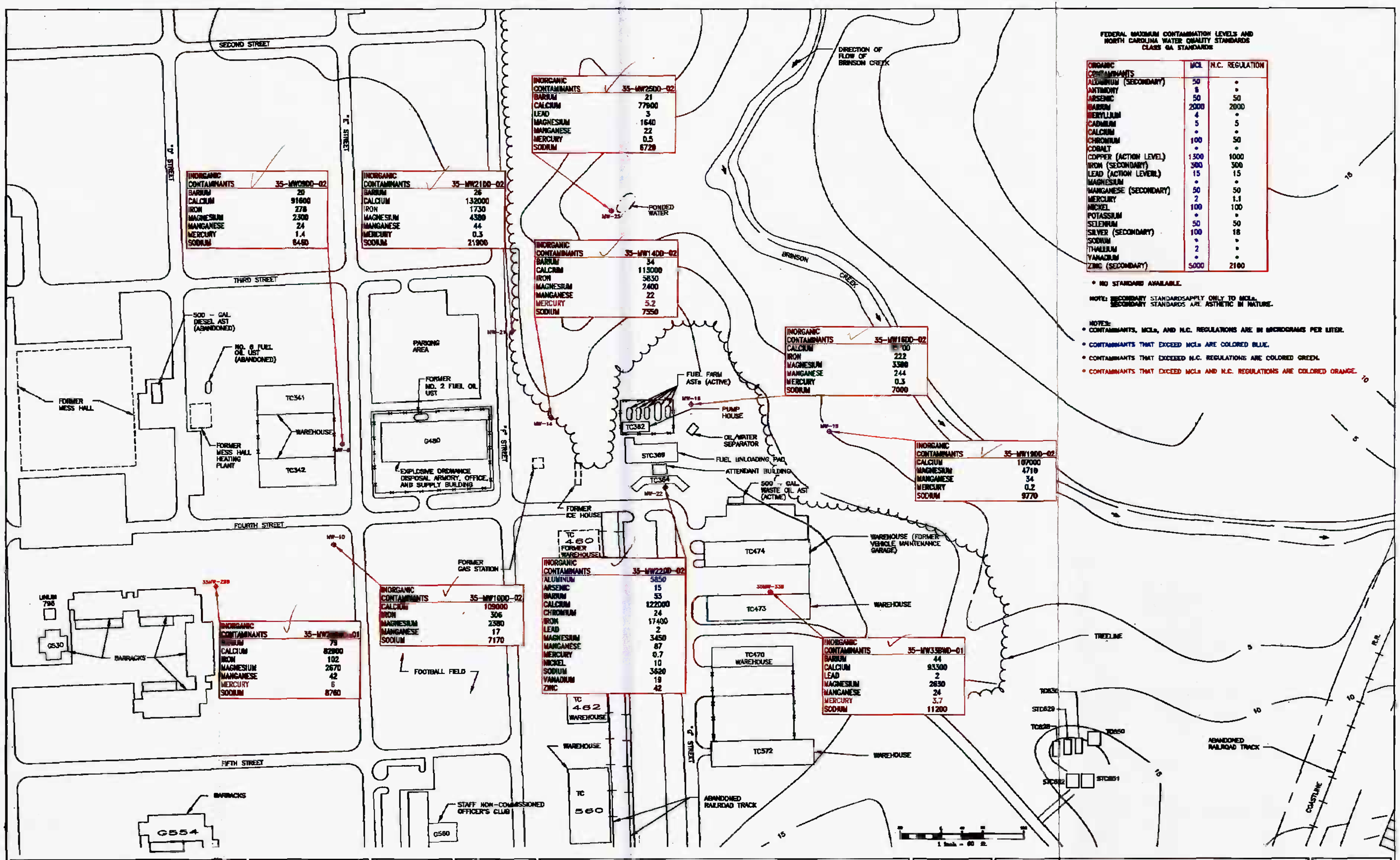
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED TOTAL INORGANICS IN LOWER
PORTION OF SURFICIAL AQUIFER
CONTRACT TASK ORDER – 0232

SCALE 1" = 80'
DATE MAY 1995

FIGURE No.
4–8



INORGANIC CONTAMINANTS	35-MW09DD-02
BARIUM	20
CALCIUM	91600
IRON	278
MAGNESIUM	2300
MANGANESE	24
MERCURY	1.4
SODIUM	6450

INORGANIC CONTAMINANTS	35-MW21DD-02
BARIUM	26
CALCIUM	132000
IRON	1730
MAGNESIUM	4300
MANGANESE	44
MERCURY	0.3
SODIUM	21900

INORGANIC CONTAMINANTS	35-MW25DD-02
BARIUM	21
CALCIUM	77900
LEAD	3
MAGNESIUM	1640
MANGANESE	22
MERCURY	0.5
SODIUM	6720

INORGANIC CONTAMINANTS	35-MW14DD-02
BARIUM	34
CALCIUM	115000
IRON	5830
MAGNESIUM	2400
MANGANESE	22
MERCURY	5.2
SODIUM	7550

INORGANIC CONTAMINANTS	35-MW16DD-02
CALCIUM	[illegible]00
IRON	222
MAGNESIUM	3300
MANGANESE	244
MERCURY	0.3
SODIUM	7000

INORGANIC CONTAMINANTS	35-MW19DD-02
CALCIUM	107000
MAGNESIUM	4710
MANGANESE	34
MERCURY	0.2
SODIUM	9770

INORGANIC CONTAMINANTS	35-MW10DD-02
CALCIUM	109000
IRON	306
MAGNESIUM	2380
MANGANESE	17
SODIUM	7170

INORGANIC CONTAMINANTS	35-MW2[illegible]-01
[illegible]	79
CALCIUM	82900
IRON	102
MAGNESIUM	2670
MANGANESE	42
MERCURY	6
SODIUM	8760

INORGANIC CONTAMINANTS	35-MW22DD-02
ALUMINUM	5850
ARSENIC	15
BARIUM	53
CALCIUM	122000
CHROMIUM	24
IRON	17400
LEAD	2
MAGNESIUM	3450
MANGANESE	87
MERCURY	0.7
NICKEL	10
SODIUM	3620
VANADIUM	19
ZINC	42

INORGANIC CONTAMINANTS	35-MW33BWD-01
BARIUM	44
CALCIUM	93300
LEAD	2
MAGNESIUM	2630
MANGANESE	24
MERCURY	3.7
SODIUM	11200

FEDERAL MAXIMUM CONTAMINATION LEVELS AND
NORTH CAROLINA WATER QUALITY STANDARDS
CLASS GA STANDARDS

ORGANIC CONTAMINANTS	MCL	N.C. REGULATION
ALUMINUM (SECONDARY)	50	•
ANTIMONY	6	•
ARSENIC	50	50
BARIUM	2000	2000
BERYLLIUM	4	•
CADMIUM	5	5
CALCIUM	•	•
CHROMIUM	100	50
COBALT	•	•
COPPER (ACTION LEVEL)	1300	1000
IRON (SECONDARY)	300	300
LEAD (ACTION LEVEL)	15	15
MAGNESIUM	•	•
MANGANESE (SECONDARY)	50	50
MERCURY	2	1.1
NICKEL	100	100
POTASSIUM	•	•
SELENIUM	50	50
SILVER (SECONDARY)	100	18
SODIUM	•	•
THALLIUM	2	•
VANADIUM	•	•
ZINC (SECONDARY)	5000	2100

• NO STANDARD AVAILABLE.

NOTE: SECONDARY STANDARDSAPPLY ONLY TO MCLs.
SECONDARY STANDARDS ARE ASTHETIC IN NATURE.

NOTES:
- CONTAMINANTS, MCLs, AND N.C. REGULATIONS ARE IN MICROGRAMS PER LITER.
- CONTAMINANTS THAT EXCEED MCLs ARE COLORED BLUE.
- CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.
- CONTAMINANTS THAT EXCEED MCLs AND N.C. REGULATIONS ARE COLORED ORANGE.

LEGEND

-x-x- FENCE LINE
—15— CONTOUR LINES DEPICTING SURFICIAL RELIEF
MW-10 ● MONITORING WELL INSTALLED UNDER CSA (1991) BY LAW.
35MW-29B ● MONITORING WELL INSTALLED UNDER BAKER III (1994).

DATE	OCT. 1994
SCALE	1" = 60'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23290081

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

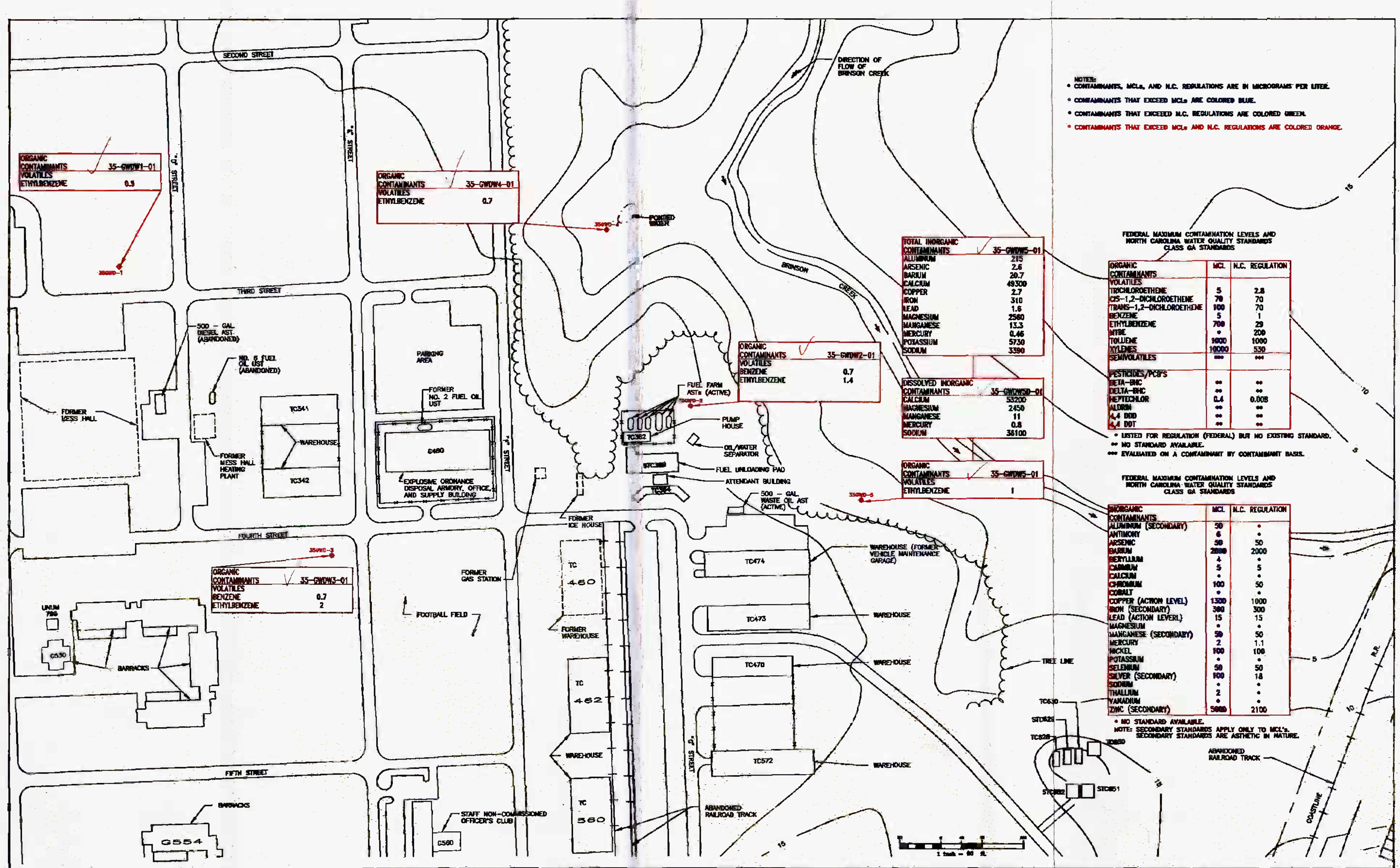
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED DISSOLVED INORGANICS IN THE
LOWER PORTION OF THE SURFICIAL AQUIFER
CONTRACT TASK ORDER - 0232

SCALE 1" = 60'
DATE OCT. 1994

FIGURE No.
4-9



ORGANIC CONTAMINANTS ✓	35-GWDW1-01
VOLATILES	
ETHYLBENZENE	0.5

ORGANIC CONTAMINANTS ✓	35-GWDW4-01
VOLATILES	
ETHYLBENZENE	0.7

ORGANIC CONTAMINANTS ✓	35-GWDW2-01
VOLATILES	
BENZENE	0.7
ETHYLBENZENE	1.4

ORGANIC CONTAMINANTS ✓	35-GWDW3-01
VOLATILES	
BENZENE	0.7
ETHYLBENZENE	2

TOTAL INORGANIC CONTAMINANTS ✓	35-GWDW5-01
ALUMINUM	215
ARSENIC	2.6
BARIUM	20.7
CALCIUM	49300
COPPER	2.7
IRON	310
LEAD	1.6
MAGNESIUM	2560
MANGANESE	13.3
MERCURY	0.46
POTASSIUM	5730
SODIUM	3390

DISSOLVED INORGANIC CONTAMINANTS	35-GWDW5D-01
CALCIUM	53200
MAGNESIUM	2450
MANGANESE	11
MERCURY	0.8
SODIUM	38100

ORGANIC CONTAMINANTS ✓	35-GWDW5-01
VOLATILES	
ETHYLBENZENE	1

NOTES:
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- CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.
- CONTAMINANTS THAT EXCEED MCLs AND N.C. REGULATIONS ARE COLORED ORANGE.

FEDERAL MAXIMUM CONTAMINATION LEVELS AND
NORTH CAROLINA WATER QUALITY STANDARDS
CLASS GA STANDARDS

ORGANIC CONTAMINANTS	MCL	N.C. REGULATION
VOLATILES		
TRICHLOROETHENE	5	2.8
CIS-1,2-DICHLOROETHENE	70	70
TRANS-1,2-DICHLOROETHENE	100	70
BENZENE	5	1
ETHYLBENZENE	700	29
MTBE	*	200
TOLUENE	1000	1000
XYLENES	10000	530
SEMIVOLATILES	***	***
PESTICIDES/PCB'S		
BETA-BHC	**	**
DELTA-BHC	**	**
HEPTECHLOR	0.4	0.008
ALDRIN	**	**
4,4 DDD	**	**
4,4 DDT	**	**

* LISTED FOR REGULATION (FEDERAL) BUT NO EXISTING STANDARD.
** NO STANDARD AVAILABLE.
*** EVALUATED ON A CONTAMINANT BY CONTAMINANT BASIS.

FEDERAL MAXIMUM CONTAMINATION LEVELS AND
NORTH CAROLINA WATER QUALITY STANDARDS
CLASS GA STANDARDS

INORGANIC CONTAMINANTS	MCL	N.C. REGULATION
ALUMINUM (SECONDARY)	50	•
ANTIMONY	6	•
ARSENIC	50	50
BARIUM	2000	2000
BERYLLIUM	4	•
CADMIUM	5	5
CALCIUM	•	•
CHROMIUM	100	50
COBALT	•	•
COPPER (ACTION LEVEL)	1300	1000
IRON (SECONDARY)	300	300
LEAD (ACTION LEVERL)	15	15
MAGNESIUM	•	•
MANGANESE (SECONDARY)	50	50
MERCURY	2	1.1
NICKEL	100	100
POTASSIUM	•	•
SELENIUM	50	50
SILVER (SECONDARY)	100	18
SODIUM	•	•
THALLIUM	2	•
VANADIUM	•	•
ZINC (SECONDARY)	5000	2100

• NO STANDARD AVAILABLE.
NOTE: SECONDARY STANDARDS APPLY ONLY TO MCL's.
SECONDARY STANDARDS ARE ASTHETIC IN NATURE.

LEGEND
- —◆—◆— - FENCE LINE
- —15— - CONTOUR LINES DEPICTING SURFICIAL RELIEF
- 35GWD-3 ● - MONITORING WELL INSTALLED UNDER BAKER RI (1994).

DATE	OCT. 1994
SCALE	1" = 80'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-282-0000-07000
CADD#	23290116

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

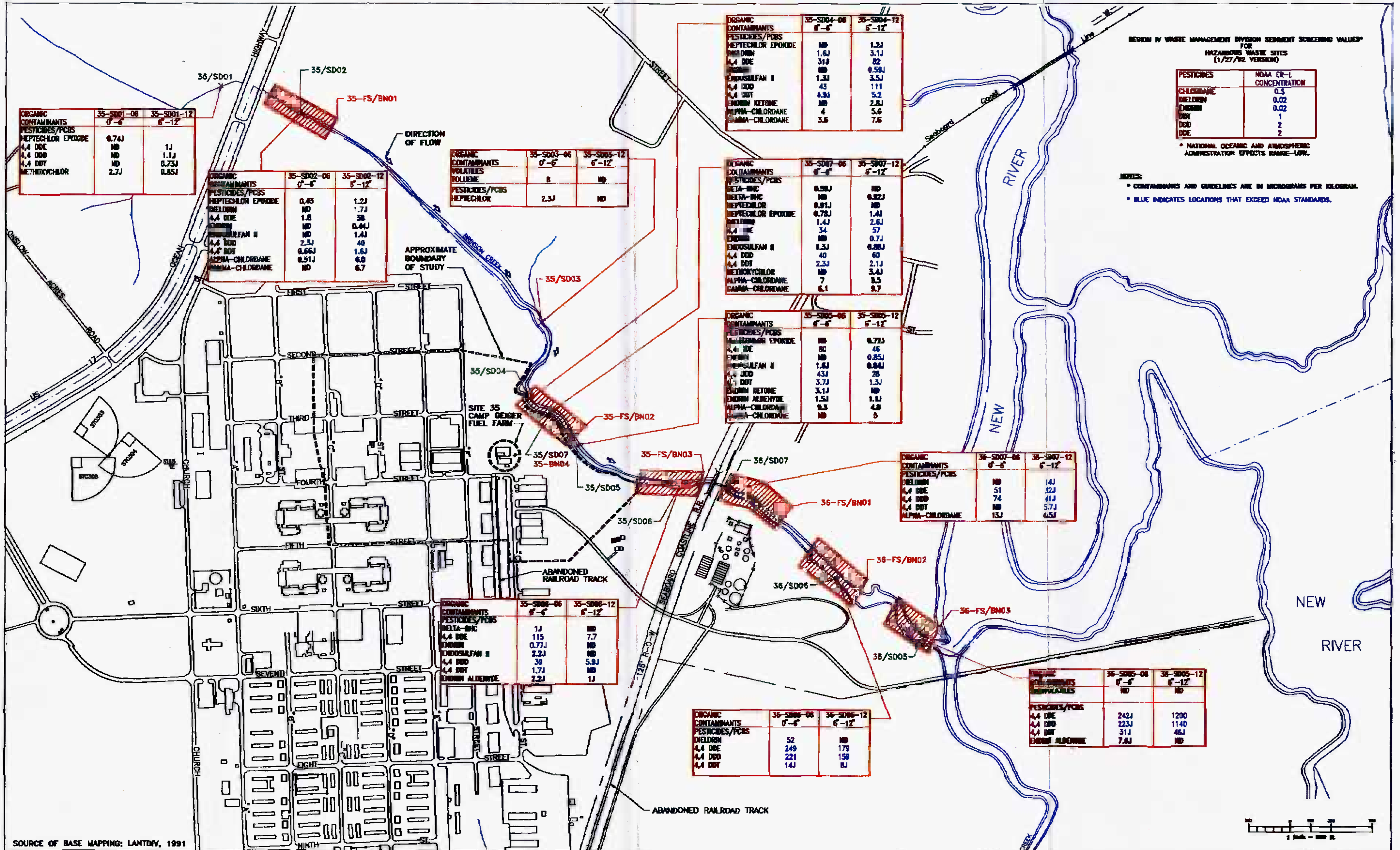
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED ORGANICS AND TOTAL DISSOLVED INORGANICS
IN UPPER PORTION OF CASTLE HAYNE AQUIFER
CONTRACT TASK ORDER - 0232

SCALE	1" = 80'	DATE	OCT. 1994

FIGURE No.
4-10



SOURCE OF BASE MAPPING: LANTDIV, 1991

ORGANIC CONTAMINANTS	35-SD01-06 0"-6"	35-SD01-12 6"-12"
PESTICIDES/PCBS		
HEPTECHLOR EPOXIDE	0.74J	
4,4 DDE	ND	1J
4,4 DDD	ND	1.1J
4,4 DDT	ND	0.73J
METHOXYCHLOR	2.7J	0.65J

ORGANIC CONTAMINANTS	35-SD02-06 0"-6"	35-SD02-12 6"-12"
PESTICIDES/PCBS		
HEPTECHLOR EPOXIDE	0.45	1.2J
DIELDRIN	ND	1.7J
4,4 DDE	1.8	38
ENDRIN	ND	0.44J
ENDOSULFAN II	ND	1.4J
4,4 DDD	2.3J	40
4,4' DDT	0.66J	1.6J
ALPHA-CHLORDANE	0.51J	6.0
GAMMA-CHLORDANE	ND	6.7

ORGANIC CONTAMINANTS	35-SD03-06 0"-6"	35-SD03-12 6"-12"
VOLATILES		
TOLUENE	8	ND
PESTICIDES/PCBS		
HEPTECHLOR	2.3J	ND

ORGANIC CONTAMINANTS	35-SD04-06 0"-6"	35-SD04-12 6"-12"
PESTICIDES/PCBS		
HEPTECHLOR EPOXIDE	ND	1.2J
DIELDRIN	1.6J	3.1J
4,4 DDE	31J	82
ENDRIN	ND	0.58J
ENDOSULFAN II	1.3J	3.5J
4,4 DDD	43	111
4,4 DDT	4.9J	5.2
ENDRIN KETONE	ND	2.8J
ALPHA-CHLORDANE	4	5.6
GAMMA-CHLORDANE	3.6	7.6

ORGANIC CONTAMINANTS	35-SD07-06 0"-6"	35-SD07-12 6"-12"
PESTICIDES/PCBS		
BETA-BHC	0.58J	ND
DELTA-BHC	ND	0.92J
HEPTECHLOR	0.91J	ND
HEPTECHLOR EPOXIDE	0.78J	1.4J
DIELDRIN	1.4J	2.6J
4,4 DDE	34	57
ENDRIN	ND	0.7J
ENDOSULFAN II	8.3J	0.88J
4,4 DDD	40	60
4,4 DDT	2.3J	2.1J
METHOXYCHLOR	ND	3.4J
ALPHA-CHLORDANE	7	8.5
GAMMA-CHLORDANE	6.1	9.7

ORGANIC CONTAMINANTS	35-SD05-06 0"-6"	35-SD05-12 6"-12"
PESTICIDES/PCBS		
HEPTECHLOR EPOXIDE	ND	0.72J
4,4 DDE	80	46
ENDRIN	ND	0.85J
ENDOSULFAN II	1.6J	0.84J
4,4 DDD	43J	28
4,4 DDT	3.7J	1.3J
ENDRIN KETONE	3.1J	ND
ENDRIN ALDEHYDE	1.5J	1.1J
ALPHA-CHLORDANE	9.5	4.8
GAMMA-CHLORDANE	ND	5

ORGANIC CONTAMINANTS	36-SD07-06 0"-6"	36-SD07-12 6"-12"
PESTICIDES/PCBS		
DIELDRIN	ND	14J
4,4 DDE	51	32J
4,4 DDD	74	41J
4,4 DDT	ND	5.7J
ALPHA-CHLORDANE	13J	6.5J

ORGANIC CONTAMINANTS	35-SD06-06 0"-6"	35-SD06-12 6"-12"
PESTICIDES/PCBS		
DELTA-BHC	1J	ND
4,4 DDE	115	7.7
ENDRIN	0.77J	ND
ENDOSULFAN II	2.2J	ND
4,4 DDD	39	5.9J
4,4 DDT	1.7J	ND
ENDRIN ALDEHYDE	2.2J	1J

ORGANIC CONTAMINANTS	36-SD06-06 0"-6"	36-SD06-12 6"-12"
PESTICIDES/PCBS		
DIELDRIN	52	ND
4,4 DDE	249	179
4,4 DDD	221	158
4,4 DDT	14J	8J

ORGANIC CONTAMINANTS	36-SD05-06 0"-6"	36-SD05-12 6"-12"
VOLATILES	ND	ND
PESTICIDES/PCBS		
4,4 DDE	242J	1200
4,4 DDD	223J	1140
4,4 DDT	31J	46J
ENDRIN ALDEHYDE	7.6J	ND

REGION IV WASTE MANAGEMENT DIVISION SEDIMENT SCREENING VALUES*
FOR
HAZARDOUS WASTE SITES
(1/27/92 VERSION)

PESTICIDES	NOAA ER-L CONCENTRATION
CHLORDANE	0.5
DIELDRIN	0.02
ENDRIN	0.02
DDT	1
DDD	2
DDE	2

* NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION EFFECTS RANGE-LOW.

NOTES:
- CONTAMINANTS AND GUIDELINES ARE IN MICROGRAMS PER KILOGRAM.
- BLUE INDICATES LOCATIONS THAT EXCEED NOAA STANDARDS.

LEGEND

36/SD01 × – LOCATION OF SEDIMENT COLLECTION POINT

36-FS/BN02 ▨ – SAMPLE ZONE FOR FISH AND BENTHIC SAMPLES

DATE	OCT. 1994
SCALE	1" = 300'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	232011N

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

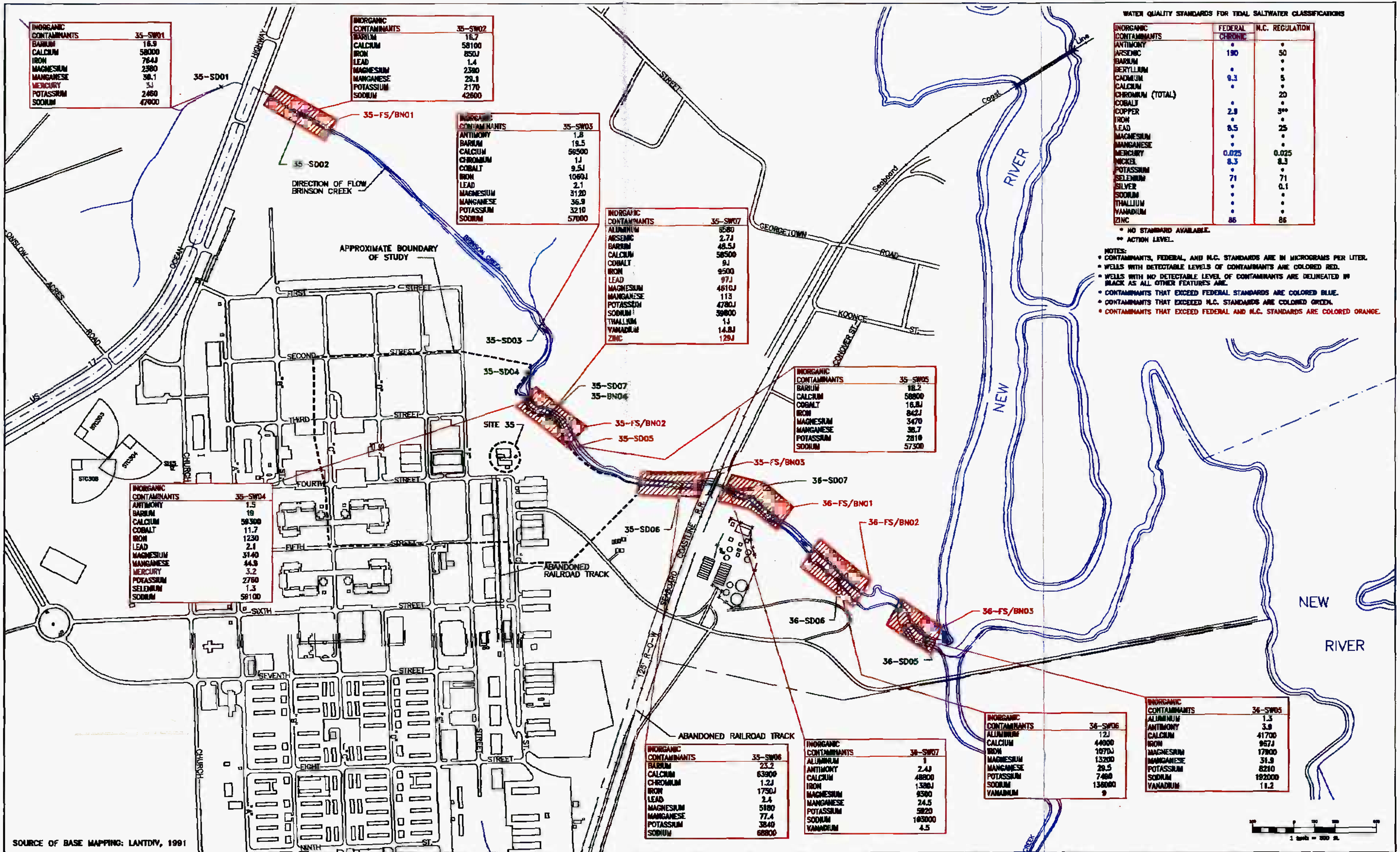
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED ORGANICS
IN SEDIMENT
CONTRACT TASK ORDER – 0232

SCALE 1" = 300'   DATE OCT. 1994

SHEET NO.
4-11



INORGANIC CONTAMINANTS	35-SW01
BARIUM	16.9
CALCIUM	58000
IRON	764J
MAGNESIUM	2380
MANGANESE	38.1
MERCURY	3J
POTASSIUM	2460
SODIUM	47000

INORGANIC CONTAMINANTS	35-SW02
BARIUM	16.7
CALCIUM	58100
IRON	850J
LEAD	1.4
MAGNESIUM	2390
MANGANESE	29.1
POTASSIUM	2170
SODIUM	42600

INORGANIC CONTAMINANTS	35-SW03
ANTIMONY	1.8
BARIUM	19.5
CALCIUM	59500
CHROMIUM	1J
COBALT	9.5J
IRON	1060J
LEAD	2.1
MAGNESIUM	3120
MANGANESE	36.9
POTASSIUM	3210
SODIUM	57000

INORGANIC CONTAMINANTS	35-SW07
ALUMINUM	6580
ARSENIC	2.7J
BARIUM	48.5J
CALCIUM	58500
COBALT	9J
IRON	9500
LEAD	97J
MAGNESIUM	4610J
MANGANESE	113
POTASSIUM	4780J
SODIUM	59800
THALLIUM	1J
VANADIUM	14.8J
ZINC	129J

INORGANIC CONTAMINANTS	35-SW05
BARIUM	18.2
CALCIUM	58800
COBALT	16.8J
IRON	842J
MAGNESIUM	3470
MANGANESE	38.7
POTASSIUM	2810
SODIUM	57300

INORGANIC CONTAMINANTS	35-SW04
ANTIMONY	1.5
BARIUM	19
CALCIUM	59300
COBALT	11.7
IRON	1230
LEAD	2.1
MAGNESIUM	3140
MANGANESE	44.9
MERCURY	3.2
POTASSIUM	2760
SELENIUM	1.3
SODIUM	59100

INORGANIC CONTAMINANTS	35-SW06
BARIUM	23.2
CALCIUM	63900
CHROMIUM	1.2J
IRON	1750J
LEAD	2.4
MAGNESIUM	5180
MANGANESE	77.4
POTASSIUM	3840
SODIUM	68800

INORGANIC CONTAMINANTS	36-SW07
ALUMINUM	1
ANTIMONY	2.4J
CALCIUM	48800
IRON	1380J
MAGNESIUM	9500
MANGANESE	24.5
POTASSIUM	5820
SODIUM	103000
VANADIUM	4.5

INORGANIC CONTAMINANTS	36-SW06
ALUMINUM	12J
CALCIUM	44000
IRON	1070J
MAGNESIUM	13200
MANGANESE	29.5
POTASSIUM	7490
SODIUM	138000
VANADIUM	9

INORGANIC CONTAMINANTS	36-SW05
ALUMINUM	1.3
ANTIMONY	3.9
CALCIUM	41700
IRON	967J
MAGNESIUM	17900
MANGANESE	31.9
POTASSIUM	8210
SODIUM	192000
VANADIUM	11.2

WATER QUALITY STANDARDS FOR TIDAL SALTWATER CLASSIFICATIONS

INORGANIC CONTAMINANTS	FEDERAL CHRONIC	N.C. REGULATION
ANTIMONY	*	*
ARSENIC	190	50
BARIUM		*
BERYLLIUM	*	*
CADMIUM	9.3	5
CALCIUM	*	*
CHROMIUM (TOTAL)		20
COBALT	*	*
COPPER	2.9	3**
IRON	*	*
LEAD	8.5	25
MAGNESIUM	*	*
MANGANESE	*	*
MERCURY	0.025	0.025
NICKEL	8.3	8.3
POTASSIUM	*	*
SELENIUM	71	71
SILVER	*	0.1
SODIUM	*	*
THALLIUM	*	*
VANADIUM	*	*
ZINC	86	86

* NO STANDARD AVAILABLE.

** ACTION LEVEL.

NOTES:
- CONTAMINANTS, FEDERAL, AND N.C. STANDARDS ARE IN MICROGRAMS PER LITER.
- WELLS WITH DETECTABLE LEVELS OF CONTAMINANTS ARE COLORED RED.
- WELLS WITH NO DETECTABLE LEVEL OF CONTAMINANTS ARE DELINEATED IN BLACK AS ALL OTHER FEATURES ARE.
- CONTAMINANTS THAT EXCEED FEDERAL STANDARDS ARE COLORED BLUE.
- CONTAMINANTS THAT EXCEED N.C. STANDARDS ARE COLORED GREEN.
- CONTAMINANTS THAT EXCEED FEDERAL AND N.C. STANDARDS ARE COLORED ORANGE.

SOURCE OF BASE MAPPING: LANTDIV, 1991

LEGEND

35-SW/SD01 × – SAMPLE LOCATION FOR SURFACE WATER AND SEDIMENT

35-FS/BN01 ▨ – COLLECTION AREA FOR FISH AND BENTHIC SAMPLES

–•– – FENCE LINE

☐ – EXISTING STRUCTURE

DATE	OCT. 1994
SCALE	1" = 300'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23291081

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

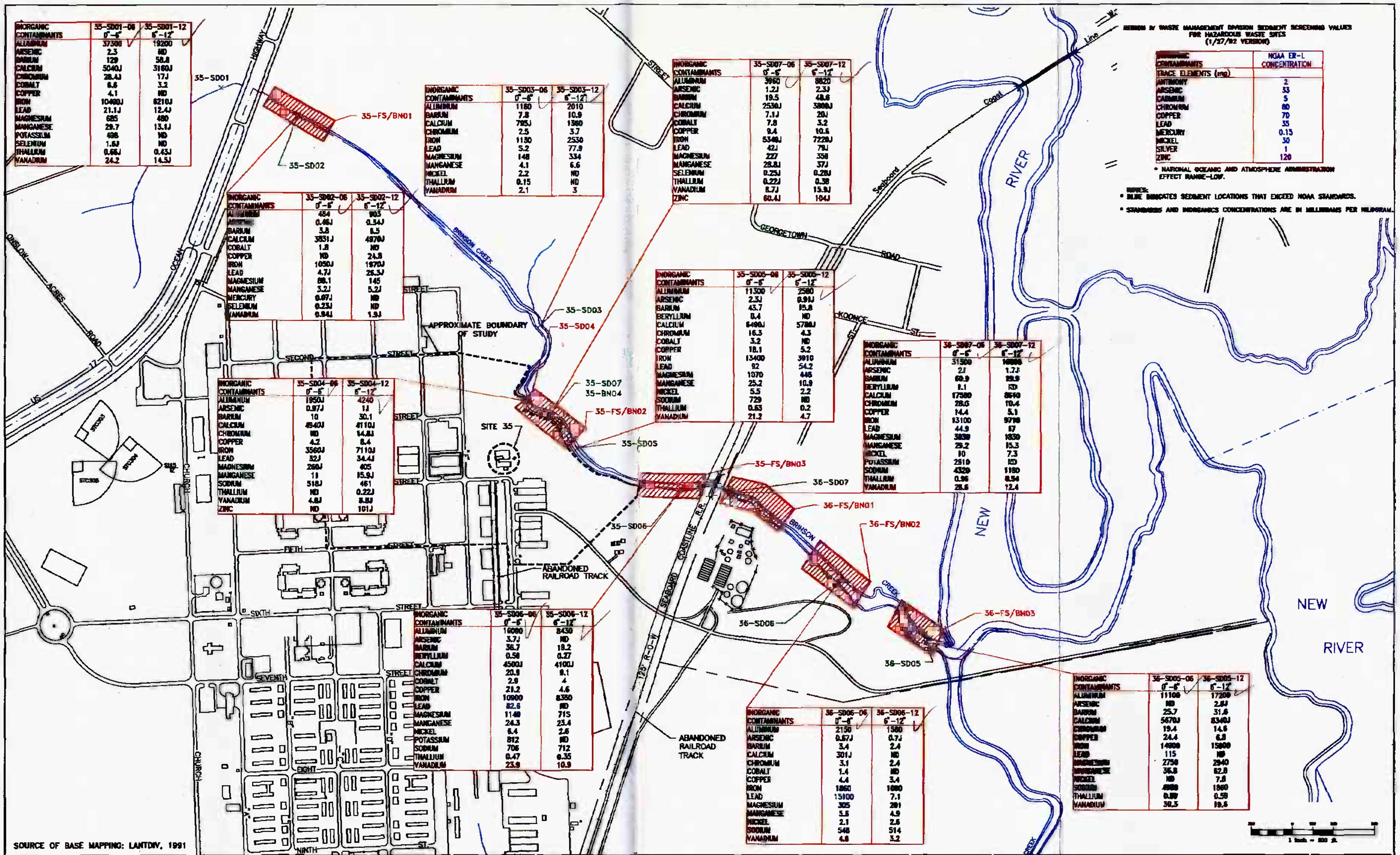
Baker
Baker Environmental, Inc.

DETECTED INORGANICS IN SURFACE WATER
CONTRACT TASK ORDER – 0232

SCALE 1" = 300'

DATE OCT. 1994

SHEET NO.
4-12



INORGANIC CONTAMINANTS	35-SD01-06 0"-6"	35-SD01-12 6"-12"
ALUMINUM	37300	19200
ARSENIC	2.3	ND
BARIUM	129	58.8
CALCIUM	5040J	3160J
CHROMIUM	28.4J	17J
COBALT	6.6	3.2
COPPER	4.1	ND
IRON	10400J	8210J
LEAD	21.1J	12.4J
MAGNESIUM	685	480
MANGANESE	29.7	13.1J
POTASSIUM	498	ND
SELENIUM	1.6J	ND
THALLIUM	0.66J	0.43J
VANADIUM	24.2	14.5J

INORGANIC CONTAMINANTS	35-SD03-06 0"-6"	35-SD03-12 6"-12"
ALUMINUM	1160	2010
BARIUM	7.8	10.9
CALCIUM	795J	1360
CHROMIUM	2.5	3.7
IRON	1130	2530
LEAD	5.2	77.9
MAGNESIUM	148	334
MANGANESE	4.1	6.6
NICKEL	2.2	ND
THALLIUM	0.15	ND
VANADIUM	2.1	3

INORGANIC CONTAMINANTS	35-SD07-06 0"-6"	35-SD07-12 6"-12"
ALUMINUM	3960	8820
ARSENIC	1.2J	2.3J
BARIUM	19.5	48.6
CALCIUM	2530J	3800J
CHROMIUM	7.1J	20J
COBALT	7.8	3.2
COPPER	9.4	10.6
IRON	5340J	7220J
LEAD	42J	79J
MAGNESIUM	227	358
MANGANESE	28.8J	37J
SELENIUM	0.25J	0.28J
THALLIUM	0.22J	0.38
VANADIUM	8.7J	15.9J
ZINC	60.4J	104J

REGION IV WASTE MANAGEMENT DIVISION SEDIMENT SCREENING VALUES
FOR HAZARDOUS WASTE SITES
(1/27/92 VERSION)

INORGANIC CONTAMINANTS	NOAA ER-L CONCENTRATION
TRACE ELEMENTS (mg)	
ANTIMONY	2
ARSENIC	33
CADMIUM	5
CHROMIUM	80
COPPER	70
LEAD	35
MERCURY	0.15
NICKEL	30
SILVER	1
ZINC	120

* NATIONAL OCEANIC AND ATMOSPHERE ADMINISTRATION EFFECT RANGE-LOW.

NOTES:
- BLUE INDICATES SEDIMENT LOCATIONS THAT EXCEED NOAA STANDARDS.
- STANDARDS AND INORGANICS CONCENTRATIONS ARE IN MILLIGRAMS PER KILOGRAM.

INORGANIC CONTAMINANTS	35-SD02-06 0"-6"	35-SD02-12 6"-12"
ALUMINUM	484	903
ARSENIC	0.46J	0.34J
BARIUM	3.8	6.5
CALCIUM	3831J	4970J
COBALT	1.8	ND
COPPER	ND	24.8
IRON	1050J	1970J
LEAD	4.7J	26.3J
MAGNESIUM	88.1	145
MANGANESE	3.2J	5.2J
MERCURY	0.07J	ND
SELENIUM	0.23J	ND
VANADIUM	0.94J	1.9J

INORGANIC CONTAMINANTS	35-SD05-06 0"-6"	35-SD05-12 6"-12"
ALUMINUM	11300	2580
ARSENIC	2.3J	0.91J
BARIUM	43.7	15.8
BERYLLIUM	0.4	ND
CALCIUM	6490J	5780J
CHROMIUM	16.3	4.3
COBALT	3.2	ND
COPPER	18.1	5.2
IRON	13400	3910
LEAD	92	54.2
MAGNESIUM	1070	446
MANGANESE	25.2	10.8
NICKEL	5.5	2.2
SODIUM	729	ND
THALLIUM	0.63	0.2
VANADIUM	21.2	4.7

INORGANIC CONTAMINANTS	36-SD07-06 0"-6"	36-SD07-12 6"-12"
ALUMINUM	31500	10800
ARSENIC	2J	1.7J
BARIUM	69.9	29.9
BERYLLIUM	1.1	ND
CALCIUM	17500	8640
CHROMIUM	28.6	10.4
COPPER	14.4	5.1
IRON	13100	9710
LEAD	44.9	17
MAGNESIUM	3830	1830
MANGANESE	29.2	15.3
NICKEL	10	7.3
POTASSIUM	2810	ND
SODIUM	4320	1180
THALLIUM	0.96	0.54
VANADIUM	28.6	12.4

INORGANIC CONTAMINANTS	35-SD04-06 0"-6"	35-SD04-12 6"-12"
ALUMINUM	1950J	4240
ARSENIC	0.97J	1J
BARIUM	10	30.1
CALCIUM	4940J	4110J
CHROMIUM	ND	14.8J
COPPER	4.2	8.4
IRON	3560J	7110J
LEAD	32J	34.4J
MAGNESIUM	280J	405
MANGANESE	11	15.9J
SODIUM	518J	461
THALLIUM	ND	0.22J
VANADIUM	4.8J	8.8J
ZINC	ND	101J

INORGANIC CONTAMINANTS	35-SD06-06 0"-6"	35-SD06-12 6"-12"
ALUMINUM	16000	8430
ARSENIC	3.7J	ND
BARIUM	36.7	19.2
BERYLLIUM	0.58	0.27
CALCIUM	4500J	4100J
CHROMIUM	20.8	9.1
COBALT	2.9	4
COPPER	21.2	4.6
IRON	10900	8350
LEAD	82.6	ND
MAGNESIUM	1140	715
MANGANESE	24.3	23.4
NICKEL	6.4	2.6
POTASSIUM	812	ND
SODIUM	706	712
THALLIUM	0.47	0.35
VANADIUM	23.9	10.9

INORGANIC CONTAMINANTS	36-SD06-06 0"-6"	36-SD06-12 6"-12"
ALUMINUM	2150	1580
ARSENIC	0.67J	0.7J
BARIUM	3.4	2.4
CALCIUM	301J	ND
CHROMIUM	3.1	2.4
COBALT	1.4	ND
COPPER	4.4	3.4
IRON	1860	1080
LEAD	15100	7.1
MAGNESIUM	305	281
MANGANESE	5.6	4.9
NICKEL	2.1	2.6
SODIUM	548	514
VANADIUM	4.8	3.2

INORGANIC CONTAMINANTS	36-SD05-06 0"-6"	36-SD05-12 6"-12"
ALUMINUM	11100	17200
ARSENIC	ND	2.8J
BARIUM	25.7	31.6
CALCIUM	5670J	8340J
CHROMIUM	19.4	14.6
COPPER	24.4	6.8
IRON	14800	15800
LEAD	115	ND
MAGNESIUM	2750	2940
MANGANESE	36.8	62.8
NICKEL	ND	7.6
SODIUM	4800	1860
THALLIUM	0.97	0.58
VANADIUM	30.3	19.6

SOURCE OF BASE MAPPING: LANTDIV, 1991

LEGEND

35-SW/SD01 ×	SAMPLE LOCATION FOR SURFACE WATER AND SEDIMENT
35-FS/BN01 ▨	SAMPLE ZONE FOR FISH AND BENTHICS

DATE	OCT. 1994
SCALE	1" = 300'
DRAWN	WJH
REVIEWED	JSC
S.O.#	62470-232-0000-07000
CADD#	23291281

NORTH

SITE 35, CAMP GEIGER AREA FUEL FARM RI/FS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

DETECTED INORGANICS IN SEDIMENT
CONTRACT TASK ORDER – 0232

SCALE 1" = 300'
DATE OCT. 1994

SHEET NO.
4-13

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 OU No. 10, Site 35 that impact the fate and transport of the contaminants in the environment. The basis for this discussion of contaminant fate and transport is discussed in Section 4.0, Nature and Extent of Contamination.

5.1 Chemical and Physical Properties Impacting Fate and Transport

Table 5-1 presents the physical and chemical properties associated with a representative group of organic contaminants detected at the site which determine inherent environmental mobility and fate. 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 is not as important when evaluating groundwater and subsurface soils. Vapor pressure for monocyclic aromatics are generally higher than vapor pressures for PAHs. Contaminants with higher vapor pressures will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures.

The rate at which a contaminant is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble contaminants are usually more readily leached than less soluble contaminants. The water solubilities indicate that the volatile organic contaminants including monocyclic aromatics are usually several orders-of-magnitude more soluble than PAHs.

The octanol/water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of contaminants between octanol and water. 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. Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities and vice versa. For example, contaminants such as PAHs are relatively immobile in the environment and are preferentially bound to the soil. The 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 the weight 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

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 35, the following potential contaminant transport pathways have been identified.

- Erosion of contaminated soils and transportation of the soils to surface water and sediment.
- Off-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.
- Groundwater infiltration from the shallow aquifer to the deep aquifer.
- Groundwater discharge to surface water.

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 Erosion of Contaminated Soils and Transportation to Surface Water and Sediment

Surface run-off can transport contaminated surface soils from the site to a surface water body, contaminating the surface water and/or sediment. This is influenced by the velocity of the surface water run-off; vegetation; grain size of the soils; solubility of the contaminants; distance to the water body and the proximity of the contaminated soils to the water body.

The majority of Site 35 is covered with vegetation, therefore reducing erosion of the soils by surface water run-off. Additionally, the surface soils have a high percentage of sand, therefore indicating that most of the rainfall infiltrates the soils and becomes groundwater. However, it is possible that surface water run-off could transport contamination to Brinson Creek either directly or via the tributaries emptying into the creek.

5.2.2 Off-Site Deposition of Windblown Dust

Wind can act as a contaminant transport pathway agent by eroding exposed soil and exposed sediment and blowing it off site. This is influenced by: wind velocity, the grain size/density of the soil/sediment particles and the amount of vegetative cover over the soil or sediment.

The majority of Site 35 is vegetated (i.e., grass, trees) or is covered by permanent structures and paved roads/walkways/parking lots. This would serve to retard airborne migration of site contaminants.

5.2.3 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. 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}).

Surface water sample analytical results indicate that there has not been significant leaching of sediment contaminants into surface water (Section 4.0), based on the infrequent occurrence and level of contamination.

5.2.4 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. This is influenced by the depth to the water table, precipitation, infiltration, physical and chemical properties of the soil, and physical and chemical properties of the contaminant.

Groundwater samples were collected from shallow, intermediate, and deep monitoring wells at Site 35. 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.

5.2.5 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. The potential movement of immiscible organic liquids (non-aqueous phase liquids) will not be discussed in this section.

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 to regions (i.e., recharge areas) 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). In general, the gradient usually 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 (Lyman, et al., 1982).

The average seepage velocity of groundwater flow at Site 35 for both the shallow and deep water-bearing zones can be estimated using a variation of Darcy's Equation:

$$V_x = \frac{Ki}{N_e} \qquad (Fetter, 1988)$$

Where:
V_x = average seepage velocity
K = hydraulic conductivity (cm/sec)
i = hydraulic gradient
N_e = effective porosity

Thus, when monitoring wells or potable supply wells in sand aquifers are located hundreds of meters downgradient of a contaminant source, the average travel time for the groundwater to flow from the source to the well point is typically on the order of years. In the zone of influence created by a high capacity production well or well field, however, the artificially increased gradient could substantially increase the local velocity, and the average travel times for groundwater flow are increased.

Dispersion results from two basic processes, molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes result 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 plume). For simple hydrogeological systems, the spreading is reported to be proportional to the flow rate. Furthermore, dispersion in the direction of flow is often observed to be markedly greater than dispersion in the directions transverse (perpendicular) to the flow. In the absence of detailed studies to determine dispersive characteristics at Site 35, longitudinal and transverse dispersivities are estimated based on similar hydrogeological systems (Mackay, et al., 1985).

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 below Site 35 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 TCE, TCA, and 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. Currently, information is available on the interrelation of soil organic properties to the binding of pesticides, herbicides, and high molecular weight pollutants such as PCBs. However, data is lacking for the non-ionic components of solvents and fuels, which may potentially be responsible for groundwater contamination at Site 35. 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 active chemically; surface sites are negatively or positively charged or they are electronically neutral. Oppositely 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).

5.2.6 Groundwater Discharge to Surface Water

Groundwater discharge to Brinson Creek is very likely at Site 35. Groundwater can transport contamination to Brinson Creek but is dependent on the solubility of the contamination. Like groundwater flow, three general processes govern the flow of the water: advection, dispersion and retardation. These three processes are described in detail in section 5.2.5.

5.2.7 Groundwater Infiltration from the Shallow to the Deep Aquifer

Vertical movement of groundwater from one aquifer system to another, through a semi-confining unit is dependent on a number of factors including: intrinsic permeability of all involved units; density of the fluid (i.e., water and/or contaminant); viscosity of the fluid; hydraulic head; unit thickness; effective porosity; and bulk density of the soil comprising the semi-confining unit. At Site 35, the vertical hydraulic gradient (h) was calculated using the four deep wells (completed below the confining unit) and adjacent intermediate wells (terminated at the confining unit). A potential for downward movement through the semi-confining unit exist in the vicinity of 35GWD-05/MW-19D and 35GWD-3/MW-10D. The portions of the site represented by 35GWD-04/MW-25D and 35GWD-02/MW-16D indicate that a potential for upward movement through the semi-confining unit exists.

Contaminants concentrations above NCWQS or Federal MCLs were not detected in the deep wells indicating that contamination has not migrated from the shallow to the deep aquifer.

5.3 <u>Fate and Transport Summary</u>

The following paragraphs summarize the contaminant group fate and transport data for contaminants detected in media collected at Site 35.

5.3.1 Volatile Organic Compounds

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

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

5.3.2 Polynuclear Aromatic Hydrocarbons

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

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

PAHs are somewhat persistent in the environment. In general their persistence increases with increasing ring numbers. Photolysis and oxidation may be important removal mechanisms in surface waters and surficial soils, while biodegradation could be an important fate process in groundwater, surface soils or deeper soils. PAHs are ubiquitous in nature. The presence of PAHs in the soil may be the result of aerially deposited material, and the chemical and biological conditions in the soil which result in selective microbial degradation/breakdown.

5.3.3 Pesticides/PCBs

Pesticides/PCBs are persistent and immobile contaminants in environmental media.

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

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

5.3.4 Inorganics

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

The most complicated pathway for inorganic contaminants is migration in subsurface soils and groundwaters, where oxidation reduction potential (Eh) and pH play critical roles. Table 5-2 presents and 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.

SECTION 5.0 REFERENCES

SECTION 5.0 REFERENCES

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SECTION 5.0 TABLES

TABLE 5-1

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
REMEDIAL INVESTIGATION CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Vapor Pressure (mm Hg)	Water Solubility (mg/l)	Octanol/Water Coefficient (log K_{ow})	Sediment Partition (log K_{oc})	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index	Comments
Volatiles:								
Benzene	76	1780	2.13	1.92	0.879	5.55E-03	3.2	Very mobile
Carbon Disulfide	260	2300	1.84	2.08	1.263	1.13E-02	3.7	Very mobile
Chloroform	160	8000	1.97	1.59	1.489	3.39E-03	4.5	Very mobile
1,1-Dichloroethene	500	400	1.48	2.26	1.218	1.90E-01	3.0	Very mobile
1,1-Dichloroethane	180	5500	1.79	1.63	1.174	5.45E-03	4.4	Very mobile
1,2-Dichloroethene	200	600	1.48	2.17	1.26	5.32E-03	2.9	Very mobile
Ethylbenzene	7	152	3.15	2.93	0.867	6.44E-03	0.1	Very mobile
Tetrachloroethene	14	150	2.6	2.6	1.626	2.87E-03	0.75	Very mobile
Toluene	22	515	2.69	2.54	0.867	5.90E-03	1.5	Very mobile
1,1,2-Trichloroethane	19	4500	2.17	1.75	1.44	7.42E-04	3.2	Very mobile
1,1,2,2-Trichloroethane	5	2900	2.56	1.92	1.60	3.83E-04	2.2	Very mobile
Trichloroethene	60	1100	2.29	2.09	1.46	1.17E-03	2.7	Very mobile
Xylenes (total)	6	180	3.02	2.84	0.87	4.64E-03	0.19	Very mobile
Semivolatiles:								
Benzo(a)anthracene	5.0E-09	0.014	5.61	5.34	NA	1.0E-06	-15.5	Very Immobile
Benzo(b)fluoranthene	10E-06 to 10E-07	0.009	6.57	6.26	NA	1.22E-05	-14	Very Immobile
Benzo(k)fluoranthene	9.6E-11	0.0016	6.84	6.22	NA	3.87E-05	-19	Very Immobile
Benzo(a)pyrene	5.0E-09	0.0038	6.04	5.72	NA	4.9E-07	-16.4	Very Immobile
Chrysene	10E-06 to 10E-11	0.006	5.61	5.44	1.274	1.1E-06	-13.7	Very Immobile
1,4-Dichlorobenzene	6.0E-01	49	3.39	3.22	1.458	3.1E-03	-1.8	Slightly mobile
Fluoranthene	10E-06 to 10E-04	0.265	5.33	4.84	NA	6.5E-06	-9.4	Immobile
Indeno(1,2,3-cd)pyrene	1E-10	5.3E-04	6.51	6.20	1.070	6.95E-08	-19.5	Very Immobile
Pyrene	6.85	0.14	5.32	4.91	NA	5.1E-06	-11.9	Very Immobile

TABLE 5-1 (Continued)

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
REMEDIAL INVESTIGATION CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Vapor Pressure (mm Hg)	Water Solubility (mg/l)	Octanol/Water Coefficient (log K_{ow})	Sediment Partition (log K_{oc})	Specific Gravity (g/cm^3)	Henry's Law Constant ($atm-m^3/mole$)	Mobility Index	Comments
Pesticides/PCBs:								
Dieldrin	1.87E-04	0.1	5.6	4.31	1.75	4.57E-10	-12	Very Immobile
4,4'-DDT	1.9E-07	0.0034	6.19	4.89	NA	1.58E-05	-14	Very immobile
4,4'-DDD	10.2E-07	0.09	5.99	4.47	NA	2.2E-08	-12	Very immobile
4,4'-DDE	6.5E-06	0.04	4.28	3.66	NA	6.8E-05	-10	Immobile
Endrin	2.0E10-07	0.26	5.6	4.06	NA	4.0E-07	-11	Very Immobile
Endosulfan II	9E-03	0.1	3.62	3.47	NA	--	-6.5	Immobile

Sources:
1. Verscheuren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York.
2. Lyman, et al. 1982. Handbook of Chemical Property Estimation Methods. Environmental Behavior of Organic Compounds.
3. USEPA. 1982. Aquatic Fate Process Data for Organic Priority Pollutants. Final Report.

TABLE 5-2

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
REMEDIAL INVESTIGATION CTO-0232
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:

Se = Selenium
Zn = Zinc
Cu = Copper
Ni = Nickel
Hg = Mercury
Ag = Silver
As = Arsenic
Cd = Cadmium
Ba = Barium
Pb = Lead
Fe = Iron
Cr = Chromium
Be = Beryllium
Zn = Zinc

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

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The following subsections present the baseline human health risk assessment (BRA) conducted for Operable Unit No. 10, Site 35. The assessment was performed in concordance with "Risk Assessment Guidance for Superfund, Human Health Evaluation Manual: Part A" and USEPA Region IV Supplemental Guidance (USEPA, 1989a, USEPA, 1992c). The purpose of the baseline risk assessment is to assess whether the constituents of concern at the site pose a current or potential future risk to human health in the absence of remedial action. Because the purpose of the risk assessment is protection of human health, the approach of the USEPA guidance is designed to be conservative. This protectiveness is achieved by the use of assumptions and models that result in upper bound estimates of risk, i.e., the true or actual risk is expected to fall between the estimated value and zero. As a result, the actual site risks are unlikely to exceed the estimated upper bound values and are probably lower. The following paragraphs present a brief overview of the risk assessment process and how the assessment affects further activity at the sites.

6.1 Introduction

The BRA investigates the potential for COPCs to affect human health and/or the environment, both now and in the future, under a "no further remedial action scenario." The BRA process evaluates the data generated during the sampling and analytical phase of the RI, identifying areas of interest and contaminants of concern with respect to geographical, demographic, and physical and biological characteristics of the study area. Contaminant intakes by hypothetical receptors are determined and combined with the toxicological properties of the contaminants to estimate (inferentially) the potential public health impacts posed by constituents detected at the sites. The development of current and potential future use exposure scenarios is consistent with the methodology for baseline risk assessment, as specified by USEPA.

The National Contingency Plan (NCP) stipulates a range of acceptable cancer risk levels of 1.0 x 10^{-04} to 1.0 x 10^{-06} for total risk at a hazardous waste site (USEPA, 1990). These cancer risk levels represent the probability of an individual developing cancer over his or her lifetime if exposed to the COPCs at the site. For example, a risk level of 10^{-6} is the probability that one person in 1,000,000 exposed persons will develop cancer in a lifetime. The total noncarcinogenic acceptable risk level is a hazard index of less than or equal to 1.0. This noncancer risk level depicts a level at or below which adverse systemic effects are not expected in the exposed population.

A remedial action is recommended when either the total cancer or noncancer risks exceed the NCP established levels. Some form of remedial action also is necessary when either the current or future exposure point concentrations at the site are above the applicable or suitable analogous standards (e.g., maximum contaminant levels [MCLs] for drinking water) for those COPCs for which standards exist.

The components of the BRA include:

- Identification of contaminants of potential concern: the determination as to whether a substance has the potential to elicit an adverse effect (toxicity) upon exposure to humans;
- The exposure assessment: identification of the human population(s) likely to be expected and the development of specific exposure pathways for the population(s);

- The toxicity assessment: quantification of the relationship between the human exposure and the probability of occurrence (risk) of a toxic response;
- Risk characterization: information collected during the exposure and toxicity assessment is combined to develop a quantitative estimation of the potential risk;
- Uncertainty analysis: any major sources of uncertainty pertaining to the finding of the BRA are identified and discussed qualitatively;
- Conclusions of the BRA and potential site risk: the results of the BRA are summarized and conclusions relating to the total site risk are drawn.

This text of BRA is divided into seven sections, including the introduction. Section 6.2 establishes the criteria for the selection of COPCs. The COPCs are chosen, for each media, from an overall list of contaminants detected at the site. Section 6.3 discusses the site characteristics, identifies potential human exposure pathways, and describes potential current and future exposure scenarios, the estimation of potential exposure, discussing the estimation of daily intakes, incremental cancer risks and hazard indices. In addition, advisory criteria for the evaluation of human health is discussed. Section 6.4 discusses toxicological information for the COPCs. Section 6.5 discusses the risk characterization. Section 6.6 discusses the sources of uncertainty in the BRA. Section 6.7 provides the conclusion for the potential human health impacts in the form of total site risks. 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 potential health effects. Six environmental media were investigated during this RI: surface soils, subsurface soils, groundwater, surface water, sediments, and biota. This section presents the selection of COPCs for these media. The discussion of findings presented in Section 4.0, Nature and Extent of Contamination, was used as the basis for this section.

6.2.1 Criteria for Selecting Contaminants of Potential Concern

Quantifying risk for all positively identified contaminants may distract from the dominant risk driving contaminants at the site. Therefore, the data set was reduced to a list of COPCs. COPCs are site-related contaminants used to quantitatively estimate human exposures and associated potential health effects.

The criteria used in selecting the COPCs from the constituents detected during the field sampling and analytical phase of the investigation were:

- Historical information
- Prevalence
- Mobility
- Persistence
- Toxicity
- Examination of federal and state criteria and standards
- Comparison to Risk-Based Concentrations (RBCs)

- Comparison to investigation associated field and laboratory blank data
- Comparison to background or naturally occurring levels
- Comparison to anthropogenic levels

The criteria chosen to establish the COPCs are based on the guidance in the USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989a). A comparison to contaminant-specific criteria was also considered in the selection of COPCs. A brief description of the selection criteria used in choosing final COPCs is presented below. A contaminant did not need to fit into all of these categories in order to be retained as a COPC.

6.2.1.1 Historical Information

OU No. 10 is comprised of a single site, Site 35 (Camp Geiger Area Fuel Farm). Site 35 is located adjacent to Brinson Creek and upstream of another site, Site 36 (Camp Geiger Area Dump Near Sewage Treatment Plant). The surface water, sediment, and biota data from these two sites was combined to estimate the potential human health effects associated with contaminants identified at these sites and will be referred to as Site 35 throughout the BRA. Following is a description of the area of concern:

- Camp Geiger is located at the extreme northwest corner of MCB, Camp Lejeune, Onslow County. The main entrance to Camp Geiger is off U.S. Route 17, approximately 3.5 miles southeast of the City of Jacksonville, North Carolina. Site 35, the Camp Geiger Area Fuel Farms refers primarily to five, 15,000-gallon aboveground storage tanks (ASTs), a pump house, and a fuel unloading pad situated within Camp Geiger just north of the intersection of Fourth and "G" Streets. Previous environmental investigations at the site identified underground fuel distribution piping that connect the ASTs to existing and former underground storage tanks (USTs) and expanded the area referred to as Site 35. To date, the Site 35 study area has been roughly bounded to the west by "D" Street, to the north by Second Street, and on the east by Brinson Creek, and to the south by Fourth Street and Building No. TC474.

The association of contaminants with site activities based on historical information was used along with the following procedures to determine retention or elimination of contaminants.

6.2.1.2 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. The occurrence of a chemical must be evaluated with respect to the number of samples taken to determine the frequency criterion which warrants the inclusion of a chemical as a COPC. Contaminants that are infrequently detected, may be artifacts in the data due to 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 the contaminant to be present. Physiochemical properties (i.e., fate and transport) and toxicological properties for each infrequently detected constituent were evaluated.

6.2.1.3 Mobility

The physical and chemical properties of a contaminant are responsible for its transport in the environment. These properties, in conjunction with site conditions, determine whether a contaminant will tend to volatilize into the air from surface soils or surface waters, or be transported via advection or diffusion through soils, groundwaters, and surface waters. Physical and chemical properties also describe a contaminant's tendency to adsorb onto soil/sediment particles. Environmental mobility can correspond to either an increased or decreased potential to affect human health and/or the environment.

6.2.1.4 Persistence

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

6.2.1.5 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the human health assessment. For example the weight-of-evidence (WOE) classification should be considered in conjunction with concentrations detected at the site. Some effects considered in the selection of COPCs include carcinogenicity, mutagenicity, teratogenicity, systemic effects, and reproductive toxicity. Bioaccumulation and bioconcentration properties may affect the severity of the toxic response in an organism and/or subsequent receptors and are evaluated if relevant data exist.

Despite their inherent toxicity, certain inorganic contaminants are essential nutrients. Essential nutrients need not be considered for further consideration in the quantitative risk assessment if they are present in relatively low concentration (i.e., below two times the average base-specific background levels or slightly elevated above naturally occurring levels), or if the contaminant is toxic at doses much higher than those which could be assimilated through exposures at the site.

6.2.1.6 State and Federal Criteria and Standards

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

The State of North Carolina has developed the NCWQS for groundwater and surface water. The only enforceable federal regulatory standards for water are the federal MCLs. Regulatory guidelines were used for comparative purposes to infer the potential health risks and environmental impacts when necessary. Relevant regulatory guidelines include AWQC (Federal Ambient Water Quality Criteria) and Health Advisories. Also, off-site background information for surface water and sediment were compiled to compare site-specific sample concentrations for COPC selection.

In general, chemical-specific criteria and standards are not available for soil. Therefore, base-specific background concentrations were compiled to evaluate background levels of organic and inorganic constituents in the surface and subsurface soil. Organic contaminants were not detected in the base-specific background samples. Therefore, it is likely that all organic contaminants detected in the surface and subsurface soil, within OU No. 10, 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 COPCs.

A brief explanation of the criteria and standards used for the 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 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 two liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply.

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), and 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 of potential human carcinogens (USEPA, 1994a).

North Carolina Water Quality Standards (Surface Water) - The NCWQSs for surface water are the standard concentrations, that either alone or in combination with other wastes, in surface waters that will not render waters injurious to aquatic life or wildlife, recreational activities, public health, or impair the waters for any designated use (NC DEHNR, 1993).

Ambient Water Quality Criteria - AWQCs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). The AWQCs for the protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e. the 10E-7 to 10E-5 range).

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

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

6.2.1.7 Risk-Based Concentrations (RBCs)

The RBCs were developed by the USEPA, Region III as benchmark concentrations for evaluating site investigation data. RBCs are not intended as stand-alone decision-making tools, but as a screening tool to be used in conjunction with other information to help in the selection of COPCs. Selecting COPCs using RBCs is accomplished by the comparison of the maximum concentrations of each contaminant detected in each medium to its corresponding RBC. The 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 1.0E-06. The RBCs represent protective environmental concentrations at which the USEPA would not typically take action (USEPA, 1994b; USEPA, 1993a).

6.2.1.8 Contaminant Concentrations in Blanks

The association with 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 may eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared with results from samples with which the blanks are associated. However, due to the difficulty in determining this association between certain blanks and data, the maximum contaminant concentrations reported in the blanks will be compared to the entire sample data set to evaluate COPCs. 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 considered attributable to site activities only if the concentrations in the sample exceed ten times the maximum amount detected in any blank. If a contaminant is not a common lab contaminant, then concentrations that are less than five times the concentration found in any blank are believed to be non-site-related. The elimination of a sample result will directly correlate to a reduction in the prevalence of contaminant in a media. Consequently, a contaminant that may have been included on the basis of prevalency would be eliminated as a COPC if elimination due to blank concentration reduces the prevalence of a contaminant to less than five percent.

The maximum concentrations of detected common laboratory contaminants in blanks were as follows:

Acetone	43J µg/L
Methylene Chloride	5J µg/L
Toluene	0.6 µg/L
bis(2-ethylhexyl)phthalate	56 µg/L

Blanks containing organic constituents that were not considered common laboratory contaminants (i.e., all other TCL compounds) were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989a). All TCL compounds at 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:

Chloroform	8.0 µg/L
Methoxychlor	0.5J µg/L
Endrin Aldehyde	0.11J µg/L
Total Xylenes	1.4 µg/L

When assessing soil concentrations, the Contract Required Quantitation Limits (CRQL) and percent moisture were accounted for in order to correlate solid and aqueous quantitation limits. For example, when assessing semivolatile contaminants the CRQL for solid samples is 33 to 66 times (depending on the contaminant) that of aqueous samples. Therefore, in order to assess contaminant levels in soil samples using an aqueous blank concentration, the concentration must be multiplied by 5 or 10 (noncommon or common lab contaminant) and then multiplied by 33 or 66 to correct for the variance in the CRQL. This value is then divided by the percent moisture determined for the sample.

6.2.1.9 Background Naturally Occurring Levels

Naturally occurring levels of chemicals are present under ambient conditions. In general, comparison with naturally occurring levels is applicable only to inorganic analytes, because a majority of organic contaminants are not naturally occurring. Background samples were collected from areas that are known to be uninfluenced by site contamination. An inorganic concentration was considered site-related only if it exceeded two times the average concentration estimated for the site-specific background samples. The average for the surface soil inorganics was estimated using 30 data points. The average for the subsurface soil inorganics was estimated using inorganic results from 20 sample locations. Consequently, a 95th upper confidence limit (UCL) cannot statistically be estimated for some of these sample sets. Therefore, the maximum concentration is used to conservatively evaluate inorganic background levels.

6.2.1.10 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. A good example of ubiquitous, anthropogenic chemicals in environmental are the PAHs. In general, anthropogenic chemicals were 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 could result in the loss of important information for those potentially exposed.

The remaining 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 COPC for OU No. 10. Once this task has been completed, a final list of media-specific COPCs will be selected based on the remaining criteria (persistence, mobility, toxicity, ARARs, RBCs, blank concentrations, background concentrations, and anthropogenic concentrations).

6.2.1.11 Bioconcentration Factors

Bioconcentration factors measure the tendency for a chemical to partition from the water column or sediment and concentrate in aquatic organisms. Bioconcentration is important for ecological receptors because chemicals with high BCFs could accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain. The BCF is the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in water.

6.2.2 Selection of Contaminants of Potential Concern

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

6.2.2.1 Site 35

Surface Soil

Thirteen surface soil samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, PCBs, and inorganics. Table 6-1 presents the organic compounds detected in the surface soil while Table 6-2 presents the inorganics detected in the surface soil.

Three VOCs, carbon disulfide, toluene, and total xylenes were detected in the surface soil. All were detected infrequently, 1 out of 10, 1 out of 13, and 1 out of 13 samples, respectively. Also, all detected concentrations of these chemicals were below Region III residential soil RBC values. Therefore, these VOCs did not warrant retention as COPCs.

The SVOCs, phenol, acenaphthene, carbazole, butylbenzylphthalate, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene were all detected infrequently in 1 out of 13 samples, and therefore are not retained as COPCs. Also, bis(2-ethylhexy)phthalate was detected in the investigation QA/QC blanks at a concentration 56 µg/L, this chemical was detected in the surface soil at a concentration of 279 µ/kg which is less than 10 times the concentration (560 µ/L) detected in the QA/QC blank. On comparison to Region III residential soil RBC values, phenol, acenaphthene, carbazole, butylbenzylphthalate, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, indeno(1,2,3-cd)pyrene, fluoranthene, pyrene, and chrysene concentrations were below RBC values. Phenanthrene, benzo(b)fluoranthene, benzo(g,h,i)perylene are retained as COPCs based on frequency of detection and comparison to RBC values.

Beta-BHC, 4,4'-DDE, endrin, 4,4'-DDT, alpha-chlordane and gamma-chlordane were detected at concentrations below residential soil RBC values, therefore they are not retained as COPCs these chemicals were detected once or twice in the surface soil. Dieldrin, 4,4'-DDD, endosulfan II, endrin ketone and endrin aldehyde are retained as COPCs based on frequency of detection and comparison to RBC values.

The maximum concentrations of beryllium and thallium detected in the surface soil is less than or equal to two times the average base-wide background. Therefore these inorganics are not retained as COPCs. Aluminum, calcium, iron, and magnesium are not retained as COPCs because they are considered essential nutrients and were not expected to cause adverse effected at the detected concentrations. Antimony, barium, cadmium, chromium, cobalt, copper, nickel, selenium, vanadium and zinc were detected at concentrations below residential RBC values and therefore are not retained as COPCs. Arsenic, lead and manganese are retained as COPCs based on frequency of detection, comparison to base background concentrations, and comparison to RBC values.

Subsurface Soil

Eight subsurface soil samples were analyzed for SVOCs, pesticides, PCBs, and inorganics while nineteen subsurface soil samples were analyzed for VOCs. Table 6-3 presents the organic compounds detected in the subsurface soil while Table 6-4 presents the inorganics detected in the subsurface soil.

The presence of VOCs acetone and methylene chloride are attributable to levels detected in the investigation associated QA/QC blanks. The maximum concentrations of acetone and methylene chloride were reported as 144 µ/kg and 7 µ/kg, respectively. These concentrations are less than ten times the concentrations reported in the investigation related QA/QC blanks (430 µ/L and 50 µ/L, respectively). Tetrachloroethene was detected at a concentrations less than the residential soil RBC levels. These compounds are not retained as COPCs.

Pyrene and benzo(b)fluoranthene were the only SVOCs detected in the subsurface soil. Pyrene was detected in 1 out of 8 samples at a concentration less than residential soil RBC levels, therefore, it is not retained as a COPC. Benzo(b)fluoranthene is retained as a COPC.

Pesticides and PCBs were not detected in the subsurface soil, therefore, pesticides and PCBs are not retained as COPCs.

Aluminum, calcium, iron, magnesium and potassium were not retained as COPCs, they are considered essential nutrients and no adverse effects are expected at the detected concentrations. Aluminum, cadmium, nickel, selenium, and silver were detected at concentrations less than two times the average base-wide background concentrations. Barium, cadmium, chromium, cobalt, copper, manganese, nickel, selenium silver, vanadium, and zinc were detected at concentrations below residential soil RBC values. Therefore, the above chemicals are not retained as COPCs. Arsenic, lead, and thallium are retained as COPCs in the subsurface soil.

Groundwater

Fifty groundwater samples were analyzed for VOCs, twenty-four samples were analyzed for SVOCs and inorganics, and seven samples were analyzed for pesticides and PCBs. Table 6-5 presents the chemicals detected in the groundwater.

VOCs 1,1,2,2-tetrachloroethane (2 out of 50, 4%), 1,1,2-trichloroethane (2 out of 50, 4%), 1,1-dichloroethane (3 out of 50, 6%), chloroform (1 out of 50, 2%), and tetrachloroethene (1 out of 50, 2%) were detected infrequently in the groundwater. Also, chloroform was detected at a concentration of 0.6 μ/L which less than five times the concentration detected in the associated investigation QA/QC blanks (40 μ/L). 1,1,2-Trichloroethane, 1,1-dichloroethane, and chloroform were detected at concentrations less than all associated groundwater criteria (i.e., NCWQS, Federal MCLs, and Federal Health Advisories). Therefore, these chemicals are not retained as COPCs in the groundwater. 1,1-Dichloroethane was detected at a concentration less than tap water RBCs and therefore was not retained as a COPC. Trichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,1-dichloroethene, benzene, toluene, ethylbenzene, methyl tertiary butyl ether and xylenes are retained as COPCs in the groundwater based on prevalence, comparison to groundwater criteria, and comparison to RBCs.

Phenol, 2-methylphenol, 4-methylphenol, 2,4-methylphenol, anthracene, and carbazole were detected infrequently in the groundwater (either 1 out of 24, 4%, or 2 out of 24, 8%). On comparison to tap water RBC values, phenol, 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, fluorene and anthracene were detected at concentrations below RBC levels. Therefore, the above chemicals are not retained as COPCs in the groundwater. Naphthalene, dibenzofuran, 2-methylnaphthalene, and phenanthrene are retained as COPCs due to prevalence, comparison to groundwater criteria, and comparison to tap water RBCs.

Beta-BHC, 4,4'-DDD and 4,4'-DDT were detected at concentrations less than tap water RBC levels and are not retained as COPCs. Aldrin was only detected twice in the groundwater and was detected at concentrations below the groundwater criteria and therefore is not retained as a COPC. Delta-BHC and heptachlor are retained as COPCs in the groundwater.

Aluminum, calcium, iron, magnesium, potassium, and sodium were not retained as COPCs because they are considered essential nutrients and were not expected to cause adverse effects at the detected concentrations. Copper, mercury, and selenium were detected at concentrations less than tap water RBCs, and therefore are not retained as COPCs. Also, mercury and selenium were detected at concentrations below groundwater criteria. Arsenic, antimony, barium, beryllium, chromium, cadmium, cobalt, lead, manganese, nickel, silver, thallium, vanadium and zinc are retained as COPCs in the groundwater based on prevalence, comparison to groundwater criteria, and comparison to tap water RBCs.

Surface Water

Ten surface water samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and inorganics. There were no VOCs, SVOCs, pesticides, or PCBs detected in the surface water, therefore, organic contaminants are not retained as COPCs. Table 6-6 presents the inorganics detected in the surface water.

Aluminum, calcium, iron, magnesium, potassium and sodium were not retained as COPCs because they are considered essential nutrients and were not expected to cause adverse effects at the detected concentrations. Barium, and selenium were detected at concentrations less than two times the concentrations detected in the background samples, and therefore are not retained as COPCs. Also, barium and selenium were detected at concentrations less than the surface water criteria. Antimony, arsenic, cobalt, chromium, lead, manganese, mercury, thallium, vanadium, and zinc are retained as

COPCs due to prevalence, comparison to surface water criteria, and comparison to background concentrations.

Sediment

Twenty sediment samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and inorganics. Table 6-7 presents the chemicals detected in the sediments.

Acetone and toluene were detected infrequently in the sediment (1 out of 20 each). Additionally, acetone was detected at a concentration of 128 µ/kg which is less than ten times the concentration detected in the investigation QA/QC blank (430 µ/L). Therefore, these chemicals are not retained as COPCs.

Di-n-butyl phthalate was detected infrequently in 1 out of 20 samples, and therefore is not retained as a COPC. Bis-(2-ethylhexyl)phthalate is not retained as COPCs due the fact that it was detected at concentrations below the concentrations in the QA/QC blank in two samples, therefore the prevalence of this contaminant is 1 out of 20 samples. Di-n-butyl phthalate was the only SVOC retained as a COPC in the sediment.

Beta-BHC was detected infrequently in the sediment (1 out of 20 samples) therefore, this pesticide was not retained as a COPC. Deta-BHC and heptachlor were detected at concentrations less than two times the average background concentrations and are not retained as COPCs. Heptachlor epoxide, dieldrin, 4,4'-DDT, endrin, endosulfan II, 4,4'-DDE, 4,4'-DDD, methoxychlor, endrin aldehyde, endrin ketone, alpha-chlordane, and gamma-chlordane are retained as COPCs due to prevalence, comparison to sediment screening values, and comparison to background concentrations.

Aluminum, calcium, iron, magnesium, potassium and sodium were not retained as COPCs because they are considered essential nutrients and were not expected to cause adverse effects at the detected concentrations. Mercury was detected at a concentration less than twice the average background concentrations and was only detected once in the sediment, therefore it is not retained as a COPC. Arsenic, barium, beryllium, chromium, cobalt, copper, lead, manganese, nickel, selenium, thallium, vanadium, and zinc are retained as COPC due to prevalence, comparison to sediment screening values, and comparison to background concentrations.

Biota

Eighteen biota samples including fish fillet tissue and crab tissue were analyzed for VOCs and SVOCs, twenty-two samples were analyzed for pesticides, PCBs and inorganics. Table 6-8 presents the chemicals detected in the fish fillet and crab tissue samples.

Toluene was detected infrequently in the fish tissue (1 out of 18 samples) and therefore is not retained as a COPC. Methylene chloride, carbon disulfide, and 2-butanone were detected in the fish tissue but were not detected in either the surface water of sediment indicating that these chemicals are not site-related, therefore, they are not retained as COPCs. Acetone is retained as a COPC in the fish tissue based on prevalence and it was detected in the sediment.

SVOCs were not detected in the fish fillet tissue, therefore, SVOCs are not retained as COPCs.

Heptachlor epoxide and endrin ketone were detected infrequently in the fish fillet tissue, 1 out of 22 samples and 2 out of 22 samples, respectively. Therefore, these chemicals are not retained as COPCs. Gamma-BHC and aldrin were not detected in either the surface water or sediment indicating that these chemicals are not site related, therefore, they are not retained as COPCs. Beta-BHC, heptachlor, dieldrin, 4,4'-DDE, endrin, endosulfan II, 4,4'-DDD, 4,4'-DDT, endrin ketone, endrin aldehyde, and alpha-chlordane are retained as COPCs based on frequency of detection and all were detected in the sediment.

Arsenic, chromium, cobalt, and vanadium were all detected infrequently in the fish fillet tissue (2 out of 22, 2 out of 22, 1 out of 22, and 1 out of 22 samples, respectively), and therefore are not retained as COPCs. Calcium, iron, magnesium, potassium and sodium were not retained as COPCs because they are considered essential nutrients and were not expected to cause adverse effects at the detected concentrations. Cadmium and silver were not detected in the surface water and sediment indicating that these chemicals are not site related, therefore, they are not retained as COPCs. Aluminum, barium, copper, lead, manganese, mercury, selenium, and zinc are retained as COPCs in the fish fillet tissue.

6.2.2.2 Summary of COPCs

Table 6-9 presents a detailed summary of the potential COPCs identified in each environmental medium sampled at OU No. 10. Also, chemicals with at least one positive detect are compared to applicable standards and criteria even if not retained as COPCs. Work sheets used in the selection of COPCs are presented in Appendix T.

6.3 Exposure Assessment

This section develops the potential human exposure pathways at OU No. 10 and 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 Site Conceptual Model of Potential Exposure

A site conceptual model of potential sources, migration pathways and human receptors was developed to encompasses all current and future potential routes of exposure at all three sites. Figure 6-1 presents the conceptual site model for OU No. 10. Inputs to the site conceptual site model included qualitative descriptions of current and future land use patterns in the vicinity of OU No. 10. All available analytical data and meteorological data were considered in addition to general understanding demographics of surrounding habitats. For this information, the following list of potential receptors were developed for inclusion in the quantitative health risk analysis:

- Current military personnel
- Current recreational users (child and adult) Brinson Creek
- Future on-site residents (child and adult)
- Future Construction Worker

Contaminants detected in all media were discussed in Section 4.0 (Nature and Extent of Contamination) and in the selection of COPCs section. The migration of COPCs from these sources could potentially occur by the following routes:

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

The potential for a contaminant to migrate spatially and persist in environmental media are important in the estimation of potential exposure.

6.3.2 Exposure Pathways

This section describes the potential exposure pathways associated with each medium and each potential human receptor group, then qualitatively evaluates each pathway for further consideration in the quantitative risk analysis. Table 6-10 presents the matrices of potential human exposure scenarios for Site 35.

6.3.2.1 Surface Soils

Surface soil samples were collected from Site 35. Potential exposures to these surface soils may possibly occur through incidental ingestion, absorption via dermal contact, and inhalation of airborne particulates. Dermal intakes will also result following dermal contact with soils containing COPCs. Incidental ingestion of soil may also occur by oral contact with hands, arms, or food items which soil particles have adhered. Therefore, current (military personnel) and future (residents) potential exposures via ingestion, dermal contact, and particulate inhalation are retained for evaluation. Current recreational users are not expected to be exposed to site surface soils.

6.3.2.2 Subsurface Soils

Potential exposure to subsurface soils is limited to potential site construction workers. In the event of construction in the areas of concern, workers may be exposed to subsurface soil. Therefore, future potential exposures via ingestion, dermal contact, and inhalation of fugitive particulates are retained for evaluation.

6.3.2.3 Groundwater

Currently the shallow groundwater in the area of the sites is not used as a potable supply for residents or base personnel. However, under a future scenario (albeit unlikely due to poor transmissivity and insufficient flow) the major potential exposure pathways, retained for evaluation, include the use of on-site groundwater are ingestion, dermal contact, and the inhalation of volatile contaminants by residents while showering.

6.3.2.4 Surface Water/Sediments

The surface water body (Brinson Creek) which was sampled during the field investigation showed evidence of COPCs. Currently, these waters are infrequently used for recreational purposes (i.e., fishing). Current potential exposures to surface waters and sediments considered in the BRA include:

- Incidental ingestion of surface water and sediments during limited recreational use (recreational child and adult).
- Dermal contact of surface water and sediment during limited recreational use (recreational child and adult).

Future potential exposure to surface water and sediments are expected to be the same as current potential exposure to recreational users, therefore this exposure pathway will not be evaluated.

6.3.2.5 Air

A potential human exposure pathway exists in air through the inhalation of airborne particulates from surface soils containing COPCs. Airborne particulate emissions may result from the wind erosion and the entrainment of soil particles in ambient air. COPCs adhering to these airborne soil particles may be inhaled by potential future on-site residents (i.e., child and adult) and current military personnel.

Therefore, inhalation of airborne particulate emissions by potential future residents, future construction workers, and current military personnel is retained for quantitative evaluation. Off-site receptors would be exposed to concentrations much lower than those detected in on-site air samples of airborne particulates as a result of the dilution characteristics of ambient air and the wooded areas which separate the facility from the nearby communities. Therefore, nearby residents are not evaluated.

A potential human exposure pathway also exists in air through the inhalation of contaminants volatilized from shower water for groundwater containing COPCs. Inhalation exposures to VOCs while showering are modeled by estimating the rate of chemical releases into the air, the buildup of VOCs in the shower room air while the shower is on, and the decay of VOCs in the shower room air after the shower is turned off, and the quantity of airborne VOCs inhaled while the shower is both on and off. Therefore, inhalation of airborne VOCs while showering by potential future residents (adult and child) is retained for quantitative evaluation.

6.3.2.6 Biota

Recreational fishing occurs at Site 35 in Brinson Creek. However, subsistence fishing is not conducted in this area. Therefore, ingestion of fish by current fisherman (recreational adult) is retained for quantitative evaluation. There is no known crabbing, recreational or subsistence, that occurs along Brinson Creek at Site 35.

6.3.3 Quantification of Exposure

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

Exposure to groundwaters, sediments and surface waters can occur discretely or at a number of sampling locations. These media are transitory in that concentrations change frequently over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points at discrete locations than exist within OU No. 10. As a result, the best way to represent groundwater, sediment, and surface water contaminants from an exposure standpoint is to use a representative exposure concentration.

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

The human health assessment for future groundwater use considered groundwater data collected from all of the monitoring wells within OU No. 10.

Since all the data sets originate from a skewed underlying distribution and since log normal distribution best fits the majority of environmental data sets, the lognormal distribution was used to represent all facility media to determine representative exposure concentrations. This ensures conservatism in the estimation of chronic daily intake associated with potential exposures. Ninety-five percent upper confidence levels (95 percent UCL) derived for lognormal data sets produce concentrations in excess of the 95 percent interval derived assuming normality. For the sake of conservatism, the 95 percent UCL for the lognormal distribution was used for each contaminant in a given data set for quantifying potential exposure. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent UCL can be greater than the maximum measured concentration, therefore, in cases where the 95 percent UCL for a contaminant exceeds the maximum detected value in a given data set, the maximum result was used in the estimate of exposure of the 95 percent UCL However, the true mean may still be higher than this maximum value (i.e., the 95 percent UCL indicates a higher mean is possible), especially if the most contaminated portion of the site has not been sampled.

Data and frequency summaries and statistical summaries are presented in Appendices U and V, respectively.

6.3.4 Calculation of Chronic Daily Intakes

In order to numerically estimate the risks for current and future human receptors at OU No. 10, a CDI must be estimated for each COPC in every retained exposure pathway.

Appendix W contains the specific CDI equations for each exposure scenario of interest. These equations were adopted from USEPA's Risk Assessment Guidance for Superfund, Volume I (USEPA, 1989a).

The following paragraphs present the general equations and input parameters used in the calculation of CDIs for each potential exposure pathway. Input parameters were taken from USEPA's default exposure factors guidelines where available and applicable. All inputs not defined by USEPA were derived from USEPA documents concerning exposure or best professional judgment. All exposure assessments incorporate the representative contaminant concentrations in the estimation of intakes. Therefore, only one exposure scenario was developed for each exposure route/receptor combination.

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

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

Future residential exposure scenarios consider 1 to 6 year old children weighing 15 kg, and adults weighing 70 kg on average. For current military personnel an exposure duration of 4 years is used to estimate a military residence. A one year duration is used for future construction worker scenarios.

6.3.4.1 Incidental Ingestion of Soil

The CDI for COPCs detected in soil was estimated for all potential human receptors and is expressed as:

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

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 discuss the exposure assumptions used in the estimation of potential COPCs associated with the potential ingestion of soils.

Military Personnel

During the course of daily activities at OU No. 10, military personnel could potentially be exposed to potential COPCs by the incidental ingestion of surface soils.

The IR for military personnel exposed to surficial soils is assumed to be 100 mg/day (USEPA, 1989a) and that 100 percent of the exposure was with facility soils containing COPCs.

An exposure frequency (EF) of 350 days per year is used in conjunction with an exposure duration of 4 years.

An averaging time (AT) of 70 years or 25,550 days is used for exposure to potentially carcinogenic compounds while an averaging time of 1,460 (4 years x 365 days/year) days is used for noncarcinogenic exposures. An adult average body weight (BW) of 70 kg is used (USEPA, 1989a).

Future On-Site Residents

Future on-site residents could potentially be exposed to COPCs in the surficial soils during recreational activities or landscaping activities around their homes. Children and adults could potentially be exposed to COPCs in soils by incidental ingestion occurring through hand to mouth behavior.

Ingestion rates (IR) for adults and children in this scenario are assumed to be 100 mg/day and 200 mg/day, respectively. EFs for both receptor groups is assumed to be 350 days per year. The residential exposure duration (ED) was divided into two parts. First, a six-year exposure duration is evaluated for young children which accounts for the period of highest soil ingestion (200 mg/day), and second a 24-year exposure is assessed for older children and adults by using a lower soil ingestion rate (100 mg/day) (USEPA, 1991; USEPA, 1989a).

The BW, for a resident child is assumed to be 15 kg, representing younger individuals than those considered to be potential trespassers. The rationale was that the younger child (1 to 6 years), as a resident, will have access to affected on-site soils. The body weight for the future resident adult is assumed to be 70 kg.

ATc's of 25,550 days for potential carcinogens is used for both the adult and child. ATnc's of 8,760 days (24 years x 365 days/year) for noncarcinogenic constituents is used for estimating potential CDIs for adults, and 2,190 days (6 years x 365 days/year) is used to estimate potential CDIs for children potentially exposed to noncarcinogens.

Future Construction Worker

During the course of excavation activities construction workers could potentially be exposed to potential COPCs through the incidental ingestion of subsurface soil. The IR for future construction workers exposed to subsurface soils was assumed to be 480 mg/day (USEPA, 1991). An exposure frequency of 90 days per year was used in conjunction with an exposure duration of one year (USEPA, 1991). An adult BW of 70 kg was used (USEPA, 1989a). ATs of 25,550 days for potential carcinogens and 365 days (1 yr x 365 days/year) for noncarcinogenic constituents was used for estimating CDIs for the construction worker. A summary of the exposure factors used in the estimation of soil CDIs associated with incidental ingestion are presented in Table 6-11.

6.3.4.2 Dermal Contact with Soil

Chronic daily intakes associated with potential dermal contact of soils containing COPCs is expressed using the following equation:

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

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 = Fraction absorbed (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with the potential dermal contact with soils.

Military Personnel

During construction activities, there is a potential for base personnel to absorb COPCs by dermal contact.

It is assumed that military personnel have approximately 5,800 cm^2 (USEPA, 1992a) of skin surface (SA) available for dermal exposure with COPCs. Exposed body parts are the hands, head, forearms and lower legs are 25% of the total body surface area (23,000 cm^2). Thus, applying 25% to the upper-bound total body surface area results in a default of 5,800 cm^2 for military personnel.

Values for exposure duration (ED), exposure frequency (EF), body weight (BW), and averaging time (AT) are the same as those used for the incidental ingestion of soil scenario.

Future On-Site Residents

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

Skin surface areas (SA) used in the on-site resident exposure scenario are developed for a reasonable worst case scenario for an individual wearing a short sleeve shirt, shorts, and shoes. The exposed skin surface area is limited to the head, hands, forearms, and lower legs. Thus, applying 25 percent of the total body surface area results in a default 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. The child SA is calculated using information presented in Dermal Exposure Assessment: Principles and Applications (USEPA, 1992a).

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

Data on soil adherence (AF) are limited. A value of 1.0 mg/cm^2 (USEPA, 1992c) is used for this assessment. Additionally, an adsorption fraction (ABS) of 1.0% for organics and 0.1% for inorganics is used (USEPA, 1992c).

Future Construction Worker

Dermal contact with subsurface soil COPCs could potentially occur during excavation activities.

Skin surface area (SA) used for the construction worker exposure scenario are developed for an individual wear a short-sleeve shirt, long pants, and boots. The exposed skin surface area (4,300 cm^2) is limited to the head (1,180 cm^2), arms (2,280 cm^2), and hands (840 cm^2) (USEPA, 1992a).

The exposure frequency and exposure duration are the same as those discussed for incidental ingestion of subsurface soil.

Data on soil adherence (AF) are limited. A value of 1.0 mg/cm^2 (USEPA 1992c) is used for this assessment. Additionally, and adsorption fraction (ABS) of 1.0% for organics and 0.1% for inorganics is used (USEPA, 1992c).

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

6.3.4.3 Inhalation of Fugitive Particulates

Exposure to fugitive particulates is estimated for current military personnel, future residents, and civilian base personnel. These populations may be exposed during daily recreational or work-related activities. The chronic daily intake of contaminants associated with the inhalation of particulates is estimated using the following equation:

$$CDI = \frac{C \text{ x } IR \text{ x } ET \text{ x } EF \text{ x } ED \text{ x } 1/PEF}{BW \text{ x } AT}$$

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)

The PEF relates the concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from surface contamination. This relationship is derived by Cowherd (USEPA, 1989a). The particulate emissions from contaminated sites are due to wind erosion, and, therefore, depend on erodibility of the surface material. A default PEF obtained from USEPA, 1989b is used in this assessment.

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with the potential inhalation of particulates.

Military Personnel

During work related activities, there is a potential for military personnel to inhale COPCs emitted as fugitive dust. An inhalation rate 20 m^3/day will be used for military personnel (USEPA, 1991). Values for exposure duration, exposure frequency, body weight, and averaging time were the same as those used for the incidental ingestion scenario.

Future On-Site Residents

Future on-site residents could also be potentially exposed to COPCs in on-site soil through inhalation of particulates during activities near their home.

Inhalation rates (IR) used in the on-site resident exposure scenario are 20 m^3/day and 10 m^3/day for adults and children, respectively (USEPA, 1989a). The IR for children was derived from a child conducting light (0.8 m^3/hr) to moderate (2.0 m^3 /hr) activity for 8 hours per day. Exposure frequencies, duration, body weight, and averaging time are the same as those used for the incidental ingestion scenario. Table 6-13 presents the exposure factors used to estimate CDIs associated with the particulate inhalation scenario.

Future Construction Worker

During work related activities, there is a potential for construction workers to inhale airborne COPCs as fugitive dust. An inhalation rate of 20 m^3/day will be used for the construction worker (USEPA, 1991). Values for exposure duration, exposure frequency, body weight, and averaging time were the same as those used for the incidental exposure scenario.

6.3.4.4 Ingestion of Groundwater

Shallow groundwater is not currently being used as a potable supply at OU No. 10. Development of the shallow aquifer for potable use is unlikely because of the general water quality in the shallow zone and poor flow rates. However, there remains the possibility that upon closure of this facility, residential housing could be constructed and deep groundwater used for potable purposes in the future. Deep groundwater from OU No. 10 is currently used for potable purposes. However, supply wells which have been determined to be contaminated have been permanently abandoned. In addition, current operating wells are periodically monitored for control purposes.

The CDI of contaminants associated with the future potential consumption of groundwater are estimated using the following general equation:

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

Where:

C = Contaminant concentration in 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 discuss the exposure assumptions used in the estimation of potential COPCs with the potential ingestion of groundwater.

Future On-Site Residents

Exposure to COPCs via ingestion of groundwater is retained as a potential future exposure pathway for both children and adults.

An IR of 1.0 L/day is used for the amount of water consumed by a 1 to 6 year old child weighing 15 kg. This ingestion rate provides a health conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who could potentially be more affected than adolescents, or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year [which represents the exposure frequency (EF)]. An averaging time (AT) of 2,190 days (6 years x 265 days/year) is used for noncarcinogenic compound exposure.

The ingestion rate (IR) for adults is 2 liters/day (USEPA, 1989a). The ED used for the estimation of adult CDIs is 30 years (USEPA, 1991), which represents the national upper-bound (90th percentile) time at one residence. The averaging time for noncarcinogens is 10,950 days. An averaging time (AT) of 25,550 days (70 years x 365 days/year) is used to evaluate exposure for both children and adults to potential carcinogenic compounds.

Table 6-14 presents a summary of the input parameters for the ingestion of groundwater scenarios.

6.3.4.5 Dermal Contact with Groundwater

Shallow groundwater is not currently being used as a potable supply at OU No. 10. However, there remains the possibility that upon closure of this facility residential housing could be constructed and groundwater used for residential purposes in the future.

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

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

Where:

C = Contaminant concentration is groundwater (mg/L)
SA = Surface area available for contact (cm^2)
PC = Dermal permeability constant (cm/hr)
ET = Exposure time (hour/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)

CF = Conversion factor (1 L/1000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with potential dermal contact with groundwater.

Future On-Site Residents

Children and adults could contact COPCs through dermal contact with groundwater while bathing or showering.

It was assumed that bathing would take place 350 days/year using site groundwater as the sole source. The whole body skin surface area (SA) available for dermal absorption is estimated to be 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992a). The permeability constant (PC) reflects the movement of a chemical across the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose, yet many compounds do not have literature PC values. For contaminants in which a PC value has not been established, the permeability constant for water (1.55E-03 cm/hr), is used (USEPA, 1992a). This value may in fact be a realistic estimate of the adsorption rate of a chemical when COPC concentrations are in the part-per-billion range.

An exposure time (ET) of 0.25 hour/day (USEPA, 1992a) is used to conservatively estimate the duration of bathing or showering. The exposure duration, body weight, and averaging time are the same as those used for the ingestion of groundwater scenario. Table 6-15 presents the exposure factors used to estimate CDIs associated with the future dermal contact with COPCs in groundwater.

6.3.4.6 Inhalation of Volatile Organics While Showering

In order to quantitatively assess the inhalation of contaminants volatilized from shower water, the model developed by Foster and Chrostowski (Foster, 1986) is utilized. Contaminant concentrations in air, due to VOCs while showering, are modeled by estimating the following: the rate of chemical releases into air (generation rate), the buildup of VOCs in the shower room air while the shower was on, the decay of VOCs in the shower room after the shower was turned off, and the quantity of airborne VOCs inhaled while the shower was both on and off. The contaminant concentrations calculated to be in the air are then used as the concentration term.

The CDI associated with the inhalation of airborne (vapor phase) VOCs from groundwater while showering is estimated using the following general equation:

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

Where:

C = Contaminant concentration in air (mg/L)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)

ED = Exposure duration (years)
BW = Body weight (kg)
AT_c = Averaging time carcinogen (days)
AT_{nc} = Averaging time noncarcinogen (days)

Future On-Site Residents

Both children and adults could inhale vaporized volatile organic COPCs during showering. It is assumed that showering would take place 350 days/year, using site groundwater as the sole source, for children weighing 15 kg, and adults weighing 70 kg (USEPA, 1989a). An inhalation rate of 0.6 m^3/hr is used for both receptors (USEPA, 1989a). An exposure time of 0.25 hrs/day is used for both receptors (USEPA, 1989a). The exposure duration and averaging times remain the same as for groundwater ingestion.

Table 6-16 presents the exposure factors used to estimate CDIs associated with the inhalation of VOCs from groundwater while showering.

6.3.4.7 Incidental Ingestion of Surface Water

The CDI for contaminants associated with incidental ingestion of affected surface water is expressed using the following equation:

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

Where:

C = Contaminant concentration in surface water (mg/L)
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)
ET = Exposure time (hours/day)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with potential incidental ingestion of surface water.

Current Recreational Adult and Child

Adults and children who may potentially come into contact with the surface water are assumed to conservatively ingest surface water at a rate of 0.05 L/hour, (USEPA, 1989b). In addition, an exposure frequency (EF) of 20 days/year (4 days/month x 5 months) and an exposure duration (ED) of 6 years (age 1-6) for a child, and 30 years for an adult are used (USEPA, 1989b).

A summary of the surface water exposure factors associated with incidental ingestion of surface water are presented in Table 6-17.

6.3.4.8 Dermal Contact with Surface Water

The CDI of contaminants associated with the dermal contact of affected surface water is expressed using the following general equation:

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

Where:

C = Contaminant concentration in surface water (mg/L)
CF = Conversion factor (1 L/1000 cm^3)
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)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with potential dermal contact with surface water.

The surface areas of the head, arms, hands, forearms, and lower extremities are used to estimate the risk to adults (11,500 cm^2) and children (4,600 cm^2) (USEPA, 1992a). Exposure time, frequency, and duration are the same as for the surface water ingestion scenario. The exposure factors for this potential exposure pathway are summarized in Table 6-18.

6.3.4.9 Incidental Ingestion of Sediment

The CDI of COPCs associated with the accidental ingestion of affected sediment is expressed using the following general equation:

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

Where:

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

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with potential incidental ingestion of sediments.

Current Recreational Adult and Child

Accidental ingestion of COPCs in sediments is also possible during activities occurring in the surface water bodies at OU No. 10.

An ingestion rate (IR) of 100 mg/day is used in calculating the chronic daily intake for children and adults. The exposure frequency (EF) of 20 days/year (4 days/month x 5 months) is used as a conservative site-specific assumption. An exposure duration (ED) of 6 years and 30 years is used in the estimation of potential COPCs for a child and adult, respectively. A summary of exposure factors for this scenario are presented in Table 6-19.

6.3.4.10 Dermal Contact with Sediment

The CDI of contaminants associated with the dermal contact of affected sediments is expressed using the following general equation:

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

Where:

C = Contaminant concentration in sediment (mg/kg)
CF = Conversion factor (kg/mg)
SA = Surface area available for contact (cm^2/day)
AF = 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 discuss the exposure assumptions used in the estimation of potential COPCs with potential dermal contact with sediment.

Current Recreational Adult and Child

If surface water within the OU No. 10 were encountered, direct contact with sediments could occur.

Recreational activities in the surface water body within OU No. 10 would not involve swimming. Consequently, the body surface area potentially exposed would include the head, arms, hands, forearms, and lower extremities. Body surface areas of 4,600 cm^2 and 11,500 cm^2 (USEPA, 1992a) are used to estimate risks to children and adults, respectively. Using professional site-specific assumptions, an exposure frequency is estimated to be 20 days/year (4 days/month x 5 months). An averaging time (AT) of 70 years or 25,550 days is used for exposure to potentially carcinogenic compounds. An averaging time of 365 days/year times the exposure duration of 6 years for the child and 30 years for the adult is used for exposure to noncarcinogenic COPCs (USEPA, 1989b).

Table 6-20 provides a complete summary of the input parameters used in the estimation of CDIs for this scenario.

6.3.4.11 Biota

The CDI associated with the potential ingestion of biota (fish fillet) was expressed using the following equation:

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

Where:

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

Current Recreational Adult

The ingestion rate is 0.145 kg/day which represents the upper 95th percentile consumption rate occurring in conjunction with recreational fishing (USEPA, 1993b). The fraction of fish ingested from the source (Fi) for adults is estimated to be 1.0 (100 percent) for the 90th percentile consumption rate. The exposure frequency is equal to 48 meals/year (USEPA, 1989a). The exposure duration (ED) for adults is set at 9 years, and an averaging time (AT) of 70 years or 25,550 days is used for exposure to carcinogenic compounds (USEPA, 1993b). An AT of 10,950 days is used for exposure to noncarcinogenic COPCs (USEPA, 1989a).

Table 6-21 presents a summary of the exposure factors used for the ingestion of fish fillet scenario.

6.4 Toxicity Assessment

Section 6.3 identified potential exposure pathways and potentially affected populations for this BRA. This section will review the available toxicological information for the potential COPCs.

6.4.1 Toxicological Evaluation

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

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

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

6.4.2 Dose-Response Evaluation

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

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

6.4.2.1 Carcinogenic Slope Factor

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

These slope factors are also accompanied by USEPA WOE classifications which designate the strength of the evidence that the COPC is a potential human carcinogen.

In assessing the carcinogenic potential of a chemical, the Human Health Assessment Group (HHAG) of USEPA classifies the chemical into one of the following groups, according to the weight of evidence from epidemiologic 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

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

- A 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 6-22. The hierarchy (USEPA, 1989a) for choosing these values was as follows:

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

The IRIS data base 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 validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they appear in the IRIS data base. Like the CSF Workgroup, the USEPA has formed a RfD Workgroup to review existing data used to derive RfDs. Once the reference doses has been verified, they also appear in IRIS.

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

6.5 Risk Characterization

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

These quantitative risk calculations for potentially carcinogenic compounds estimate ICRs levels for an individual in a specified population. This unit risk refers to the cancer risk that is over and above the background cancer risk in unexposed individuals. For example, an ICR of 1E-06 indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals.

The ICR to individuals was estimated from the following relationship:

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

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

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

Noncarcinogenic effects were estimated by calculating the hazard index (HI) which is defined as:

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

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

where $HQ_i = CDI_i / RfD_i$

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

6.5.1 Human Health Risks

The following paragraphs present the quantitative results of the human health evaluation for each medium and area of concern at OU No. 10.

Estimated ICRs are compared to the target risk range of 1 x 10^{-4} to 1 x 10^{-6}. A value of 1.0 is used for examination of the HI. The HI is calculated by comparing estimated CDIs with threshold levels below which, noncarcinogenic health effects are not expected to occur. Any HI equal to or exceeding 1.0 suggested that noncarcinogenic health effects are possible. If the HI was less than 1.0, then systemic human health effects are considered unlikely.

6.5.1.1 Site 35

Soil

Table 6-23 presents the ICR and HI values derived for the potential exposure (dermal contact, incidental ingestion, and inhalation) of on-site surface and subsurface soil. The total ICR value for the future residential child (4.4 x 10^{-5}), future residential adult (2.7 x 10^{-5}), current military personnel (3.1 x 10^{-6}), and the future construction worker (1.2 x 10) are within or below the USEPA's acceptable risk range (1 x 10^{-4} to 1 x 10^{-6}), therefore, adverse health risks to these receptors from soil ingestion, dermal contact, or inhalation are not likely. The total HI estimated for potential future residential children (0.93), future residential adults (0.10), current military personnel (0.09), and future construction worker (0.02) are less than unity (1.0), suggesting that adverse systemic health effects are unlikely. Therefore, no adverse health effects are expected from current or future exposure to surface or subsurface soil.

Groundwater

The ICR and HI values estimated for potential future residential receptors (children and adults) from ingestion and dermal contact of groundwater and inhalation of vapors are presented on Table 6-24. The total ICR value for future residential children (2.1 x 10^{-3}) and adults (4.3 x 10^{3}) exceed the USEPA's upper bound risk range (1 x 10^{-4}), therefore, adverse health effects to future residents from ingestion, dermal contact, and inhalation are plausible. The total HI estimated for potential future residential children (104) and adults (44) exceeded unity (1.0), suggesting that adverse systemic health effects are likely. The ICR and HI values were driven by the presence of trichloroethene, cis-1,2-dichloroethene, benzene, antimony, arsenic, barium, beryllium, chromium, cadmium, manganese, and vanadium.

Surface Water

The ICR and HI values estimated for potential current recreational receptors (children and adults) from ingestion and dermal contact of surface water are presented on Table 6-25. The total ICR value for potential current recreational children (1.1 x 10^{-7}) and adults (1.2 x 10^{-7}) are below the USEPA's upper bound risk range (1 x 10^{-4} to 1 x 10^{-6}), therefore, adverse health effects from ingestion and dermal contact are not likely. The total HI estimated for potential current recreational children

(<0.01) and adults (<0.01) are less than unity (1.0), suggesting that adverse systemic health effects are unlikely from ingestion or dermal contact of surface water.

Sediment

The ICR and HI values estimated for potential current recreational receptors (children and adults) from ingestion and dermal contact of sediments are presented on Table 6-26. The total ICR value for future residential children (3.3×10^{-7}) and adults (4.5×10^{-7}) are below the USEPA's upper bound risk range (1×10^{-4} to 1×10^{-6}), therefore, adverse health effects to future residents from ingestion and dermal contact of sediments are not likely. The total HI estimated for potential current recreational children (0.01) and adults (<0.01) are less than unity (1.0), suggesting that adverse systemic health effects are unlikely.

Biota

The total ICR and HI values estimated for ingestion of fish or shellfish by current recreational adults is presented on Table 6-27. The total ICR value (1.8×10^{-5}) is below the USEPA's acceptable upper bound risk range of 1×10^{-4}, and the total HI value (1.8) is slightly greater than unity (1.0). The HI value is driven by the presence of mercury.

6.6 Sources of Uncertainty

Uncertainties may be encountered throughout the process of performing a BRA. This section discusses the sources of uncertainty involved with the following:

- Analytical data
- Exposure Assessment
- Toxicity Assessment
- Compounds Not Quantitatively Evaluated

6.6.1 Analytical Data

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

Data validation serves to reduce some of the inherent uncertainty associated with the analytical data by establishing the usability of the data to the risk assessor who may or may not choose to include the data point in the estimation of risk. Data qualified as "J" (estimated) were retained for the estimation of risk at OU No. 10. Data can be qualified as estimated for many reason including a slight exceedance of holding times, high or low surrogate recovery, or intrasample variability. Organic data qualified "B" (detected in blank) or "R" (unreliable) were not used in the estimation of risk due to the unusable nature of the data. Due to the comprehensive sampling and analytical program at OU No. 10, the loss of some data points qualified "B" or "R" did not significantly increase the uncertainty in the estimation of risk.

6.6.2 Exposure Assessment

In 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 the estimation of contaminant intakes resulting from contact by a receptor with a particular medium.

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

The potential inhalation of fugitive dusts from affected soils was estimated in the BRA using USEPA's Rapid Assessment of Exposure to Particulate Emissions from Surface Contaminated Sites (Cowherd, USEPA, 1989a). The Cowherd model employs the use of a site-specific PEF for a wind erosion based on source area and vegetative cover. A conservative estimate of the PEF was derived for OU No. 10 by assuming that the entire area was not covered with vegetation and was unlimited in its erosion potential. Modeling results for fugitive dust emission exposure suggested that the potential risk associated with this pathway was not significant.

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

Currently, the shallow groundwater is not used as a potable source. Current receptors (military personnel, military dependents, and civilian base personnel) are exposed to groundwater drawn from the deep zone via ingestion, dermal contact, and inhalation. Therefore, assessing current risks to contaminants detected in the shallow aquifer for current receptors is unnecessary and if estimated may present an unlikely risk. Therefore, groundwater exposures to current receptors was not estimated for this investigation.

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

6.6.3 Sampling Strategy

Soil represents a medium of direct contact exposure and often is the main source of contaminants released into other media. The soil sampling depth should be applicable for the exposure pathways and contaminant transport routes of concern and should be chosen purposely within that depth interval. If a depth interval is chosen purposely, a random sample procedure to select a sampling point may be established. The assessment of surface exposure at all three sites is certain based on collection of samples from the shallowest depth, zero to one foot. Subsurface soil samples are important, however, if soil disturbance is likely or leaching of chemicals to groundwater is of concern.

The soil investigation included surface soil and subsurface soil sampling. The surface soil samples at the site were obtained directly or very near the suspected disposal areas. Therefore, these areas would be considered areas of very high concentration which would have a significant impact on exposures.

6.6.4 Toxicity Assessment

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

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

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

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

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

6.6.5 Compounds Not Quantitatively Evaluated

There are several COPCs that currently do not have USEPA-verified toxicity factors (i.e., RfDs and CSFs) available to quantitate risk. The following is a list of contaminants that were not evaluated in the BRA for OU No. 10:

- Lead
- Endosulfan II
- Endrin Aldehyde
- 2-Methylnaphthalene
- Thallium
- Aluminum - fish only
- Endrin Ketone
- deta - BHC
- Phenanthrene
- Naphthalene
- Benzo(g,h,i)perylene

Although these COPCs were not included in the risk evaluation, the COPCs that were evaluated exhibit properties that address the toxicological nature of the excluded chemicals. For example, arsenic was an inorganic COPC identified throughout most media of concern. Arsenic is a Class A carcinogen. It is reasonable to assume that the inclusion of arsenic as a COPC sufficiently addresses the toxicological effects of the excluded metals. Similarly, benzo(b)fluoranthene was identified as a COPC. It is assumed that the evaluation of this PAH adequately addresses the exclusion of the previously mentioned PAHs.

6.7 Conclusions of the BRA for OU No. 10

The BRA highlights the media of interest from the human health standpoint at OU No. 10 by identifying areas with elevated ICR and HI values. Current and future potential receptors at the site include current military personnel, current recreational adults and children, future residents (i.e., children and adults), and future construction workers. The total risk from each site for the these receptors is estimated by logically summing the multiple pathways likely to affect the receptor during a given activity. The following algorithms defined the total site risk for the current and future potential receptor groups assessed in a quantitative manner. The risk associated with each site is derived using the estimated risk from multiple areas of interest.

1. Current Military Personnel
    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs
2. Future Residents (Children and Adults)
    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation airborne of COPCs
    b. Ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater + inhalation of volatile COPCs

3. Future Construction Worker

    a. Incidental ingestion of COPCs in on-site subsurface soil + dermal contact with COPCs in subsurface soil + inhalation of airborne COPCs

4. Current Recreational Children and Adults

    a. Ingestion of COPCs in surface water and sediment + dermal contact with COPCs in surface water and sediment

    b. Ingestion of fish tissue (adults only)

The total site ICR and HI values associated with current and future receptors at this site are presented in Table 6-28. The total site ICR for the current recreational child (4.4 x 10^{-7}) current recreational adult (1.9 x 10^{-5}), and current military personnel (3.1 x 10^{6}) are below the USEPA's upper bound risk range (1 x 10^{-4} to 1 x 10^{-6}), therefore adverse effects are considered unlikely. The total site HI for the current recreational child (0.01) and current military personnel (0.09) did not exceed unity. Therefore, adverse effects are considered unlikely. The total site HI for the current recreational adult (1.8) is slightly above unity. The total site risk is due to potential exposure from fish fillet ingestion which is driven by the presence of mercury. However, the exposure parameters used to calculate risk from fish ingestion are very conservative; mercury was not found to be causing a risk in any other media at Site 35; and the fish collected at Site 35 are considered migratory and move along Brinson Creek, therefore this risk may not be due to contamination at the site. Therefore, the risk from ingestion of fish may not be site related.

The total site ICR and HI for the future construction worker (1.2 x 10^{-7} and 0.02, respectively) are below the USEPA's risk range, therefore, risk to this receptor is considered unlikely. The total site ICR for future adult residents (4.3 x 10^{-3}) and future child residents (2.1 x 10^{-3}) exceed the USEPA's upper bound risk range (1 x 10^{-4} to 1 x 10^{-6}). The total site risk is driven by future potential exposure to groundwater. The ICR values are driven by the presence of arsenic and beryllium. The total site HI for the future adult resident (44) and the future child resident (104) exceed unity. The total site risk is driven by future potential exposure to groundwater. The HI values are driven by the presence of cis-1,2-dichlorothene, trichloroethene, benzene, antimony, arsenic, barium, chromium, cadmium, manganese, and vanadium.

SECTION 6.0 REFERENCES

SECTION 6.0 REFERENCES

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SECTION 6.0 TABLES

TABLE 6-1

ORGANIC DATA SUMMARY
SURFACE SOIL
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Carbon Disulfide	33	1/10
Toluene	19J	1/13
Xylenes (total)	43	1/13
Phenol	3,071	1/13
Acenaphthene	196J	1/13
Phenanthrene	191J - 1,186	2/13
Carbazole	183J	1/13
Fluoranthene	423 - 1,567	2/13
Pyrene	295J - 1,173	2/13
Butylbenzyphthalate	295J	1/13
Benzo(a)anthracene	566	1/13
Chrysene	204J - 683	2/13
bis(2-Ethylhexyl)phthalate	279J	1/13
Benzo(b)fluoranthene	337J - 1,186	2/13
Benzo(a)pyrene	625	1/13
Ideno (1,2,3-cd)pyrene	381	1/13
Dibenz(a,h)anthracene	184J	1/13
Benzo(g,h,i)perylene	208J - 366	2/13
beta-BHC	0.53J - 1.6J	2/10
Dieldrin	0.35J - 212	4/10
4,4'-DDE	1.6J - 1,570	10/10
Endrin	0.68J - 7.9	3/10
Endosulfan II	0.42J - 2.9J	2/10
4,4'-DDD	0.56J - 3,240	9/10
4,4'-DDT	1.6J - 262	10/10
Endrin ketone	1.2J	1/10
Endrin aldehyde	0.37J - 1.6J	2/10
alpha-Chlordane	4.1 - 36	2/10
gamma-Chlordane	27	1/10

Note: Concentrations expressed in microgram per kilogram (μg/kg).
J - Estimated value
All rejected results have been removed from the data.
Frequencies of detection are adjusted accordingly.

TABLE 6-2

INORGANIC DATA SUMMARY
SURFACE SOIL
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Surface Soil				
	Average Base-Specific Background[1] Concentration	Twice the Average Base-Specific Background Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	2,104	4,209	2,020 - 7,870	13/13	3
Antimony	2.41	4.81	7.4J - 8J	2/10	2
Arsenic	0.39	0.77	0.29J - 66.1J	11/13	4
Barium	7.1	14.2	6.2 - 86	13/13	6
Beryllium	0.11	0.22	0.22	1/12	0
Cadmium	0.31	0.61	0.04J - 15J	10/10	1
Calcium	534	1,069	604J - 49,500J	13/13	10
Chromium	2.38	4.77	1.9 - 98.1	11/13	6
Cobalt	1.17	2.35	1.3 - 4.3	3/13	1
Copper	4.51	9.02	2 - 58.3	12/13	2
Iron	1,257	2,515	1,250 - 29,900J	13/13	6
Lead	12.1	24.2	7.2 - 71J	13/13	7
Magnesium	84.7	169	58.7 - 951	13/13	11
Manganese	7.04	14.1	4.1 - 66.7	13/13	4
Nickel	1.55	3.09	1.3 - 17.2	10/13	1
Selenium	0.37	0.74	0.94J - 1.2J	2/13	2
Thallium	0.4	0.8	0.06 - 0.53J	11/13	0
Vanadium	3.27	6.54	3.6 - 20.7	13/13	6
Zinc	4.92	9.84	138 - 430	2/2	2

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

All rejected results have been removed from the data. Frequencies of detection are adjusted accordingly.

TABLE 6-3

ORGANIC DATA SUMMARY
SUBSURFACE SOIL
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
Methylene Chloride	7J	5/19
Acetone	11J - 144J	5/19
Tetrachloroethene	8 - 60	4/19
Pyrene	283J	1/8
Benzo(b)fluoranthene	425	1/8

Note: Concentrations expressed in microgram per kilogram (μg/kg).
J - Estimated value
All rejected results have been removed from the data.
Frequencies of detection are adjusted accordingly.

TABLE 6-4

INORGANIC DATA SUMMARY
SUBSURFACE SOIL
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Subsurface Soil				
	Average Base-Specific Background(1) Concentration	Twice the Average Base-Specific Background Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	3,563	7,127	1,870J - 6,210	8/8	0
Arsenic	0.38	0.76	0.19J - 2.7J	7/8	1
Barium	5.65	11.3	4.8 - 25	8/8	3
Cadmium	0.37	0.74	0.03J - 0.49J	6/6	0
Calcium	277	554	361J - 2,420J	6/8	4
Chromium	4.19	8.37	3.1 - 14.4J	7/8	2
Cobalt	0.56	1.12	1.4	1/8	1
Copper	1.08	2.15	1.2 - 8.5	6/8	4
Iron	1,066	2,133	442J - 10,500J	8/8	3
Lead	3.64	7.27	4J - 144	8/8	6
Magnesium	106	212	63.5 - 403	7/8	2
Manganese	3.54	7.07	1.5 - 7.5	8/8	2
Nickel	1.31	2.61	1.2 - 2	4/8	0
Potassium	119	238	562	1/8	1
Selenium	0.4	0.79	0.17J - 0.67J	4/8	0
Silver	0.52	1.05	0.39J	1/8	0
Thallium	0.34	0.67	0.1 - 2.1	4/8	1
Vanadium	4.77	9.53	3J - 19.9J	8/8	2
Zinc	2.16	4.32	16.3	1/3	1

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

All rejected results have been removed from the data. Frequencies of detection are adjusted accordingly.

TABLE 6-5

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
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	Concentration Range	No. of Positive Detects/ No. of Samples	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
1,1,2,2-Tetrachloroethane	NE	NE	NE	NE	20.5 - 64.7	2/50	NA	NA	NA	NA
1,1,2-Trichloroethane	NE	5	400	1,000	1 - 1.9	2/50	NA	0	0	0
1,1-Dichloroethane	700	NE	NE	NE	2.5 - 7.6	3/50	0	NA	NA	NA
1,1-Dichloroethene	7	7	1,000	4,000	0.8 - 6.9	4/50	0	0	0	0
Chloroform	0.19	100	100	400	0.6	1/50	1	0	0	0
Tetrachloroethene	0.7	5	1,000	5,000	1.9	1/50	1	0	0	0
cis-1,2-Dichloroethene	70	70	3,000	11,000	3.2 - 973	22/50	12	12	0	0
trans-1,2-Dichloroethene	70	100	2,000	6,000	0.4 - 176	18/50	5	5	0	0
Trichloroethene	2.8	5	NE	NE	0.4 - 900	20/50	17	16	NA	NA
Benzene	1	5	NE	NE	0.2 - 1,660	29/50	17	10	NA	NA
Toluene	1,000	1,000	2,000	7,000	0.3 - 984	42/50	0	0	0	0
Ethylbenzene	29	700	1,000	3,000	0.3 - 824	42/50	8	1	0	0
Methyl Tertiary Butyl Ether	200	NE	500	2,000	6.6J - 319	15/50	4	NA	0	0
Xylenes (Total)	530	10,000	40,000	100,000	0.6 - 1,700	45/50	3	0	0	0
Phenol	NE	NE	6,000	20,000	11 - 23	2/24	NA	NA	0	0
2-Methylphenol	NE	NE	NE	NE	17	1/24	NA	NA	NA	NA
4-Methylphenol	NE	NE	NE	NE	6J	1/24	NA	NA	NA	NA
2,4-Dimethylphenol	NE	NE	NE	NE	74	1/24	NA	NA	NA	NA
Naphthalene	NE	NE	400	1,000	7J - 499	6/24	NA	NA	1	0
2-Methylnaphthalene	NE	NE	NE	NE	70 - 668	5/24	NA	NA	NA	NA
Dibenzofuran	NE	NE	NE	NE	8J - 23	3/24	NA	NA	NA	NA
Fluorene	NE	NE	NE	NE	8J - 22	3/24	NA	NA	NA	NA
Phenanthrene	NE	NE	NE	NE	10J - 52	3/24	NA	NA	NA	NA

TABLE 6-5 (Continued)

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
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	Concentration Range	No. of Positive Detects/ No. of Samples	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
Anthracene	NE	NE	NE	NE	7J	1/24	NA	NA	NA	NA
Carbazole	NE	NE	NE	NE	12 - 13	2/24	NA	NA	NA	NA
beta-BHC	NE	NE	NE	NE	0.022J - 0.023J	3/7	NA	NA	NA	NA
delta-BHC	NE	NE	NE	NE	0.05J	1/7	NA	NA	NA	NA
Heptachlor	0.008	0.4	5	5	0.011J - 0.013J	2/7	2	0	0	0
Aldrin	NE	NE	0.3	0.3	0.013J - 0.017J	2/7	NA	NA	0	0
4,4'-DDD	NE	NE	NE	NE	0.21J	1/7	NA	NA	NA	NA
4,4'-DDT	NE	NE	NE	NE	0.014J	1/7	NA	NA	NA	NA
Aluminum	NE	NE	NE	NE	215 - 380,000	23/24	NA	NA	NA	NA
Antimony	NE	6	10	15	3.8J - 10.2J	2/10	NA	1	1	0
Arsenic	50	50	NE	NE	1.9J - 165J	21/23	3	3	NA	NA
Barium	2,000	2,000	NE	NE	20.7 - 3,440	24/24	4	4	NA	NA
Beryllium	NE	4	4,000	20,000	0.14J - 63.5	22/24	NA	10	0	0
Calcium	NE	NE	NE	NE	13,510 - 2,050,000	24/24	NA	NA	NA	NA
Chromium	50	100	200	800	4.6 - 1,540	22/24	19	14	13	4
Cadmium	5	5	5	20	0.31 - 340	22/24	8	8	0	1
Cobalt	NE	NE	NE	NE	12J - 281	13/24	NA	NA	NA	NA
Copper	1,000	1,300	NE	NE	2 - 140	23/24	0	0	NA	NA
Iron	300	NE	NE	NE	67.7 - 255,000	24/24	23	NA	NA	NA
Lead	15	15	NE	NE	1.2J - 64	21/24	7	7	NA	NA
Magnesium	NE	NE	NE	NE	2,560 - 42,600	24/24	NA	NA	NA	NA
Manganese	50	50(4)	NE	NE	13.3 - 1,420	24/24	19	19	NA	NA
Mercury	1.1	2	NE	2	0.15J - 0.84J	5/24	0	0	NA	0

TABLE 6-5 (Continued)

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
	NCWQS[1]	MCL[2]	Federal Health Advisories[3]		Concentration Range	No. of Positive Detects/ No. of Samples	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
Nickel	100	100	500	1,700	13.4 - 524	19/24	9	9	1	0
Potassium	NE	NE	NE	NE	2,740 - 22,300	17/24	NA	NA	NA	NA
Selenium	50	50	NE	NE	1.4J - 13.5J	8/16	0	0	NA	NA
Silver	18	NE	200	200	4 - 20	3/24	1	NA	0	0
Sodium	NE	NE	NE	NE	4,470 - 68,200	23/24	NA	NA	NA	NA
Thallium	NE	2	7	20	0.9 - 5	15/24	NA	8	0	0
Vanadium	NE	NE	NE	NE	8J - 886	22/24	NA	NA	NA	NA
Zinc	2,100	5,000[4]	3,000	10,000	41.9 - 1,850	16/18	0	0	0	0

Notes: Concentrations expressed in microgram per liter (µg/L).

[1] NCWQS = North Carolina Water Quality Standards for Groundwater

[2] MCL = Safe Drinking Water Act Maximum Contaminant Level

[3] Longer Term Health Advisories for a 10 kg Child and 70 kg Adult

[4] SMCL = Secondary Maximum Contaminant Level

NE - No Criteria Established

NA - Not Applicable

NJ - Estimated/tentative value

J - Estimated value

All rejected results have been removed from the data. Frequencies of detection are adjusted accordingly.

TABLE 6-6

SURFACE WATER DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Criteria			Average Reference Station Background Concentration	Twice the Average Reference Station Average Concentration	Contaminant Frequency/Range		Comparison to Criteria			No. of Times Exceeded Twice the Average Background Concentration
	NCWQS(1)	Federal Health AWQCs(2)				No. of Positive Detects/ No. of Samples	Contaminant Range	Positive Detects Above NCWQS	Positive Detects Above AWQC		
		Water & Organisms	Organisms Only						Water & Organisms	Organisms Only	
Aluminum	NE	NE	NE	333.17	666.3	4/10	1 - 6,580	NA	NA	NA	1
Antimony	NE	14	4300	ND	ND	4/10	1.5 - 3.9	NA	0	0	NA
Arsenic	NE	0.018	0.14	ND	ND	1/10	2.7J	NA	1	1	NA
Barium	NE	2,000	NE	25.7	51.4	7/10	16.7 - 48.5J	NA	0	NA	0
Calcium	NE	NE	NE	17,566	35,132	10/10	41,700 - 63,900	NA	NA	NA	10
Chromium	NE	NE	NE	ND	ND	2/10	1J - 1.2J	NA	NA	NA	NA
Cobalt	NE	NE	NE	ND	ND	4/10	9J - 16.8J	NA	NA	NA	NA
Iron	NE	300	NE	575.7	1,151.4	10/10	764J - 9,500	NA	10	NA	4
Lead	NE	NE	NE	ND	ND	5/10	1.4 - 97J	NA	NA	NA	NA
Magnesium	NE	NE	NE	1,744.7	3,489.4	10/10	2,380 - 17,900	NA	NA	NA	5
Manganese	NE	50	100	ND	ND	10/10	24.5 - 113	NA	2	1	NA
Mercury	NE	0.14	0.15	ND	ND	2/10	3J - 3.2J	NA	2	2	NA
Potassium	NE	NE	NE	ND	ND	10/10	2,170 - 8,210	NA	NA	NA	NA
Selenium	NE	NE	NE	0.82	1.66	1/10	1.3J	NA	NA	NA	0
Sodium	NE	NE	NE	9,830	19,660	10/10	42,600 - 192,000	NA	NA	NA	10
Thallium	NE	1.7	6.3	ND	ND	1/10	1J	NA	0	0	NA
Vanadium	NE	NE	NE	ND	ND	4/10	4.5 - 14.8J	NA	NA	NA	NA
Zinc	NE	NE	NE	ND	ND	1/10	129J	NA	NA	NA	NA

Notes: Concentrations expressed in microgram per liter (µg/L).
(1) NCWQS = North Carolina Water Quality Criteria for Surface Water
(2) AWQC = Ambient Water Quality Standard
NE - Not Established
NA - Not Applicable
J - Estimated value
All rejected results have been removed from the data. Frequencies of detection are adjusted accordingly.

TABLE 6-7

SEDIMENT DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

	Sediment Screening Values (SSVs)				Contaminant Frequency/Range		Comparison to Screening Values		
Analyte	ER-L	ER-M	Average Reference Station Background Concentration	Twice the Average Reference Station Concentration	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M	No. of Times Exceeded Twice the Average Concentration
Acetone	NE	NE	NE	NE	1/20	128J	NA	NA	NA
Toluene	NE	NE	NE	NE	1/20	8J	NA	NA	NA
Diethylphthalate	NE	NE	NE	NE	4/20	352J - 2,135J	NA	NA	NA
Di-n-butyl phthalate	NE	NE	NE	NE	1/20	218J	NA	NA	NA
Bis-(2-ethylhexyl)phthalate	NE	NE	NE	NE	3/20	469J - 704J	NA	NA	NA
beta-BHC	NE	NE	2.51	5.02	1/20	0.59J	NA	NA	0
delta-BHC	NE	NE	0.64*	1.28	2/20	0.92J - 1J	NA	NA	0
Heptachlor	NE	NE	1.18	2.36	2/20	0.91J - 2.3J	NA	NA	0
Heptachlor epoxide	NE	NE	ND	ND	7/20	0.43J - 1.4J	NA	NA	NA
Dieldrin	0.02	8	1.50*	3.0	7/20	1.4J - 52	7	2	3
4,4'-DDD	2	20	1.57	3.14	17/20	1.1J - 1,140	16	14	15
4,4'-DDT	1	7	2.20	4.40	15/20	0.66J - 46J	13	4	7
4,4'-DDE	2	15	2.42	4.84	17/20	1J - 1,200	15	14	15
Endrin	0	45	ND	ND	5/20	0.44J - 0.85J	5	0	NA
Endosulfan II	NE	NE	ND	ND	8/20	0.84J - 3.5J	NA	NA	NA
Methoxychlor	NE	NE	0.94*	1.88	6/20	0.49J - 3.4J	NA	NA	3
Endrin aldehyde	NE	NE	0.59*	1.18	5/20	1J - 7.6J	NA	NA	3
Endrin Ketone	NE	NE	ND	ND	2/20	2.8J - 3.1J	NA	NA	NA
alpha-Chlordane	0.5$^{(1)}$	6$^{(1)}$	1.20	2.40	10/20	0.51J - 13J	10	5	9
gamma-Chlordane	0.5$^{(1)}$	6$^{(1)}$	1.44	2.88	6/20	3.6 - 9.7	6	4	6

TABLE 6-7 (Continued)

SEDIMENT DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Average Reference Station Background Concentration	Twice the Average Reference Station Concentration	Contaminant Frequency/Range		Comparison to Screening Values		No. of Times Exceeded Twice the Average Concentration
	ER-L	ER-M			No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M	
Aluminum	NE	NE	1,165.6	2,331.2	20/20	484 - 37,300	NA	NA	12
Arsenic	33	85	0.37	0.74	15/16	0.34J - 3.7J	0	0	11
Barium	NE	NE	6.46	12.9	20/20	2.4 - 129	NA	NA	13
Beryllium	NE	NE	0.09	0.18	4/14	0.27 - 1.1	NA	NA	4
Calcium	NE	NE	1,967.1	3,934.2	19/20	301J - 17,500J	NA	NA	12
Chromium	80	145	1.86	3.72	17/20	2.4 - 28.6	0	0	13
Cobalt	NE	NE	ND	ND	9/20	1.4 - 7.8	NA	NA	NA
Copper	70	390	0.75	1.50	16/20	3.4 - 24.8	0	0	16
Iron	NE	NE	433.7	867.4	20/20	1,050J - 15,900	NA	NA	20
Lead	35	110	0.79	1.58	18/18	4.7 - 15,100	9	2	18
Magnesium	NE	NE	45.25	90.5	20/20	88.1 - 3,830	NA	NA	19
Manganese	NE	NE	3.63	7.26	20/20	3.2J - 62.8	NA	NA	14
Mercury	0	1	0.14	0.28	1/1	0.07J	0	0	0
Nickel	30	50	ND	ND	12/20	2.1B - 13.6B	0	0	NA
Potassium	NE	NE	ND	ND	3/20	498 - 2,610	NA	NA	NA
Selenium	NE	NE	0.19	0.38	4/20	0.23J - 1.6J	NA	NA	1
Sodium	NE	NE	ND	ND	11/20	461 - 4,980	NA	NA	NA

TABLE 6-7 (Continued)

SEDIMENT DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Average Reference Station Background Concentration	Twice the Average Reference Station Concentration	Contaminant Frequency/Range		Comparison to Screening Values		No. of Times Exceeded Twice the Average Concentration
	ER-L	ER-M			No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M	
Thallium	NE	NE	0.10	0.20	14/20	0.15 - 0.96	NA	NA	13
Vanadium	NE	NE	1.52	3.04	20/20	0.94J - 39.3	NA	NA	15
Zinc	120	270	0.11	10.22	3/3	60.4J - 104J	0	0	3

Notes: (1) Values for Total Chlordane.
Organic concentrations expressed in microgram per kilogram (µg/kg).
Inorganic concentrations expressed in milligram per kilogram (mg/kg).
NE - Not Established
NA - Not Applicable
J - Estimated value
* - Maximum Concentration
All rejected results have been removed from the data. Frequencies of detection are adjusted accordingly.

TABLE 6-8

ORGANIC AND INORGANIC FISH FILLET AND CRAB TISSUE DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Range of Positive Detection	Frequency of Detection	Bioconcentration Factor (L/kg)	Contaminant Detected in Surface Water?	Contaminant Detected in Sediment?
ORGANICS (µg/kg)					
Methylene Chloride	26 - 16,317	6/18	0.9⁽¹⁾	No	No
Acetone	58 - 372,323	11/18	NA	No	Yes
Carbon Disulfide	196 - 1,328	15/18	NA	No	No
2-Butanone	63 - 5108	2/18	NA	No	No
Toluene	24	1/18	26⁽²⁾	No	Yes
PESTICIDES/PCBS (µg/kg)					
beta-BHC	4.2 - 11	7/22	130⁽¹⁾	No	Yes
gamma-BHC	2.1 - 5.5	6/22	130⁽¹⁾	No	No
Heptachlor	2.6 - 4.3	3/22	11,200⁽¹⁾	No	Yes
Aldrin	2.3 - 6.6	3/22	4,670⁽¹⁾	No	No
Heptachlor Epoxide	3.9	1/22	11,200⁽¹⁾	No	Yes
Dieldrin	4.3 - 48	18/22	4,670⁽¹⁾	No	Yes
4,4'-DDE	39 - 572	22/22	53,600⁽¹⁾	No	Yes
Endrin	2.5 - 52	9/22	3,970⁽¹⁾	No	Yes
Endosulfan II	3.6 - 9.6	4/22	NA	No	Yes

TABLE 6-8 (Continued)

ORGANIC AND INORGANIC FISH FILLET AND CRAB TISSUE DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Range of Positive Detection	Frequency of Detection	Bioconcentration Factor (L/kg)	Contaminant Detected in Surface Water?	Contaminant Detected in Sediment?
PESTICIDES/PCBS (µg/kg) (continued):					
4,4'-DDD	19 - 256	22/22	53,600⁽¹⁾	No	Yes
4,4'-DDT	2.5 - 15	11/13	53,600⁽¹⁾	No	Yes
Endrin Ketone	3.6 - 3.8	2/13	NA	No	Yes
Endrin Aldehyde	2.8 - 4	2/13	3,970⁽¹⁾	No	Yes
alpha-Chlordane	3.6 - 38	9/13	14,100⁽¹⁾*	No	Yes
INORGANICS (mg/kg)					
Aluminum	19.3 - 27.3	6/13	231⁽²⁾	Yes	Yes
Arsenic	1.4	1/13	44⁽¹⁾	Yes	Yes
Barium	0.41 - 2.2	8/13	8⁽²⁾	Yes	Yes
Cadmium	0.16 - 0.8	5/13	64⁽¹⁾	No	No
Calcium	676 - 13,300	12/13	NA	Yes	Yes
Chromium	3 - 4	2/22	16	Yes	Yes
Cobalt	6.9	1/13	40⁽²⁾	Yes	Yes
Copper	2.3 - 27.5	13/13	36⁽¹⁾	No	Yes

TABLE 6-8 (Continued)

ORGANIC AND INORGANIC FISH FILLET AND CRAB TISSUE DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Range of Positive Detection	Frequency of Detection	Bioconcentration Factor (L/kg)	Contaminant Detected in Surface Water?	Contaminant Detected in Sediment?
INORGANICS (mg/kg) (continued):					
Iron	20.4 - 48	8/13	NA	Yes	Yes
Lead	0.51 - 0.61	3/13	49(1)	Yes	Yes
Magnesium	833 - 1,550	13/13	NA	Yes	Yes
Manganese	1 - 3.1	10/13	35(2)	Yes	Yes
Mercury	0.3 - 0.98	4/4	5,500(1)	Yes	Yes
Potassium	9,180 - 19,000	13/13	NA	Yes	Yes
Selenium	0.72 - 0.8	2/13	6(1)	Yes	Yes
Silver	1 - 3.3	5/18	0.5	No	No
Sodium	1,970 - 21,900	13/13	NA	Yes	Yes
Vanadium	1.7	1/22	NA	Yes	Yes
Zinc	38 - 130	5/5	47(1)	Yes	Yes

* Value for Total Chlordane

(1) Region IV Water Quality Standards, 1992

(2) Region III, BTAG Screening Values

All rejected results have been removed from the data. Frequencies of detection are adjusted accordingly.

TABLE 6-9

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Groundwater		Surface Water		Sediment		Fish	
VOCs												
Acetone				X						X	●	X
1,1,2,2-Tetrachloroethane						X						
Chloroform						X						
Methylene Chloride				X								X
1,1,2-Trichloroethane						X						
1,1-Dichloroethane						X						
1,1-Dichloroethene					●	X						
2-butanone												X
Benzene					●	X						
Carbon disulfide		X										X
cis-1,2-Dichloroethene					●	X						
Ethylbenzene					●	X						
Methyl Tertiary Butyl Ether					●	X						
Tetrachloroethane				X		X						
Toluene		X			●	X				X		X
trans-1,2-Dichloroethene					●	X						
Trichloroethene					●	X						
Xylenes (Total)		X			●	X						
SVOCs												
Benzo(a) pyrene		X										
Indeno(1,2,3-cd) pyrene		X										
Dibenz(a,h) anthracene		X										
Benzo(g.h,i) perylene	●	X										
4-Methylphenol						X						
2,4-Dimethylphenol						X						
Naphthalene					●	X						
Dibenzofuran					●	X						
Fluorene						X						
Anthracene						X						
Carbazole						X						
Diethylphthalate									●	X		
Di-n-butylphthalate										X		
Bis(2-ethylhexyl)phthalate		X								X		
Phenol		X				X						
2-Methylnaphthalene					●	X						

TABLE 6-9 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Ground-water		Surface Water		Sediment		Fish	
2-Methylphenol						X						
Acenaphthene		X										
Phenanthene	●	X			●	X						
Carbazole		X										
Fluoranthene		X										
Pyrene		X		X								
Butylbenzlphthalate		X										
Benzo(a)anthracene		X										
Chrysene		X										
Benzo(b) fluoranthene	●	X	●	X								
Pesticides												
Aldrin						X						X
gamma-BHC												X
alpha-Chlordane		X							●	X	●	X
beta-BHC		X				X				X	●	X
Dieldrin	●	X							●	X	●	X
Endosulfan II	●	X							●	X	●	X
Endrin Ketone	●	X							●	X	●	X
Endrin Aldehyde	●	X							●	X	●	X
Endrin		X							●	X	●	X
delta-BHC					●	X				X		X
gamma-Chlordane		X							●	X		
Heptachlor					●	X				X	●	X
Heptachlor Epoxide									●	X		X
Methoxychlor									●	X		
4,4'-DDE		X							●	X	●	X
4,4'-DDT		X				X			●	X	●	X
4,4'-DDD	●	X				X			●	X	●	X
Inorganics												
Aluminum		X		X		X		X		X	●	X
Antimony		X			●	X	●	X				
Arsenic	●	X	●	X	●	X	●	X	●	X		
Barium		X		X	●	X		X	●	X	●	X
Beryllium		X			●	X			●	X		
Cadmium		X		X	●	X						X
Calcium		X		X		X		X		X		

TABLE 6-9 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Ground-water		Surface Water		Sediment		Fish	
Chromium		X		X	●	X	●	X	●	X		
Cobalt		X		X	●	X	●	X	●	X		
Copper		X		X		X			●	X	●	X
Lead	●	X	●	X	●	X	●	X	●	X	●	X
Magnesium		X		X		X		X		X		
Manganese	●	X		X	●	X	●	X	●	X	●	X
Mercury						X	●	X		X	●	X
Nickel		X		X	●	X			●	X		
Potassium				X		X		X		X		
Selenium		X		X		X		X	●	X	●	X
Silver				X	●	X						
Sodium						X		X		X		
Thallium		X	●	X	●	X	●	X	●	X		
Vanadium		X		X	●	X	●	X	●	X		
Zinc		X		X	●	X	●	X	●	X	●	X
Iron		X		X		X		X		X		

● = Selected as COPC
X = Positively detected in media

TABLE 6-10

MATRIX OF POTENTIAL HUMAN EXPOSURE
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium/ Exposure Route	Current Military Personnel	Future Construction Worker	Future Residential Adult & Child	Current Recreational Adult & Child
Soil				
Incidental Ingestion	M	W	A, C	NE
Dermal Contact	M	W	A, C	NE
Groundwater				NE
Ingestion	NE	NE	A, C	NE
Dermal Contact	NE	NE	A, C	NE
Surface Water				
Ingestion	NE	NE	NE	A, C
Dermal Contact	NE	NE	NE	A, C
Sediment				
Incidental Ingestion	NE	NE	NE	A, C
Dermal Contact	NE	NE	NE	A, C
Air				
Inhalation of Vapor Phase Chemicals Indoor	NE	NE	A, C	NE
Inhalation of Particulates Outdoor	M	W	A, C	NE
Biota				
Fish Ingestion	NE	NE	NE	A

A = Adult
C = Child
M = Military lifetime exposure
W = Construction duration exposure
NE = Not Exposed

TABLE 6-11

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION OF SOIL CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Future Construction Worker				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, May 1992d
IR	Ingestion Rate	Child Adult Military Personnel Construction Worker	200 mg/day 100 mg/day 100 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 Military Personnel Construction Worker	350 days/yr 350 days/yr 350 days/yr 90 days/yr	USEPA, December 1989a USEPA, March 1991
ED	Exposure Duration	Child Adult Military Personnel Construction Worker	6 years 24 years 4 years 1 year	USEPA, March 1991 USEPA, December 1989a
BW	Body Weight	Child Adult Military 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 Military Personnel Construction Worker	2,190 days 8,760 days 1,460 days 365 days	USEPA, December 1989a

TABLE 6-12

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Future Construction Worker			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 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 Military Personnel 5,800 cm^2 Construction Worker 4,300 cm^2	USEPA, January 1992a Reasonable worst case: individual skin area limited to head, hands, forearms, lower legs
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2	USEPA, Region IV, 1992c
ABS	Fraction Absorbed (unitless)	Organics 1.0% Inorganics 0.1%	USEPA, Region IV, 1992c
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Military Personnel 350 days/yr Construction Worker 90 days/yr	USEPA, December 1989a USEPA, March 1991
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years Construction Worker 1 year	USEPA, March 1991 USEPA, December 1989a
BW	Body Weight	Child 15 kg Adult 70 kg Military 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 Military Personnel 1,460 days Construction Worker 365 days	USEPA, December 1989a

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Construction Worker			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992d
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Military Personnel 350 days/yr Construction Worker 90 days/yr	USEPA, December 1989a
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years Construction Worker 1 year	USEPA, March 1991
IR	Inhalation Rate	Child 10 m^3 Adult 20 m^3 Military Personnel 20 m^3 Construction Worker 20 m^3	USEPA, March 1991 USEPA, May 1989b
BW	Body Weight	Child 15 kg Adult 70 kg Military 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 Noncarcinogens	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days Construction Worker 365 days	USEPA, December 1989a
PEF	Site-Specific Particulate Emission Factor	4.63E09 m^3/kg	Cowherd, USEPA, December 1989a

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/kg)	USEPA, May 1992d
EF	Exposure Frequency	Child	350 days/yr	USEPA, December 1989a
		Adult	350 days/yr	
		Military Personnel	350 days/yr	
ED	Exposure Duration	Child	6 years	USEPA, March 1991
		Adult	24 years	
		Military Personnel	4 years	
IR	Inhalation Rate	Child	10 m^3	USEPA, March 1991
		Adult	20 m^3	USEPA, May 1989b
		Military Personnel	20 m^3	
BW	Body Weight	Child	15 kg	USEPA, December 1989a
		Adult	70 kg	
		Military Personnel	70 kg	
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child	2,190 days	USEPA, December 1989a
		Adult	8,760 days	
		Military Personnel	1,460 days	
PEF	Site-Specific Particulate Emission Factor	4.63E09 m^3/kg		Cowherd, USEPA, December 1989a

TABLE 6-14

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF GROUNDWATER CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0232
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 6-15

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH GROUNDWATER CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0232
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 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 6-16

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF GROUNDWATER VOLATILE CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL	(mg/m^3)	USEPA, May 1992d
IR	Inhalation Rate	Child Adult	0.6 m^3/hr 0.6 m^3/hr	USEPA, December 1989a
ET	Exposure Time	All	0.25 hr/day	USEPA, January 1992a
EF	Exposure Frequency	All	350 day/yr	USEPA, December 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, December 1989a
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 Noncarcinogens	Child Adult	2,190 days 10,950 days	USEPA, December 1989a

TABLE 6-17

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SURFACE WATER
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Recreational Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/L)	USEPA, May 1992d
IR	Ingestion Rate	Child 0.05 L/hr Adult 0.05 L/hr	USEPA, December 1989a
EF	Exposure Frequency	Child 20 events/yr Adult 20 events/yr	Site-Specific Professional Judgement (4 days/month x 5 months/year)
ED	Exposure Duration	Child 6 years Adult 30 years	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 Noncarcinogens	Child 2,190 days Adult 10,950 days	USEPA, December 1989a

TABLE 6-18

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SURFACE WATER
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Recreational 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 4,600 cm^2 Adult 11,500 cm^2	50 percent whole body (head, arms, hands, forearms, lower extremities)
ET	Exposure Time	Child 2.6 hr/day Adult 2.6 hr/day	USEPA, January 1992a
EF	Exposure Frequency	Child 20 days/yr Adult 20 days/yr	Site-Specific Professional Judgement (4 days/month x 5 months/year)
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, December 1989a
CF	Volumetric Conversion Factor for Water	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
PC	Permeability Constant	Chemical-Specific	USEPA, January 1992a

TABLE 6-19

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SEDIMENT
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Recreational Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992d
IR	Soil Ingestion Rate	Child 100 mg/day Adult 100 mg/day	USEPA, December 1989a
EF	Exposure Frequency	Child 20 days/yr Adult 20 days/yr	Site-Specific Professional Judgement (4 days/month x 5 months/year)
ED	Exposure Duration	Child 6 years Adult 30 years	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
CF	Conversion Factor	1E-06 kg/mg	USEPA, December 1989a

TABLE 6-20

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SEDIMENT
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Recreational Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992d
SA	Surface Area of Skin Available for Contact	Child 4,600 cm^2 Adult 11,500 cm^2	50 percent whole body (head, arms, hands, forearms, lower extremities) USEPA, January 1992a
AF	Sediment Adherence Factor	1.0 mg/cm^2	USEPA, Region IV, 1992c
ABS	Absorption Factor (dimensionless)	Organics 1.0% Inorganics 0.1%	USEPA, Region IV, 1992c
EF	Exposure Frequency	Child 20 events/yr Adult 20 events/yr	Site-Specific Professional Judgement (4 days/month x 5 months/year)
ED	Exposure Duration	Child 6 years Adults 30 years	USEPA, December 1989a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	All 70 years	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 6 years Adult 30 years	USEPA, December 1989a
CF	Conversion Factor	1E-06 kg/mg	USEPA, December 1989a

TABLE 6-21

EXPOSURE ASSESSMENT SUMMARY
FISH FILLET INGESTION
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Current Recreational Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992d
IR	Ingestion Rate	0.145 kg/meal	USEPA, 1993b
Fi	Fraction Ingested from Contaminated Source	1.0	90th Percentile Consumption Rate
EF	Exposure Frequency	48 meal/year	USEPA, December 1989a
ED	Exposure Duration	9 years	USEPA, 1993b
BW	Body Weight	70 kg	USEPA, December 1989a
AT_c	Averaging Time Carcinogen	25,550 days	USEPA, December 1989a
AT_{nc}	Averaging Time Noncarcinogen	10,950 days	USEPA, December 1989a

TABLE 6-22

TOXICITY FACTORS
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD	RfC	CSF	CSFI	WOE	Reference
Volatiles:						
Benzene	3.0E-04	1.7E-03	2.9E-02	2.9E-02	A	EPA/ECAO
cis-1,2-Dichloroethene	1.0E-02	--	--	--	--	IRIS, 1994
Tetrachloroethene	1.0E-02	ND	5.2E-02	2.0E-03	--	IRIS, 1994; USEPA, 1992b
1,1-Dichloroethene	9.0E-03	--	6.0E-01	1.75E-01	C	IRIS,1994
Toluene	2.0E-01	4.0E-01	--	--	D	IRIS, 1994
trans-1,2-Dichloroethene	2.0E-02	--	--	--	--	
Trichloroethene	6E-03	PDG	1.1E-02	6.0E-03	B2	IRIS, 1994; USEPA 1992b
Xylenes (total)	2.0E+00	PDG	--	--	D	IRIS, 1994
Acetone	1.00E-1	--	--	--	--	IRIS, 1994
Ethylbenzene	1.0E-1	2.9E-01	--	--	F	IRIS, 1994
Methyl Tertiary Butyl Ether	5.0E-03	8.6E-01	--	--	D	IRIS, 1994, EPA/ECAO
Semivolatiles:						
Benzo(b)fluoranthene	--	--	7.30E-01	6.10E-01	B2	IRIS, 1994
Diethylphthalate	8.0E-01	--	--	--	--	IRIS, 1994
Dibenzofuran	4.0E-03	--	--	--	--	EPA/ECAO
Pesticides/PCBs:						
4,4'-DDD	ND	ND	2.4E-01	--	B2	IRIS, 1994
4,4'-DDE	ND	ND	3.4E-01	--	B2	IRIS, 1994
4,4'-DDT	5.0E-04	ND	3.4E-01	3.4E-01	B2	IRIS, 1994
Dieldrin	5.0E-05	--	1.6E+01	1.6E+01	B2	IRIS, 1994
Heptachlor	5.0E-05	--	4.5E+00	4.55E+00	B2	IRIS, 1994
Heptachlor Epoxide	5.0E-05	ND	4.5E+00	9.1E+00	B2	IRIS, 1994
Endrin	5.0E-04	--	--	--	D	IRIS, 1994
Methoxychlor	5.0E-03	--	--	--	D	IRIS, 1994
Total Chlordane	6.0E-05	UR	1.3E+00	1.3E+00	B2	IRIS, 1994
beta-BHC	--	--	1.8E+00	1.8E+00	--	IRIS, 1994
Inorganics:						
Arsenic	3.0E-04	ND	1.7E+00	1.5E+01	A_I	IRIS, 1994
Antimony	4.0E-04	--	--	--	--	
Barium	7.0E-02	--	--	--	--	IRIS, 1994
Beryllium	5.0E-03	ND	4.3E+00	8.4E+00	B2	IRIS, 1994
Cadmium	5.0E-04	PDG	--	6.3E+00	B1	IRIS, 1994
Chromium	5.0E-03	--	--	--	--	IRIS, 1994
Cobalt	6.0E-02	--	--	--	--	
Copper	3.7E-02	--	--	--	D	
Manganese	5.0E-03	1.4E-05	--	--	D	IRIS, 1994
Mercury	3.0E-04	8.6E-05	--	--	D	HEAST, 1994
Nickel	2.0E-02	PDG	--	--	--	IRIS, 1994
Selenium	5.0E-03	ND	--	--	D	IRIS, 1994
Vanadium	7.0E-03	--	--	--	--	HEAST, 1994
Zinc	3.0E-01	--	--	--	D	IRIS, 1994

TABLE 6-22 (Continued)

TOXICITY FACTORS
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Notes:

RfD	Oral Reference Dose (mg/kg - day)
RfC	Inhalation Reference Concentration (mg/kg-day)$^{-1}$
CSF	Oral Cancer Slope Factor (mg/kg-day)$^{-1}$
CSFI	Inhalation Cancer Slope Factor (mg/kg-day)$^{-1}$
WOE	Weight of Evidence
IRIS	Integrated Risk Information System
HEAST	Health Effects Assessment Summary Tables
USEPA	United States Environmental Protection Agency
ND	Not Determined
PDG	Pending
WOE	Weight of Evidence
PDG	Pending
UR	Under Review by USEPA
A	Human Carcinogen
B1	Probable Human Carcinogen - Limited Evidence
B2	Probable Human Carcinogen - Sufficient Evidence
C	Possible Human Carcinogen
D	Not Classifiable as to Human Carcinogenicity
I	Ingestion

TABLE 6-23

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 10 (SITE 35)
SOIL
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Receptor Group							
	Future Residential Child		Future Residential Adult		Current Military Personnel		Future Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion	4.0E-05	0.91	1.71E-05	0.10	2.9E-06	0.09	1.2E-07	0.02
Dermal Contact	4.6E-06	0.02	9.9E-06	<0.01	1.7E-07	<0.01	1.1E-09	<0.01
Inhalation of Particulates	3.3E-09	5.5E-15	5.6E-09	9.5E-15	9.3E-10	2.8E-14	8.9 x 10^{-12}	NA
Total	4.5E-05	0.93	2.7E-05	0.10	3.1E-06	0.09	1.2E-07	0.02

NA - Not Applicable

TABLE 6-24

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 10 (SITE 35)
GROUNDWATER
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Receptor Group			
	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Ingestion	2.0E-03	101	4.3E-03	43
Dermal Contact	1.1E-04	2.1	2.0E-05	1.0
Inhalation of Vapors	1.0E-05	<0.01	2.3E-05	<0.01
Total	2.1E-03	103	4.3E-03	44

TABLE 6-25

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 10 (SITE 35)
SURFACE WATER
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Receptor Group			
	Current Recreational Child		Current Recreational Adult	
	ICR	HI	ICR	HI
Ingestion	1.1E-07	<0.01	1.1E-07	<0.01
Dermal Contact	3.2E-09	<0.01	8.6E-09	<0.01
Total	1.1E-07	<0.01	1.2E-07	<0.01

TABLE 6-26

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 10 (SITE 35)
SEDIMENT
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Receptor Group			
	Current Recreatoinal Child		Current Recreational Adult	
	ICR	HI	ICR	HI
Ingestion	2.3E-07	0.01	2.4E-07	<0.01
Dermal Contact	1.0E-07	<0.01	2.1E-07	<0.01
Total	3.3E-07	0.01	4.5E-07	<0.01

TABLE 6-27

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 10 (SITE 35)
FISH
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Current Recreational Adult	
	ICR	HI
Ingestion	1.8E-05	1.8
Total	1.8E-05	1.8

TABLE 6-28

TOTAL SITE RISK
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

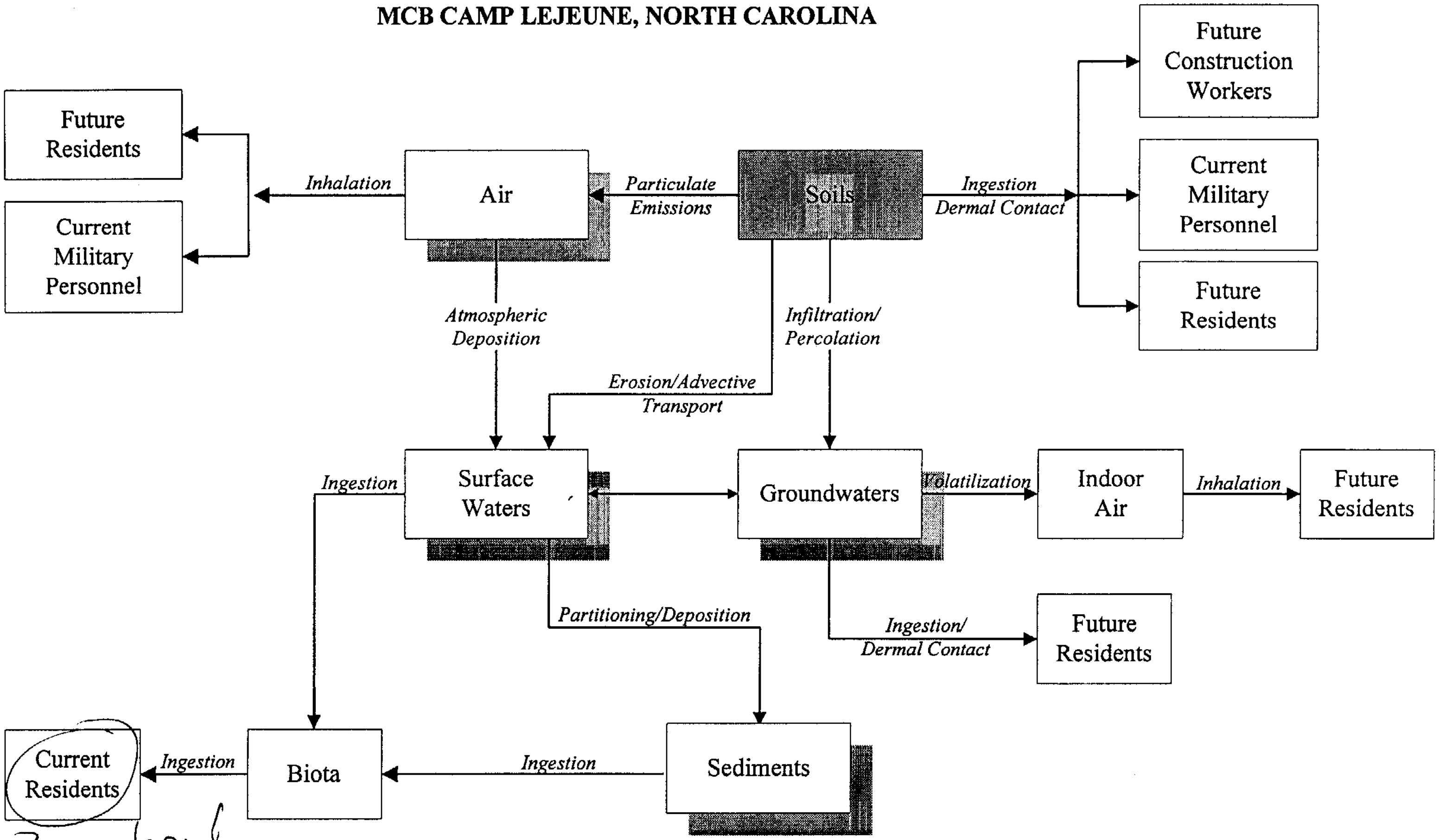
Receptors	Soil		Groundwater		Surface Water		Sediment		Fish		TOTALS	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Future Child Resident	4.5E-05 (<1)	0.93 (1)	2.1E-03 (99)	103 (99)	NA	NA	NA	NA	NA	NA	2.1E-03	104
Future Adult Resident	2.7E-05 (<1)	0.10 (<1)	4.3E-03 (99)	44 (99)	NA	NA	NA	NA	NA	NA	4.3E-03	44
Future Construction Worker	1.2E-07 (100)	0.02 (100)	NA	NA	NA	NA	NA	NA	NA	NA	1.2E-07	0.02
Current Military Personnel	3.1E-06 (100)	0.09 (100)	NA	NA	NA	NA	NA	NA	NA	NA	3.1E-06	0.09
Current Recreational Child	NA	NA	NA	NA	1.1E-07 (27)	<0.01 (<1)	3.3E-07 (73)	0.01 (99)	NA	NA	4.4E-07	0.01
Current Recreational Adult	NA	NA	NA	NA	1.2E-07 (<1)	<0.01 (<1)	4.5E-07 (<1)	<0.01 (<1)	1.8E-05 (99)	1.8 (99)	1.9E-05	1.8

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
ND = Not Determined
NA = Not Applicable
( ) = Percent Contribution to Total Risk

SECTION 6.0 FIGURES

FIGURE 6-1

CONCEPTUAL SITE MODEL
OPERABLE UNIT NO. 10
SITES 35, CAMP GEIGER FUEL FARM
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA



Current Recreational User.

7.0 ECOLOGICAL RISK ASSESSMENT

7.1 Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, directs EPA 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 presents the ecological risk assessment (ERA) conducted at OU No. 10 that assesses the potential impacts to ecological receptors from contaminants detected. OU No. 10 is comprised of a single site (i.e., Site 35 - Camp Geiger Area Fuel Farm). Additional data obtained along Brinson Creek, downstream of Site 35, was also used in the ERA.

7.1.1 Objectives

The objective of this ERA was to evaluate if past reported disposal practices at Site 35 potentially are adversely impacting the ecological integrity of the terrestrial and aquatic communities on, or adjacent to the site. This assessment also evaluated the potential effects of contaminants at Site 35 on sensitive environments including wetlands, protected species, and fish nursery areas. The conclusions of the ERA will be 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.

7.1.2 Scope

This ERA evaluated and analyzed the results from the RI and historical data collected during other studies. The RI included sampling and chemical analysis of the surface water, sediments, biota, soil, and groundwater.

Surface water, sediment, fish, and benthic macroinvertebrate samples were collected from the entire stretch of Brinson Creek. Site 35 was located in the upper portion of the creek. Because the field team already was mobilized for Site 35, it was decided that the lower portion of the creek should be investigated to evaluate potential downstream impacts.

In addition, surface water, sediment, fish, and benthic macroinvertebrate samples were collected in May, 1994 from three creeks in the White Oak River Basin (Holland Mill Creek, Hadnot Creek, and Webb Creek) as reference stations. The fish from this sampling event were not chemically analyzed because fish collected in Hadnot Creek and the White Oak River by Baker in September to October, 1993 were chemically analyzed and were used as reference data for this ERA (Baker, 1994).

Information used to evaluate sensitive environments was obtained from historical data and previous studies conducted at Marine Corps Base (MCB) Camp Lejeune, North Carolina. In addition, a qualitative evaluation was conducted at each of the sites to identify potential terrestrial receptors.

The media of concern for this ERA were the surface water, sediment, biota (i.e., fish and benthic macroinvertebrates) and surface soil. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

The risk assessment methodologies used in this evaluation were consistent with those outlined in the Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information found in the following documents was used to supplement the USEPA guidance document:

- USEPA 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)
- Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1990)
- Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Water (USEPA, 1993a)

7.1.3 Organization

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, 1992). The problem formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the analysis, the data is evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the risk characterization, the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section also evaluates the potential impact on the ecological integrity at the site from the contaminants detected in the media.

7.2 Problem Formulation

Problem formulation is the first step of an ERA and includes a preliminary characterization of exposure and effects, as well as scientific data needs, policy and regulatory issues, and site-specific factors to define the feasibility, scope, and objectives for the ERA (USEPA, 1992).

The results of the various site investigations indicated the presence of contaminants in the surface water, biota, sediment, soil and groundwater. As discussed above, CERCLA directs USEPA to protect the environment with respect to releases of contaminants. Due to the potential for ecological receptors to be exposed to the contaminants detected at OU No. 10, an ERA was performed.

Three types of information are needed to evaluate potential links between the contaminants of potential concern (COPCs) and the ecological endpoints. First, chemical analyses of the appropriate media are necessary to establish the presence, concentrations, and variabilities of the COPCs. Second, ecological surveys are necessary to establish if adverse ecological effects have occurred. Finally, toxicological information is necessary to evaluate the potential effects of the COPCs on the ecological receptors. The combination of all three types of data allows the assessment of the relative contribution of other potential causes of the observed effects (as measured by the ecological endpoints) that may be unrelated to the toxic effects of the contaminants of concern (e.g., habitat alterations and natural variability). Therefore, confidence in cleanup and monitoring decisions is greatly enhanced when based on a combination of chemical, ecological, and toxicological data.

Chemical analyses were performed on samples collected from the surface water, sediment, biota, soil, and groundwater to evaluate the presence, concentrations, and variabilities of the COPCs. Ecological surveys also were conducted as part of Baker's field activities during the RI. Based on these observations and available habitats, potential ecological receptors were identified. Finally, toxicological information for the COPCs detected in the media was obtained from available references and literature and used to evaluate the potential adverse ecological effects to the ecological receptors.

The components of the problem formulation include stressor characteristics, ecosystems potentially at risk, ecological effects, endpoint selection, and a conceptual model. The following sections discuss each of these components, and how they were evaluated in this ERA.

7.2.1 Stressor Characteristics

One of the initial steps in the problem formulation stage of an ERA is identifying the stressor characteristics. For this ERA, the stressors that were evaluated include the contaminants detected in the surface water, sediment, biota, and surface soils. Contaminants in the subsurface soils and groundwater were not evaluated in this ERA.

The nature and extent of these contaminants were discussed in Section 4.0 of this report. The location of samples was based on historical information available for the site and a site visit to evaluate potential ecosystems and ecological receptors.

7.2.1.1 Contaminants of Potential Concern (COPCs)

The contaminants of potential concern (COPCs) for the ERA were selected using procedures presented in the following paragraphs.

For the aquatic endpoints, the contaminant concentrations in the surface water and sediment samples initially were compared to the concentrations of those contaminants in the off-site background samples. Contaminants that were detected at a concentration less than twice the average background concentration were not retained as COPCs. Common and naturally occurring contaminants unrelated to Site 35 (i.e., calcium, magnesium, potassium, and sodium) were not retained as COPCs even if they exceeded the background concentrations. The concentrations of these inorganic contaminants are highly variable in natural waters, (especially tidally influenced waters), and there is no toxicological data in the literature with which to evaluate them. Finally, common laboratory contaminants that were detected at a concentration of greater than ten times the concentration in a blank sample, or other constituents that were detected at a concentration of greater than five times the concentration in a blank sample were not retained as COPCs.

The concentration of the remaining contaminants were compared aquatic reference values (ARVs) including saltwater North Carolina Water Quality Standards (WQS) and USEPA Region IV Water Quality Screening Values (WQSVs), or Sediment Screening Values (SSVs) (see Tables 7-1 and 6-7). Section 7.2.3, Ecological Effects Characterization, presents a more detailed description of these ARVs.

A contaminant was not retained as a COPC if it did not exceed one it's respective ARVs in at least one of the samples. Contaminants without aquatic toxicological information that were detected in ten percent (or less) of the samples were not retained as COPCs for the ERA. Finally, contaminants detected in more that ten percent of the samples were retained as COPCs if an aquatic reference value did not exist and no other information evaluating it's toxicity to aquatic life was located in the literature. However, these COPC only were evaluated qualitatively.

For the terrestrial endpoints, the concentrations of contaminants in the site surface soils were compared to the background concentrations. A contaminant was not retained as a COPC if its maximum concentration was less than twice the average base-specific background sample concentration. In addition, common and naturally occurring chemicals unrelated to the site and contaminants associated with blank contamination were not retained as COPCs (as discussed above). Anthropogenic contaminants (i.e., PAHs), that were detected in less than ten percent of the samples were not retained as COPCs. There are no state, or USEPA Region IV soil screening values that take into account potential risk to terrestrial receptors via food chain ingestion. Therefore, any contaminants remaining after the above evaluations that were detected in more than five percent of the surface soil samples were retained as COPCs.

Similar to the other media, common and naturally occurring chemicals unrelated to the site and contaminants associated with blank contamination in the tissue samples were not retained as COPCs. In addition, contaminants detected in less than ten percent of the tissue samples were not retained as COPCs if they were not detected in any of the surface water or sediment samples. There are no state, or USEPA Region IV fish tissue screening values. Any contaminants remaining after the above evaluation that were detected in more than ten percent of the samples were retained as COPCs.

The following sections present the COPC selection process for each of the media.

Surface Water

Surface water samples were collected upstream and downstream of Site 35 in Brinson Creek. No semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), pesticides, or PCBs were detected in any of the surface water samples. Therefore, no organics were retained as surface water COPCs.

Eighteen inorganics were detected in the surface water samples. Calcium, magnesium, potassium, and sodium were not retained as COPCs because they are common naturally occurring chemicals, not related to site activities, and no toxicological data were located in the literature to evaluate their potential risks to aquatic life. In addition, barium and selenium were not retained as COPCs because they were detected at a concentration less than twice the average off-site background concentration. Finally, antimony, arsenic and chromium were not retained as COPCs because they did not exceed any of the ARVs.

The following chemicals detected in the surface water samples were included in the ERA for evaluation of the aquatic endpoints: aluminum, cobalt, iron, lead, manganese, mercury, thallium, vanadium and zinc.

COPCs - Sediments

Surface water samples were collected upstream and downstream of Site 35 in Brinson Creek.

Two VOCs were detected in the sediment samples. Acetone and toluene were not retained as COPC because they were detected in five percent of the samples (1/20). In addition, acetone was detected at a concentration of 128 µg/L which is less than ten times the concentration in the QA/QC blank (430 µg/L).

Three SVOCs were detected in the sediment samples. Di-n-butylphthalate was not retained as a COPC because it did was detected in five percent of the samples (1/20). Bis(2-cthylhexyl)phthalate was not retained as a COPC because it was detected at concentrations below the concentrations in the QA/QC blank samples after accounting for difference in sediment concentrations (see Section 6.2.1.8).

Fifteen pesticides were detected in the sediment samples. Beta-BHC, delta-BHC, and heptachlor were not retained as COPCs because they were detected at concentrations less than twice the average off-site background concentration. In addition, endrin ketone was not retained as COPC because it was detected in ten percent of the samples and no information was located in the literature regarding their toxicity to aquatic life.

Twenty inorganics were detected in the sediment samples. Calcium, magnesium, potassium, and sodium were not retained as COPCs because they are common naturally occurring chemicals, not related to site activities, and no toxicological data was located in the literature to evaluate their potential risks to aquatic life. Arsenic, chromium, copper, mercury, nickel, and zinc were not retained as COPCs because they did not exceed their respective ARVs. In addition, mercury was detected at a concentration less than twice the average off-site background concentration.

The following chemicals detected in the sediment were retained as COPCs: diethylphthalate, alpha-chlordane, gamma chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, endrin, endrin aldehyde, endosulfan II, heptachlor epoxide, methoxychlor, aluminum, barium, beryllium, cobalt, iron, lead, manganese, selenium, thallium, and vanadium.

COPCs - Surface Soils

Three VOCs and 11 pesticides were detected in the surface soils. All the VOCs and pesticides were retained as COPCs.

Fifteen SVOCs were detected in the surface soil samples. The following contaminants were not retained as COPCs because they are anthropogenic contaminants and they were detected in less than 10 percent of the samples: acenaphthene, benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl-phthalate, butylbenzylphthalate, carbazole, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene. In addition, bis(2-ethylhexyl-phthalate was detected at a concentration of 279 µg/kg which is less than ten times the concentration in the QA/QC blank (560 µg/L).

Twenty inorganics were detected in the surface soil samples. Calcium and magnesium were not retained as COPCs because they are common naturally occurring chemicals, not related to site activities, and no toxicological data was located in the literature to evaluate their potential risks to aquatic life. Beryllium and thallium were not retained as COPCs because none of their samples exceeded twice the average base-specific maximum concentration.

The following chemicals detected in the surface soils were retained as COPCs: carbon disulfide, toluene, xylenes, benzo(b)fluoranthene, benzo(g.h,i)perylene, chrysene, fluoranthene, phenanthrene, phenol, pyrene, alpha-chlordane, gamma chlordane, beta-BHC, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, endrin, endosulfan II, endrin ketone, endrin aldehyde, aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, vanadium, and zinc.

Tissue Samples - Whole Body

Six VOCs were detected in the whole body tissue samples. Methylene chloride was not retained as COPC because it was detected at a concentration of less than ten times the concentration in the blank sample. 1,1-Dichloroethane, carbon disulfide, and xylenes were not retained as COPC because they were not detected in the any of the surface water of sediment samples and they are not expected to significantly bioaccumulate in tissue based on their low bioconcentration factors.

Fourteen pesticides were detected in the whole body tissue samples. Gamma-BHC, heptachlor, and aldrin were not retained as COPCs because they were detected infrequently (1 out of 12 samples). In addition, gamma-BHC and aldrin were not detected in any of the surface water or sediment samples, and heptachlor in the sediments was associated with background concentrations.

Sixteen inorganics were detected in the whole body tissue samples. Calcium, magnesium, potassium, and sodium were not retained as COPCs because they are common naturally occurring chemicals, not related to site activities, and no toxicological data was located in the literature to evaluate their potential risks to aquatic life. In addition, cadmium and silver were not retained as COPCs because they were not detected in any of the surface water or sediment samples,

The following contaminants detected in the whole body tissue samples were retained as COPCs: acetone, toluene, beta-BHC, dieldrin, 4,4'-DDE, endrin, endosulfan II, 4,4'-DDD, 4,4'-DDT, endrin ketone, endrin aldehyde, alpha-chlordane, gamma-chlordane, aluminum, barium, chromium, copper, iron, lead, manganese, mercury, selenium, and zinc.

Tissue Samples - Fillet

Five VOCs were detected in the fillet tissue samples. Methylene chloride, 2-butanone, and carbon disulfide were not retailed as COPCs because they were not detected in the any of the surface water or sediment samples and they are not expected to significantly bioaccumulate in tissue based on their low bioconcentration factors. In addition, toluene was not retained as a COPC because it was detected infrequently (1 out of 18 samples).

Fourteen pesticides were detected in the fillet tissue samples. Heptachlor epoxide and endrin ketone were not retained as COPCs because they were detected infrequently (1 out of 22 and 2 out of 22 samples, respectively). In addition, gamma-BHC and aldrin were not retained as COPCs because they were not detected in any of the surface water or sediment samples.

Nineteen inorganics were detected in the fillet tissue samples. Calcium, magnesium, potassium, and sodium were not retained as COPCs because they are common naturally occurring chemicals, not related to site activities, and no toxicological data was located in the literature to evaluate their potential risks to aquatic life. Arsenic, chromium, cobalt, and vanadium were not retained as COPCs because they were detected infrequently (2 out 22, 2 out of 22, 1 out of 22, and 1 out of 22 samples, respectively). Also, neither arsenic or chromium exceeded any of the ARVs in any of the surface water or sediment samples. Finally, cadmium and silver were not retained as COPCs because they were not detected in any of the surface water or sediment samples.

The following contaminants detected in the fillet tissue samples were retained as COPCs: acetone, beta-BHC, dieldrin, 4,4'-DDE, endrin, endosulfan II, 4,4'-DDD, 4,4'-DDT, endrin ketone, endrin aldehyde, alpha-chlordane, aluminum, barium, copper, iron, lead, manganese, mercury, selenium, and zinc.

7.2.1.2 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), water solubility, organic carbon partition coefficient, octanol water partition coefficient, and vapor pressure. Table 7-2 summarizes these values for the COPCs detected in the sediment, surface water, surface soil, and biota samples for Site 35. Information from these tables was used in the risk characterization to assess the fate and transport of the constituents and the potential risks to the environmental receptors at Site 35. The following paragraphs discuss the significance of each parameter included in the table.

Bioconcentration factors measure the tendency for a chemical to partition from the water column or sediment and concentrate in aquatic organisms. Bioconcentration factors are important for ecological receptors because chemicals with high BCFs could accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain. The BCF is the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in the water. Therefore, the BCF is unitless.

Water solubility is important in the ecological environment because it measures the tendency for a chemical to remain dissolved in the water column, partition to soil or sediment, or bioconcentrate in aquatic organisms. Chemicals with high water solubilities tend to be more bioavailable to aquatic organisms. However, they will not significantly bioconcentrate in the organisms. On the other hand, chemicals with a low water solubility will remain bound to the sediment and soils but may bioconcentrate in organisms to a significant degree.

The organic carbon partition coefficient (Koc) measures the tendency for a chemical to partition between soil or sediment particles containing organic carbon and water. This coefficient is important in the ecological environment because it determines how strongly an organic chemical will be bound to the organics in the sediments.

The octanol/water partition coefficient (Kow) is the ratio of a chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and with adsorption to soil or sediment.

The vapor pressure measures the tendency for a chemical to partition into air. This parameter is important for the ecological environment because it can be used to determine the concentrations of the constituents in air.

7.2.2 Ecosystems Potentially at Risk

Based on the site-specific and regional ecology, several ecological receptors are potentially at risk from contaminants at the sites. Contaminants were detected in the surface water, sediment, soil, groundwater, and biota samples at the sites. Potential receptors of contaminants in surface water and sediment include fish, benthic macroinvertebrates, other aquatic flora and fauna and some terrestrial faunal species. Potential receptors of contaminants in soils include: deer, rabbits, foxes, raccoons, birds and other terrestrial flora and fauna.

7.2.3 Ecological Effects

The ecological effects data that were used to assess potential risks to aquatic and/or terrestrial receptors in this ERA include aquatic reference values (North Carolina Water Quality Standards, USEPA Water Region IV Quality Screening Values, USEPA Ambient Water Quality Criteria, the Aquatic Information Retrieval Database, Sediment Screening Values) and terrestrial reference values. The following paragraphs discuss each of the above data sources.

The North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) has promulgated Water Quality Standards (WQS) that are used to evaluate the quality of waters in North Carolina. These WQS meet the requirements of both federal and state law. These standards are regulatory values and are enforceable.

The Region IV USEPA has adopted Water Quality Screening Values (WQSVs) (USEPA, 1995a). These values are intended as preliminary screening tools to review chemical data from hazardous waste sites. Exceedances of the screening level values indicate that there may be a need for further investigation of the site.

Section 304(a)(1) of the Clean Water Act of 1977 (P.L. 95-217) requires the Administrator of the USEPA to publish criteria for water quality accurately reflecting the latest scientific knowledge on the type and extent of all identifiable effects on health and welfare which may be expected from the presence of pollutants in any body of water, including groundwater. In accordance with the Clean Water Act, the USEPA Office of Water Regulations and Standards, Criteria and Standards Division has published Ambient Water Quality Criteria (AWQC) documents for several chemicals. These documents can be used to evaluate potential risks to aquatic organisms. In addition, potential risks to aquatic plants from contaminants can be evaluated using these documents.

The Aquatic Information Retrieval Database (AQUIRE) is an on-line system that contains information on acute, chronic, bioaccumulative, and sublethal effects data from tests performed on freshwater and saltwater organisms excluding bacteria, birds, and aquatic mammals. This database can be accessed to evaluate potential risks to aquatic organisms.

Currently, promulgated sediment quality criteria do not exist. Until these criteria are developed, USEPA Region IV is using Sediment Screening Values (SSV) for evaluating the potential for chemical constituents in sediments to cause adverse biological effects (Long and Morgan, 1991). The lower ten percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-

Median [ER-M]) of biological effects have been developed for several of the chemicals identified during the sediment investigations at OU No. 10. If sediment contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable. If contaminant concentrations are between the ER-M and ER-L, adverse effects on the biota are considered possible. Finally, if contaminant concentrations are below the ER-L, adverse effects on the biota are considered unlikely (Long and Morgan, 1991).

There are no standards, criteria, or other screening values for assessing potential impacts to terrestrial ecological receptors from contaminants in soils. A literature search was conducted to identify levels of contaminants in the soil that could cause adverse effects to terrestrial flora and invertebrates. However, these data cannot be used to evaluate potential risks to other terrestrial fauna (e.g., birds, deer, rabbits), since the exposure doses for these species are different than exposure doses for invertebrates and plants, which are in constant direct contact with the contaminants in the soil. In addition, the sensitivity of the organisms to the COPCs is not similar.

Terrestrial reference values (TRVs) for evaluating estimated chronic daily intakes (CDIs) of COPCs for the deer, quail, rabbit, fox and raccoon were calculated from available toxicity data. The TRVs were developed from No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from the Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry toxicological profiles, mineral tolerance levels for domestic animals (SMTA, 1992) or other toxicological data in the literature. These values are used to assess the potential effects of contaminants on terrestrial fauna.

7.2.4 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics, ecosystems potentially at risk, and ecological effects) was used to select the ecological endpoints for this ERA. The following section of this report contains a description of the ecological endpoints selected for this ERA, and the reason they were selected.

There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are environmental characteristics, which, if they were 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 were used in the ecological risk evaluation and are discussed in the following sections.

7.2.4.1 Assessment Endpoints

Assessment endpoints are the ultimate focus of risk characterization and link the measurement endpoints to the risk management process. There are five criteria that an assessment endpoint should satisfy (Suter, 1993):

- Societal relevance
- Biological relevance
- Unambiguous operational definition
- Accessibility to prediction and measurement

- Susceptibility to the hazardous agent

Societal relevance is important because risk to ecological receptors of little intrinsic interest to the public (e.g., nematodes, zooplankton) are unlikely to influence decisions unless they can be shown to indicate risks to biota of direct human interest (e.g., fish, wildlife). The biological significance of a property is determined by its importance to a higher level of the biological hierarchy (Suter, 1993). The endpoint should be well defined and operational with a subject (e.g., benthic macroinvertebrates) and a characteristic of the subject (e.g., decrease in numbers of benthic macroinvertebrate) (USEPA, 1989c). The endpoint should be measurable (e.g., numbers of individuals) or predictable from measurements (e.g., toxicity tests). Finally, the endpoint must be susceptible to the contaminant being assessed.

The assessment endpoints in this ERA were decreased integrity of aquatic and terrestrial floral and faunal communities.

Aquatic organisms (e.g., fish, benthic macroinvertebrates) are socially relevant because humans enjoy the sport of fishing and they also are a food source for many people. The organisms are biologically relevant because they serve as food sources for other aquatic and terrestrial organisms. The endpoint is defined with a subject (aquatic organisms), and a characteristic of the subject (decreased viability to aquatic organisms). The risk may be predicted by contaminant concentrations in media exceeding published aquatic reference values. Finally, aquatic organisms are susceptible to the COPCs at Site 35.

Terrestrial organisms (e.g., rabbits, deer, fox, raccoon, quail) are socially relevant because humans enjoy the sport of hunting and they also are a food source for many people. The organisms are biologically relevant because they serve as food sources for other terrestrial organisms and some also consume smaller mammals and plants which potentially have been contaminated. The endpoint is defined with a subject (rabbit, deer, fox, raccoon, and quail communities), and a characteristic of the subject (decreased integrity to rabbit, deer, fox, raccoon, and quail). The TRVs can be used to predict risks to terrestrial organisms. Finally, terrestrial organisms are susceptible to the COPCs at Site 35.

7.2.4.2 Measurement Endpoints

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.

Endpoints are divided into four primary ecological groups: individual, population, community, and ecosystem endpoints. Individual endpoints (e.g., death, growth, tissue concentrations) are evaluated through toxicity tests, models, and other methods used to assess the effects on individual organisms.

Population endpoints (e.g., occurrence, abundance, reproductive performance) are evaluated to determine presence and absence of species through field studies. Community endpoints (e.g., number of species, species diversity) are used to describe the complexity of the community. Finally, ecosystem endpoints (e.g., biomass, productivity, nutrient dynamics) are used to determine the effects between groups of organisms, and between organisms and the environment. Individual, population, and community endpoints were evaluated in this assessment.

The primary goal in deciding upon which ecological endpoints to evaluate was to determine the current effects that the contamination is having on the environment. The following sections discuss the measurement endpoints that were chosen for the ERA.

Aquatic Endpoints

As discussed earlier in this report, aquatic species inhabit MCB Camp Lejeune including fish and benthic macroinvertebrates, and potentially are exposed to the COPCs at Site 35. Therefore, fish and benthic macroinvertebrates are potential ecological receptors at risk and were collected as part of the field activities.

Potential effects from contaminants detected at Site 35 to these species were evaluated by comparing the exposure levels of COPCs in the surface water and sediments to aquatic reference values. In addition, the potential for decreased integrity to the aquatic community was evaluated by comparing the number and type of fish collected in Brinson Creek to the number and type of fish collected at the appropriate off-site background stations. The COPCs detected in the tissue of the fish and crabs collected from Brinson Creek were compared to chemical concentrations in fish collected at off-site locations, fish data collected in other studies, and literature toxicity values to determine if the levels of COPCs in the site fish were elevated or present at toxic levels.

The potential for decreased integrity to the benthic macroinvertebrate community was evaluated by comparing the type of species, the species diversity, macroinvertebrate biotic index (MBI), and community similarity of the benthic macroinvertebrates collected in Brinson Creek to the appropriate off-site background stations. The following paragraphs discuss how the species diversity, MBI, and community similarity are calculated and how they are interpreted.

Species Diversity

The benthic macroinvertebrate community was examined using a mathematical expression of community structure called a diversity index. Diversity data are useful because they condense a substantial amount of data into a single value. The Shannon-Wiener diversity and Brillouin diversity were both calculated for the benthic species.

The Shannon-Wiener (H^{1}) function is one of the more commonly used formulas for calculating species diversity. Species diversity was calculated in logarithmic base 10 for the benthic macroinvertebrate species collected during the ecological investigation using the following equation (Brower, 1977):

$$H^{1} = \sum (p_i \cdot \log(p_i)).$$

H^1 = mean species diversity
p_i = proportion of the total number of individuals occurring in species i.

Brillouin's diversity (H) is used if a set data is not considered to be a random sample. This situation arises when data comprising an entire population is available, or for data that are from a sample obtained non-randomly from a population. Brillouin's diversity is calculated using the following equation (Brower, 1977):

$$H = \frac{(\log n! - \sum (\log (f_i!))}{n}.$$

H = species diversity
n = the sample size
f = the number of observations in category i

Typically, in waterways that are unpolluted and contain suitable habitat for aquatic life, diversity ranges from three to four, while in polluted rivers or rivers with unsuitable habitat diversity generally is less than one (USEPA, 1989d). The operative assumption in the interpretation of diversity values is that relatively undisturbed environments tend to support communities that consist of a large number of species with no single species present in overwhelming abundance. Many forms of stress tend to reduce diversity by producing an environment that is less desirable for some taxa and therefore giving a competitive advantage to other taxa. As will be further discussed later in this ERA, the unsuitable habitat in some of the estuaries will cause the diversity of the benthic macroinvertebrate population to be less than one (Tenore, 1972).

Macroinvertebrate Biotic Index

Most of the benthic macroinvertebrates collected during the ecological investigation have been assigned a pollution tolerance rating. The tolerances were obtained from the NC DEHNR DEM, Environmental Sciences Branch (Lenat, 1993) and the USEPA Environmental Monitoring Systems Laboratory (USEPA, 1990). NC DEHNR maintains a complete list of benthic macroinvertebrate species collected, or known to occur, in North Carolina on a database called BINDEX. BINDEX contains the species Latin name, order, biotic index (BI), and feeding group. Biotic indices have not been established for many estuarine species. The BI ranges from zero to ten; a zero is assigned to taxa found only in unaltered streams of high water quality, and a ten is assigned to taxa known to occur in streams with intermediate degrees of pollution or disturbance. In addition, the EPA lists many common benthic macroinvertebrate species along with their tolerance to organic wastes, heavy metals and acids (USEPA, 1990).

The MBI was developed to provide a rapid stream quality assessment. North Carolina had a data set of over 2,000 stream macroinvertebrate samples that were divided into five water-quality ratings. This data set was used to derive preliminary tolerance values for over 500 benthic macroinvertebrate taxa. The MBI is intended for the examination of the general level of pollutants regardless of the source. The index is an average of BI weighted by organism abundance, and is calculated as follows:

$$MBI = \sum (n_i * BI)/N.$$

MBI = the macroinvertebrate biotic index
n_i = the number of individuals occurring in the ith taxa
BI = the Biota Index assigned to the ith taxa
N = the total number of individuals in the sample

The sampled benthic macroinvertebrate populations were assigned a general stream/water quality condition based on the MBI value. The five classes and their corresponding MBI values are given below (Lenat, 1993):

Excellent Water Quality	Good Water Quality	Good-Fair Water Quality	Fair Water Quality	Poor Water Quality
< 5.24	5.25-5.95	5.96-6.67	6.68-7.70	> 7.71

The MBI for the benthic macroinvertebrate stations was calculated using the values listed in BINDEX. When a BI for a specific species was not listed, either the family BI (if available) was used or the species was not included in the MBI calculations.

Community Similarity

Community similarity between benthic macroinvertebrate stations was measured using two qualitative indices of community similarity, the Jaccard coefficient (S_J) and the SΦrenson index (S_S). The indices use two possible attributes of the ecosystem, that is whether a species was or was not present in the collected sample. Because these coefficients are based on the number of species collected and not the number of individuals, a few organisms from several taxa could significantly change the similarity value, whereas there may not be an overall significant difference between the communities.

The S_J is better than the S_S at discriminating between highly similar collections and has been used widely in stream pollution investigations. The S_J ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation (Brower, 1977):

$$Sj = \frac{a}{a+b+c}$$

a = number of species common to both collections
b = number of species in the first collection but not the second
c = number of species in the second collection but not in the first

The S_S places more emphasis on common attributes, and is better than the S_J at discriminating between highly dissimilar collections. The S_S ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation (Brower, 1977):

$$Ss = \frac{2a}{2a+b+c}$$

Where a, b, and c are as described above.

These indices were used to detect changes in the community structure. Stressed communities presumably will have different species than relatively non-stressed communities, given that all other factors are equal. Several factors determine the type of benthic population that will inhabit an area including salinity fluctuations, sediment type, size of water body, and time of collection. As will be discussed later in this ERA, the creeks which were selected for the reference stations were not exact replicates of the site stations with respect to all the above factors. Therefore, although the community similarity indices will give some indication as to the similarities of the communities, more weight will be placed on the types of species that were collected, the relative densities and species diversities of the site stations as compared to the reference stations.

Terrestrial Endpoints

Several distinct habitats are present in the vicinity of Site 35. Potential receptors include terrestrial fauna, particularly birds, small mammals, reptiles, amphibians, and larger mammals like deer, grey fox, and raccoons. Potential effects from contaminants detected at OU No. 10 to these species were evaluated by comparing the CDIs to TRVs. In addition, comparisons of COPC concentrations in the soil to published plant and earthworm toxicity information was used to evaluate potential effects to some of these terrestrial species.

7.2.5 The Conceptual Model

This section of the report contains a list of hypotheses regarding how the stressors might affect ecological components of the natural environment:

- Aquatic receptors potentially may be adversely affected by exposure to contaminated water, sediment and contaminated biota they ingest.
- Terrestrial receptors potentially may be adversely affected by exposure to contaminants in the surface water and surface soil.
- Terrestrial receptors potentially may be adversely affected by exposure to contaminated biota they ingest.

7.3 Analysis Phase

The next phase after the problem formulation is the analysis that consists of the technical evaluation of the data on the potential effects and exposure of the stressor. This phase includes the ecological exposure characterization and the ecological effects characterization.

7.3.1 Characterization of Exposure

Characterization of exposure evaluates the interaction of the stressor with the ecological component. The following sections characterize the exposure in accordance with the stressors, ecosystem, exposure analysis, and exposure profile.

7.3.1.1 Stressor Characterization: Distribution or Pattern of Change

The remedial investigations involved collecting samples from five media; surface water, sediment, soil, groundwater, and biota. The analytical results of these investigations are presented in Section 4.0 of this report along with a discussion of the extent of contamination.

7.3.1.2 Ecosystem Characterization

This section describes the regional ecology of the coastal plain and the habitats present at Site 35. Information on sensitive environments and endangered species is also included.

Site Description

The description of the sites, including regional ecology of the coastal plain and habitats present at Site 35 are presented in Section 2.0 of this report.

Reference Stations

Off-site reference stations were located in three creeks in the White Oak River watershed: Hadnot Creek, Holland Mill Creek, and Webb Creek. Surface water and sediment samples were collected from these creeks for chemical analysis, while fish and benthic macroinvertebrates were collected from these creeks for population statistics. In September 1993, fish samples were collected from Hadnot Creek for chemical analysis of their fillets (Baker, 1994). The results of this sampling were included in the ERA and compared to the data collected at Site 35. These reference station samples were used to determine the regional background concentrations of chemicals in the surface water, sediment, and fish tissue. Chemicals detected at the site that were within the range of the chemicals detected at the reference stations were excluded from further evaluation.

The sampling of these creeks initially was to consist of three stations from each creek; one upstream freshwater station, one midstream freshwater/saltwater stations, and one downstream saltwater station. An upstream freshwater station was not collected in Webb Creek because a good undisturbed location was not found. Therefore, two upstream locations were sampled in Hadnot Creek.

The White Oak River watershed is smaller than the New River watershed. It begins in the Hoffman Forest and flows approximately 48 miles and empties into the Atlantic Ocean. Approximately 77 percent of the watershed is within the Hoffman Forest and the Croatan National Forest. This watershed has very little development, with Swansboro being the largest town. Therefore, the reference stations should be representative of an aquatic system with relatively few impacts due to point and non-point sources of pollution of an industrial nature similar to MCB Camp Lejeune.

Biological Sampling

Biological samples collected at Site 35 and downstream of Site 35 consisted of fish, crabs, crayfish, and benthic macroinvertebrates. The biological samples were collected to obtain population statistics for fish and benthic macroinvertebrates and to obtain tissue samples (fish, crabs, and crayfish) for chemical analysis. Prior to initiating the sampling event at each station, the following information describing the site was recorded in the field log book:

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

Water quality measurements were collected during the benthic macroinvertebrate sampling, at a minimum, and during collection of some of the fish samples. On-site water quality measurements at these stations consisted of temperature, pH, specific conductance, salinity and dissolved oxygen. These measurements were conducted prior to sample collection. The station locations and sampling procedures for the collection of the biological samples are discussed in Section 2.0 of this report.

Biological Sampling Results

The following sections present the results of sampling the abiotic habitat and biotic communities from the ecological investigation. The results of the tissue samples are presented in Section 4.0 of this report.

Abiotic Habitat

Information describing the abiotic habitat at Sites 35 and downstream of Site 35, and the reference stations was recorded in the field log books at each station and was later transferred to data sheets.

Fish and benthic macroinvertebrates were sampled at three and four stations adjacent to and upstream of Site 35, respectively, while fish and benthic macroinvertebrates were sampled at three stations downstream of Site 35 (see Figure 2-5). Fish and benthic macroinvertebrates also were sampled as part of a background study at two stations in Webb Creek, four stations in Hadnot Creek, and three stations in Holland Mill Creek (see Figures 2-6, 2-7, and 2-8). All three of these creeks are located within the White Oak River system.

Brinson Creek

Station 35-FS/BN01 was shaded and surrounded by mixed forests. A North Carolina Department of Transportation vehicle maintenance facility was located on the eastern side of the sample station. The creek dimensions for this sampling station were 10 to 15 feet wide and 0.5 feet deep. The water was clear with low creek velocity. At Station 35-FS/BN01, between 40 to 64 ounces of sediments were collected for the benthic macroinvertebrate replicates. The sediments did not have a discernible odor. Grain size analysis on the sediments showed a medium to fine sand (0.075 to 2.0 mm) present at 100 percent.

Station 35-FS/BN02 was partly shaded and surrounded by thick deciduous forest. The creek dimensions for this sampling station were 20 to 30 feet wide and 1.5 feet deep. The water was turbid to opaque with negligible creek velocity. At Station 35-FS/BN02, between 16 to 24 ounces of sediments were collected for the benthic macroinvertebrate replicates. The sediments had a discernible petroleum odor. In addition to the petroleum odor, a visible oil sheen was present upon removal of the ponar sampler. Grain size analysis on the sediments showed a medium to fine sand (0.075 to 2.0 mm) present at 93.4 percent and a silt (0.005 to 0.075 mm) present at 3.6 percent.

Station 35-FS/BN03 was partly open and surrounded by deciduous forest. The creek dimensions for this sampling station were 75 feet wide and 3.5 feet deep. The water was slightly turbid with negligible creek velocity. At Station 35-FS/BN03, between 16 to 32 ounces of sediments were collected for the benthic macroinvertebrate replicates. The sediments had a strong discernible petroleum odor. Grain size analysis on the sediments showed a medium to fine sand (0.075 to 2.0 mm) present at 55.7 percent, a silt (0.005 to 0.075 mm) present at 31 percent, and clay/colloids (<0.005 mm) present at 13.4 percent.

Station 35-BN04 was partly shaded and surrounded by deciduous forest. Creek dimensions for this sampling station were 20 to 30 feet in width and 1.5 feet in depth. The water was slightly turbid with negligible creek velocity. At Station 35-BN04, 8 ounces of sediments were collected for the benthic macroinvertebrate replicates. The sediments did exhibit a strong discernible petroleum odor. Grain size analysis on the sediments showed a medium to fine sand (0.075 to 2.0 mm) present at 65.1 percent, a silt (0.005 to 0.075 mm) present at 26.5 percent, and clay/colloids (<0.005 mm) present at 8.4 percent.

Station 36-FS/BN01 was partly open and surrounded by forest with wetland areas noted along shorelines. The creek dimensions for this sampling station were 40 feet wide and 3 to 4 feet deep. The water was slightly turbid with negligible creek velocity. The sediments had a discernible petroleum odor. Grain size analysis on the sediments showed a medium to fine sand (0.075 to 2.0 mm) present at 79.6 percent, a silt (0.005 to 0.075 mm) present at 11.2 percent, and clay/colloids (<0.005 mm) present at 9.1 percent.

Station 36-FS/BN02 was partly open and surrounded by forest. The creek dimensions for this sampling station were 50 feet wide and 4 to 5 feet deep. The water was slightly turbid with negligible creek velocity. The sediments had a discernible petroleum odor. In addition to the petroleum odor, a visible oil sheen was present upon removal of the ponar sample. Grain size analysis on the sediments showed a medium to fine sand (0.075 to 2.0 mm) present at 91.4 percent and a silt (0.005 to 0.075 mm) present at 5.5 percent.

Station 36-FS/BN03 was partly open and surrounded by coniferous forest with apparent wetland vegetation on the creek edges. The creek dimensions for this sampling station were 40 feet wide and 3 to 4 feet deep. The water was slightly turbid with negligible creek velocity. The sediments had a discernible anaerobic odor. In addition to the anaerobic odor, a visible oil sheen was present upon removal of the ponar sampler. Grain size analysis on the sediments showed a medium to fine sand (0.075 to 2.0 mm) present at 89.6 percent and a silt (0.005 to 0.075 mm) present at 7.3 percent.

Webb Creek

Station WC02 was open and surrounded by forests. The water was slightly turbid and brown. The stream at this station was 40 feet wide and 4 to 5 feet deep. At this station, between 16 to 80 ounces of sediments were collected for the benthic macroinvertebrate replicates. The sediments had an anaerobic odor. The sediments in the first replicate were mostly silt with traces of sand and approximately 55 percent woody debris. The sediment in the second and third replicates contained more woody debris.

Station WC03 was open and surrounded by forests. The water was slightly turbid and brown. The stream at this station was 250 feet wide and approximately 25 feet deep. At Station WC03, between 16 and 56 ounces of sediments were collected for each benthic macroinvertebrate replicate. The sediment had a slight anaerobic odor. The sediment was silt/muck with organic material with some clay was observed in the third replicate.

Hadnot Creek

Station HC01 was shaded and in an urban area surrounded by forest. The stream depth was approximately 5 feet and the width was approximately five feet. The water was clear and brown. Between 24 to 80 ounces of sediments were collected for the benthic macroinvertebrate replicates. There was a slight anaerobic odor to the sediments. The sediments were silty with some woody debris.

Station HC02 was partly shaded and surrounded by forests. The stream at this station was 6.5 feet deep and 40 feet wide. The water was slightly turbid and brown. Between 16 to 40 ounces of sediments were collected for the benthic macroinvertebrate replicates. There was an anaerobic odor to the sediments. The sediment were fine silty-sand with woody debris which included pine needles.

Station HC03 was in an urban area surrounded by forests. The width and the depth of the White Oak River was not measured due to its large size. The water was turbid with a brown. Approximately 8 ounces of sediments were collected for each benthic macroinvertebrate replicate. There was a slight anaerobic odor to the sediments. The sediments were silty-sand with some woody debris.
Station HC04 was shaded and surrounded by forests. The water at this station was approximately 1 to 3 feet deep and 5 to 7 feet wide. The water was clear. Approximately eight ounces of sediments were collected for each benthic macroinvertebrate replicate. There was a slight anaerobic odor to the sediments. The sediments were sandy with little woody material.

Holland Mill Creek

Station HM01 was shaded in an urban area surrounded by forest. The stream depth was approximately 0.5 to 1.5 feet and the width was approximately 10 feet. The water was clear. Between 16 to 40 ounces of sediments were collected for the benthic macroinvertebrate replicates. There was a slight anaerobic odor to the sediments. The sediments were sandy with a light brown color.

Station HM02 was partly open and surrounded by forests. The stream at this station was approximately 3 to 4 feet deep and 50 feet wide. The water was turbid and brown. Between 32 to 40 ounces of sediments were collected for the benthic macroinvertebrate replicates. There was a slight anaerobic odor in the sediments. The sediment were mostly silty with traces of sand. Approximately 50 percent of the sample was woody debris.

Station HM03 was open and in an urban area surrounded by forest. The width and depth of the White Oak River was not measured due to its large size. The water was opaque and brown. Between 8 and 16 ounces of sediments were collected for each benthic macroinvertebrate replicate. There was an anaerobic odor to the sediments. The sediment was very fine silt with shell fragments. Approximately 10 percent of the sample was woody debris.

Field Chemistry Results

Table 7-3 is a summary of the field chemistry results for Brinson Creek. The field chemistry data for Webb Creek, Hadnot Creek, and Holland Mill Creek are presented in Appendix S. Samples from these surface water bodies were collected from the water surface and bottom.

Brinson Creek

The water temperature at the two upstream stations (35-SW/SD01, 35-SW/SD02) ranged from 17.8 to 19.9°C. The salinity was 0 ppt at both stations, while the conductivity ranged from 282 to 506 micromhos/cm. The dissolved oxygen ranged from 8.8 to 9.8 mg/L, while the pH ranged from 7.32 to 7.4 S.U. The pH and dissolved oxygen concentrations detected in these surface water samples were within aquatic reference value ranges.

The water temperature at the remaining eight stations (35-SW/SD03 - 07 and 35-SW/SD05 - 07) ranged from 16.0 to 25.3°C. The salinity ranged from 0 to 1.2 ppt, while the conductivity at these stations ranged from 269 to 3,320 micromhos/cm. The dissolved oxygen ranged from 4.7 to 18.0 mg/L. Several of the dissolved oxygen values appeared to be higher than expected based on the water temperature indicating that the meter may not have been operating properly at all of the stations. Finally, the pH ranged from 6.95 to 8.8 S.U. One dissolved oxygen concentration (in the bottom waters of Station 35-SW/SD-06) was detected at a value (4.7 mg/L) slightly below aquatic reference value criteria (5.0 mg/L). However, surface water samples collected in the background streams also exhibited dissolved oxygen concentrations below aquatic reference values. Three surface water stations (36-SW/SD-05, 36-SW/SD-06, and 36-SW/SD-07) exhibited pH concentrations slightly above aquatic reference value ranges (8.5 S.U.).

Webb Creek

At Webb Creek, the salinity at station WC02 ranged from 0 to 7 ppt. Conductivity ranged from 850 to 10,500 micromhos/cm. Dissolved oxygen levels ranged from 4.4 to 9 mg/L. The pH ranged from 6.85 to 7.48 S.U. and the water temperature ranged from 17.5 to 21°C.

At WC03, the salinity ranged from 10 to 12.8 ppt. The conductivity ranged from 16,500 to 18,000 micromhos/cm. Dissolved oxygen levels ranged from 8.5 to 10 mg/L. The pH at ranged from 7.33 to 7.56 S.U. and the water temperature ranged from 19 to 23°C.

Hadnot Creek

In Hadnot Creek, the salinity at station HC01 was 0 ppt. The conductivity was 13.5 micromhos/cm. The dissolved oxygen level was 7.7 mg/L. The pH was 6.89 S.U and the water temperature was 17°C.

At station HC02, the salinity ranged from 0 to 16.5 ppt. The conductivity ranged from 720 to 22,800 micromhos/cm. The dissolved oxygen levels ranged from 1 to 7.3 mg/L. The pH at HC02 ranged from 6.7 to 7.3 S.U. and the water temperature ranged from 15.5 to 22°C.

At station HC03, the salinity ranged from 17 to 17.9 ppt. The conductivity ranged from 25,500 to 26,500 micromhos/cm. The dissolved oxygen level was 12 mg/L. The pH ranged from 7.69 to 7.79 S.U. and the water temperature ranged from 17.5 to 17.8°C.

At station HC04, the salinity was 0 ppt. The conductivity was 65 micromhos/cm and the dissolved oxygen level was 5.3 mg/L. The pH at HC04 was 6.16 S.U. and the water temperature was 17.3°C.

Holland Mill Creek

In Holland Mill Creek, the salinity was 0 ppt at station HM01. The conductivity was 140 micromhos/cm, and the dissolved oxygen level was 8.0 mg/L. The pH 6.9 S.U. and the water temperature was 17.5°C.

At station HM02, the salinity ranged from 1 to 25 ppt. The conductivity ranged from 2,490 to 38,000 micromhos/cm. The dissolved oxygen levels ranged from 5.0 to 11.8 mg/L. The pH ranged from 6.72 to 7.9 S.U. and the water temperature ranged from 15.2 to 21°C.

At station HM03, the salinity ranged from 13.5 to 22 ppt. The conductivity ranged from 19,000 to 32,000 micromhos/cm. The dissolved oxygen levels ranged from 3.4 to 10.8 mg/L. The pH ranged from 6.81 to 7.90 S.U. and the water temperature ranged from 17.5 to 17.8°C.

Biotic Habitat

Fish Population Results

The following sections discuss the fish population statistics for Brinson, Webb, Hadnot, and Holland Mill Creeks. Appendix X presents the results of fish populations collected in Brinson Creek, and all background sampling stations. Table 7-4 presents a summary of the fish species collected in Brinson Creek. The distribution and characterization of the fish collected in Brinson Creek is presented on Table 7-5. Appendix S contains a summary of the fish species collected at all background stations. It should be noted that all of the fish collected from Brinson Creek and all of the background stations appeared healthy and did not have tumors or other abnormalities.

Brinson Creek

Species were collected from three stations at Site 35; Stations 35-FS01, 35-FS02, and 35-FS03. A total of 19 fish species consisting of 669 individuals were collected at these stations. Species were collected from three stations downstream of Site 35; Stations 36-FS01, 36-FS02, and 36-FS03. A total of 14 fish species consisting of 108 individuals were collected at these stations.

Six species of fish were collected at Station 35-FS01 with the predominant fish species consisting of stripped mullet and spot. One hundred and twenty-five stripped mullet and 76 spot were collected at this station. Other species collected from 35-FS01 included pumpkinseed, green sunfish, sharptail goby, and American eel. The majority of the fish collected at this station were juveniles.

Fifteen species of fish were collected at Station 35-FS02 with the predominant fish species consisting of spot, stripped mullet, and sheepshead minnow. Two hundred and sixteen spot, 55 stripped mullet, and 12 sheepshead minnows were collected at this station. The majority of these fish were juveniles. Other species collected from 35-FS02 included mud catfish (yellow bullhead), pumpkinseed, longnose gar, banded killifish, lesser killifish, fat sleeper, brown bullhead, summer flounder, mummichog, pinfish, eastern mosquitofish, and American eel. The species included both juvenile and adult fish. Twelve crayfish also were collected at this station.

Ten species of fish were collected at Station 35-FS03 with the predominant fish species consisting of spot, mud catfish, and the longnose gar. Ninety-five spot, 10 mud catfish, and nine longnose gar were collected at this station. Other species collected from 35-FS03 included stripped mullet, pumpkinseed, warmouth, bluegill, pinfish, eastern mosquitofish, and American eel. The species included both juvenile and adult fish. One crayfish also was collected at this station.

Eight species of fish were collected at Station 36-FS01 with the predominant species consisting sheepshead minnow and the mummichog. Twenty-one sheepshead minnows and nineteen mummichogs were collected at this station. Other species collected from 36-FS01 included stripped mullet, pumpkinseed, bluegill, white catfish, summer flounder, and pinfish. The species included both juvenile and adult fish.

Six species of fish were collected at Station 36-FS02 with the predominant species consisting of white catfish and stripped mullet. Eight white catfish and four stripped mullet were collected at this station. Other species collected from 36-FS02 included largemouth bass, pinfish, sharptail goby, and eastern mosquitofish. The species included both juvenile and adult fish. Eleven blue crabs also were collected at this station.

Finally, 10 species of fish were collected at Station 36-FS03 with the predominant species consisting of white catfish, stripped mullet, and pinfish. Ten white catfish, eight stripped mullet, and seven pinfish were collected at this station. Other species collected from 36-FS03 included spot, pumkinseed, longnose gar, warmouth, largemouth bass, mummichog, and eastern mosquitofish. Twenty-one blue crabs and twenty-three grass shrimp also were collected at this station. The species included both juvenile and adult fish.

Webb Creek

A total of 12 fish species were collected at the two sampling stations located at Webb Creek. Of the 13 species collected at Webb Creek, 86 individuals were collected. Three grass shrimp also were collected at this site.

Nine fish species were collected at station WC02 in Webb Creek. The predominant fish species collected were the pinfish and longnose gar. Twenty-five pinfish were collected at station WC02. Nine longnose gar were collected at station WC02. In addition, the following species were collected at WC02: four spot, four stripped mullet, three mud catfish, one redbreast-sunfish, one white catfish, four bluegill, two largemouth bass, and three yellow bullhead catfish.

Four fish species and one other aquatic species (grass shrimp) were collected at station WC03 in Webb Creek. One summer flounder and five longnose gar were collected at station WC03. In addition, 24 pinfish, three mummichog, and three grass shrimp were collected at station WC03.

Hadnot Creek

Species were collected from four stations, HC01, HC02, HC03 and HC04, at Hadnot Creek. A total of 18 fish species consisting of 56 individuals and one other aquatic species (crayfish) consisting of three individuals were collected in Hadnot Creek.

Of the six fish species collected at station HC01 in Hadnot Creek, the predominant fish species collected were the mud catfish and American flier. Three mud catfish and three American flier were collected at station HC01. In addition, the following species also were collected at HC01: two redbreast sunfish, two yellow bullhead catfish, one chain pickerel, and one redear fish.

Two species of fish were collected at station HC02. Three pumpkinseed and one warmouth were collected.

Eight species of fish were collected at station HC03. The most abundant fish species collected at HC03 was the spot. Twelve spot were collected. Five pinfish, five Atlantic croaker, three stripped mullet, two Atlantic menahaden, one white perch, one hogchocker, and the three blue fish were also collected at station HC03.

Two species of fish and one other aquatic species (crayfish) were collected at station HC04. Eight pirate perch, two redfin pickerel, and three crayfish were collected at station HC04.

Holland Mill Creek

Species were collected from three stations, HM01, HM02, and HM03, at Holland Mill Creek. A total of 18 fish species consisting of 299 individuals and 3 other aquatic species consisting of 17 individuals were collected in Holland Mill Creek.

Six species of fish and two other aquatic species were collected at station HM01. Sixteen pumpkinseed, six swamp darter, two bluegill, two chain pickerel, one mud sunfish and one freshwater goby were collected at station HM01. Also, three crayfish were collected at station HM01.

Twelve species of fish and one other aquatic species were collected from station HM02. The following fish species were collected from HM02: 11 stripped mullet, seven pinfish, three longnose gar, two gizzard shad, two spotted sunfish, two pumpkinseed, one summer flounder, one black drum, one largemouth bass, one bluegill, six mummichog, and one freshwater goby. Also, 13 grass shrimp were collected at station HM02.

Six fish species were collected at station HM03. Seventeen summer, eight spot, three stripped mullet, two hogchoker, and four pinfish were collected at station HM03.

Benthic Macroinvertebrate Population Results

Table 7-6 and Appendix S contain a systematic listing of all benthic organisms collected from the sampling stations in Brinson Creek and background sampling stations, respectively. Individual organisms were classified based on the specific genus or species classification. Tables 7-7 and Appendix X contain the benthic macroinvertebrate sensitivity to metals and organic wastes, and North Carolina Biotic Index for the species collected in Brinson Creek and the background stations, respectively.

Table 7-8 and Appendix X contain summary statistics for the benthic macroinvertebrates collected from Brinson Creek and the background stations, respectively. Appendix X contains the raw benthic macroinvertebrate data for Brinson Creek. Appendix S contains the raw benthic macroinvertebrate data for the background stations. The parameters include the number of benthic species collected at each station, the number of benthic organisms identified at each station, the species density, the species diversity, and the macroinvertebrate biotic index.

Overall species richness is indicated by the number of benthic species collected at each station. The macroinvertebrate biotic index (MBI), ranging from 0 to 10, summarizes overall population tolerance to a single value, which is used specifically for detecting organic pollution. The results of the benthic macroinvertebrate sample collection from the Brinson Creek and the reference stations at Webb Creek, Hadnot Creek, and Holland Mill Creek are presented in the following sections.

Brinson Creek

A total of 22 species consisting of 692 individuals were collected from the four sampling stations at Site 35. These individuals were from the following phyla: Nematoda, Annelida, Arthropoda, and Mollusca. Approximately 45 percent were the chironomidae Chironomus decorus and 39 percent of the individuals were the tubificidae Limnodrilus hoffmeisteri.

A total of 17 species consisting of 764 individuals were collected from the four sampling stations at Site 36. These individuals were from the Annelida and Arthropoda phyla. Approximately 55 percent were the nereidae Nereis succinea, 20 percent of the individuals were the ampharetidae Hypaniola grayi, and 12 percent were the chironomidae Chironomus decorus.

Species abundance was highest at Station 36-BN03 with 13 species, with the number of species at the remaining stations ranging from 5 at 35-BN02 and 35-BN04 to 12 at 35-BN03. The number of individuals was highest at 35-BN01 with 430 individuals, with the number of individuals at the remaining stations ranging from 372 at 36-BN03 to 44 at 36-BN01. Species density was highest at 35-BN01 with 2,741 individuals/m^2, with the species density ranging from 2,371 individuals/m^2 at 36-BN03 to 280 individuals/m^2 at 36-BN01.

The Shannon-Weiner and Brillouin's species diversity were highest at Station 36-BN01 with value of 0.742 and 0.632, respectively. The Shannon-Weiner and Brillouin's species diversity at the remaining stations ranged from 0.718 and 0.649 at 35-BN03 to 0.208 and 0.176 at 35-BN02, respectively. Finally, the MBI value was lowest at 36-BN01 with a value of 8.88, with the MBI at the remaining stations ranging from 9.10 at 36-BN02 to 9.49 at 36-BN03.

Webb Creek

In Webb Creek, 11 species consisting of 153 individuals were collected at the two sampling stations. The identified phyla were Nemertea, Annelida, Arthropoda, and Mollusca. Approximately 69 percent of the individuals was the chironomidae Chrironomus decorus and 14 percent were the ampharetidae Hypaniola grayi. Most of the benthic macroinvertebrate species found in Webb Creek were from the Arthropoda phylum.

Seven species of benthic macroinvertebrate were found at station WC02 and station WC03. At station WC02, 79 individual were collected, while 74 individuals were collected at station WC03. Species density was 503 individuals/m^2 at station WC02, and 472 individuals/m^2 at station WC03. The Shannon-Wiener species diversity was 0.570 at station WC02 and 0.323 at station WC03. The Brillouin's species diversity was 0.518 at station WC02 and 0.279 at station WC03. The MBI was 9.4 at WC02 and 9.6 at WC03.

Hadnot Creek

A total of 36 species consisting of 774 individuals were collected from the four sampling stations at Hadnot Creek. The identified phyla were Nemertea, Annelida, Arthropoda, and Mollusca. Approximately 26 percent of the individuals was the tubificidae Isochaetides freyi and 11 percent of the individuals were the corophiidae Corophium lacuatre. The next abundant group of benthic macroinvertebrate species was the ampharetidae Hypaniola grayi, found at a frequency of approximately nine percent.

Species abundance was highest at station HC01 (20) followed by 4, 8, and 13 at stations HC02, HC03, and HC04, respectively. The largest number of individuals were collected at station HC01 (286), followed by 244, 165, and 79 individuals were detected at stations HC03, HC04 and HC02, respectively. Species density was 1,823 organisms/m^2 at station HC01, 504 at station HC02, 1,555 at station HC03, and 1,052 at station HC04.

The Shannon-Weiner species diversity was highest at station HC04 (0.807), followed by 0.802 at station HC01, 0.196 at station HC02, and 0.683 at station HC03. The Brillouin's species diversity was highest at station HC04 (0.757), followed by 0.755 at station HC01, 0.072 at station HC02, and 0.675 at station HC03. The MBI was 7.8 at HC01, and 7.6 at HC02 and HC04. A MBI was not calculated at the HC03 since only one benthic macroinvertebrate species at this station had a BI.

Holland Mill Creek

A total of 22 species consisting of 846 individuals were collected from the three sampling stations at Holland Mill Creek. The identified phyla were Nemertea, Annelida, Arthropoda, and Mollusca. Approximately 45 percent of the individuals (383 out of 846) was the chironomidae Chironomus decorus gr., and 28 percent was the chironomidae Tribelos lucundum.

Species abundance was greatest at station HM01 (13), followed by 4 and 7 at stations HM02 and HM03, respectively. The highest number of individuals were collected at station HM02 (404), followed by 345 and 97 individuals at stations HM01 and HM03, respectively. Species density was greatest at stations HM02 (2,575 organisms/m^2), followed by 2,199 at station HM01 and 618 at station HM03. The Shannon-Weiner species diversity was greatest at station HC03 (0.538), followed by 0.525 at station HM01 and 0.128 at station HM02. The Brillouin's species diversity was greatest at station HM01 (0.500); the diversity was 0.122 at station HM02 and 0.497 at station HM03. The MBI was lowest at HM01 with 6.9, followed by a MBI of 9.6 at HM02 and HM03.

7.3.1.3 Exposure Analysis/Profile

In the next step in the characterization of exposure the spatial and temporal distributions of both the ecological environment and the stressor are combined to evaluate exposure. This section of the ERA addresses and quantifies each exposure pathway via surface water, sediment, air, soil, and groundwater.

To evaluate if ecological exposure via these pathways may occur the exposure pathways were identified and characterized. The following four elements were examined to determine if a complete exposure pathway was present:

- A source and mechanism of chemical release
- An environmental transport medium
- A feasible receptor exposure route
- A receptor exposure point

Potential Exposure Scenarios

This section discusses the potential exposure scenarios at Site 35 including surface water, sediments, soil, groundwater and air.

Surface Water

Potential release sources to be considered in evaluating the surface water pathway are contaminated surface soils and groundwater. Groundwater seepage and surface runoff can release contaminats from the soil. Ecological exposure receptors may then be exposed to the contaminants to via ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the surface water on site, off site, or downgradient can release contaminants from the soil.

At Site 35, COPCs were detected in the surface water, demonstrating a release from a source to the surface water. Potential receptors that may be exposed to contaminants in surface waters in/or around the site fish, invertebrates, reptiles and amphibians, birds, and mammals.

Aquatic organisms (i.e., fish, benthic macroinvertebrates) are exposed to contaminants in the surface water by direct contact and by ingesting water while feeding. In addition because of their position within a food web or food chain, aquatic organisms may ingest other aquatic flora and fauna that have bioconcentrated chemicals from the surface water. Overall, aquatic organisms have a high exposure to contaminants in the surface water.

Terrestrial fauna may be exposed to contaminants in the surface water through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they spend in the contaminated waters. In addition because of their position within a food web or food chain, terrestrial species may ingest organisms (e.g., fish, insects, plants) that have bioconcentrated contaminates from the surface water.

Sediment

The potential release sources to be considered in evaluating the sediment pathway are contaminated surface soils and groundwater. Groundwater seepage and surface runoff can release contaminats to sediments. Ecological receptors are exposed to the contaminated sediments via ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the sediments.

COPCs were detected in the sediment demonstrating a release from a source to the sediment transport medium. Potential receptors that may be exposed to contaminants in sediments include benthic macroinvertebrates, bottom feeding fish, aquatic vegetation, other aquatic life, and terrestrial species that feed on aquatic organisms living in sediments.

Aquatic organisms (i.e., fish, benthic macroinvertebrates) are exposed to contaminants in the sediments by ingesting them while feeding and by direct contact. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioconcentrated chemicals from the sediments. Overall, aquatic organisms have a high exposure to contaminants in the sediment.

Terrestrial faunal receptors may be exposed to contaminants in the sediments through ingestion and dermal contact. The magnitude of the exposure depends on feeding habits and the amount of time spent in the contaminated sediments. In addition, terrestrial species may ingest organisms (e.g., fish, insects, small mammals, plants) that have bioconcentrated contaminants from the sediments.

Soil

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. Contaminated soil may be released via fugitive dust, leaching, and surface runoff. The potential routes to be considered for ecological exposure to the contaminated soils are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the soils.

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 include plants, and animals that feed or burrow in contaminated areas.

Terrestrial receptors may be exposed to contaminants in the soils through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on the feeding habits and the amount of time spent in the contaminated soils. For example, burrowing animals such as earthworms, groundhogs, or moles will be exposed to a greater degree than grazing animals who occasionally feed in the area. In addition, terrestrial species may ingest organisms (e.g., insects, small mammals, plants) that have bioconcentrated contaminants from the soils.

Groundwater

The potential release source to be considered in evaluating the groundwater pathway is contaminated soils; contaminants may leach from contaminated soils to groundwater. 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. Since organisms are not directly exposed to groundwater at Site 35, the groundwater to surface water exposure is taken into account in the surface water section of the ERA.

Air

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil, groundwater, and surface water. The potential exposure points for receptors are areas on or adjacent to the site where they can be exposed to dust or volatilized vapors.

No data have been collected to document exposure to receptors via the air pathway. However, based on the low concentrations of VOCs detected in the soils, sediments, and surface water and the negligible vapor pressure of pesticides and metals, the air concentration of the COPCs is not expected to cause a decrease in integrity of the terrestrial receptors. Therefore, this pathway was not evaluated as part of the ERA.

7.3.2 Ecological Effects Characterization

The potential ecological effects to aquatic receptors were evaluated by direct comparisons of contaminant concentrations in surface water and sediment to aquatic reference values (ARVs) and by comparison of biosurvey results to background stations. Potential ecological effects to terrestrial receptors were evaluated by comparison to literature values and by comparing the CDIs to TRVs. The following sections further discuss these comparisons to evaluate the potential ecological effects to aquatic and terrestrial receptors from the COPCs.

Contaminant concentrations detected in the surface water at Site 35 were compared to the NC DEHNR WQS, and Region IV USEPA WQSV, and other toxicity values obtained from the literature to determine if there were any exceedances of the published values. Contaminant concentrations detected in the sediments at Site 35 were compared to the SSVs and other toxicity values obtained from the literature to determine if there were any exceedances of the established values.

7.3.2.1 Surface Water Quality

The analytical results for the COPCs detected in the surface water samples collected in Brinson Creek were compared to the ARVs. Table 7-1 contains the saltwater North Carolina WQS, and the Region IV USEPA WQSV for the COPCs detected in Brinson Creek.

Lead exceeded the chronic WQSV in one surface water sample. Mercury exceeded the WQS and the acute chronic WQSV in two surface water samples. Zinc exceeded the WQS and the acute and chronic WQSV in one sample. No other TAL inorganic compounds exceeded any of the ARVs in Brinson Creek.

The following COPCs detected in the surface water samples do not have WQS, or WQSVs: aluminum, cobalt, iron, manganese, thallium, and vanadium. Therefore, Region III WQSVs or toxicity data from AQUIRE were used to assess these COPCs, when available. No toxicity data was located in the literature for aluminum, therefore, this COPC could not be further evaluated.

The concentration of iron in the surface water (764J to 9,500 µg/L) was above the concentrations that caused adverse impacts to aquatic life of some of the studies obtained from AQUIRE (100 to 330,000 µg/L). The majority of the studies were conducted with various marine phytoplankton cultures.

The concentration of cobalt in the surface water (9J to 16.8J µg/l) is between the 10 to 20 µg/L levels that caused adverse effects to the pacific oyster (Crassostrea gigas). However, these studies did not meet the criteria for reliability.

The concentration of manganese in the surface water (24.5 to 113 µg/L) was above the Region III WQSV of 10 µg/L. Toxicity values from AQUIRE ranged from 10 to 20,000 µg/L. Therefore, the Region III WQSV of 10 ug/L may be the value from AQUIRE. According to AQUIRE, 10 µg/L caused decreased growth in the pacific oyster (Crassostrea gigas). However, this study did not meet the criteria for reliability.

The concentration of thallium in the surface water (1J µg/L) was below the Region III WQSV of 20 µg/L. Finally, the concentration of vanadium in the surface water (4.5 to 14.8J µg/L) was below the Region III WQSV of less than 10,000 µg/L.

7.3.2.2 Sediment Quality

Table 7-9 contains the sediment SSVs for the COPCs detected in Brinson Creek. Twenty sediment samples were collected from Brinson Creek. Sediment samples were collected from zero to six inches and six to twelve inches at each sediment station.

Among the pesticides, dieldrin exceeded the ER-L in seven samples and the ER-M in two samples. Sediment concentrations of 4,4'-DDD exceeded the ER-L in 16 samples and the ER-M in 14 samples. Sediment concentrations of 4,4'-DDE exceeded the ER-L in 15 samples and the ER-M in 14 samples. Sediment concentrations of 4,4'-DDT exceeded the ER-L in 13 samples and the ER-M in 4 samples. Alpha-chlordane exceeded the ER-L in 10 samples and the ER-M in five samples. Gamma-chlordane exceeded the ER-L in six samples and the ER-M in four samples. Concentrations of endrin were detected above the ER-L in five sediment samples. No other pesticides exceeded any of the sediment ARVs in Brinson Creek.

Among the inorganics, lead exceeded the ER-L in nine samples and the ER-M in two samples. No other inorganic compounds exceeded any of the sediment aquatic reference values in Brinson Creek.

The following COPCs detected in the sediments do not have SSVs for them: aluminum, barium, beryllium, cobalt, manganese, selenium, thallium, vanadium, heptachlor epoxide, endosulfan II, methoxychlor, endrin aldehyde, and diethylphthalate. Published sediment toxicity data was used to evaluate potential impacts to the aquatic community from these contaminants in the sediments. This toxicity data included Region III SSVs (USEPA, 1995b) and Apparent Effects Threshold Sediment Quality Values (AETs) developed by Tetra Tech Inc., for the Puget Sound (Tetra Tech, Inc., 1986). A COPC was not evaluated if no information was available from any of the above sources. The following table presents the results of this comparison.

Contaminant of Potential Concern	Sample Concentration (mg/kg)	Toxicity Data Concentration (mg/kg)	Source of Value
Diethylphthalate	0.352J to 2.135J	5.3	Region III SSV
Beryllium	0.27 to 1.1	0.45	AET
Iron	1,050J to 15,900	27,000	AET
Manganese	3.2J to 62.8	230	AET
Selenium	0.23J to 1.6J	> 1	AET
Thallium	0.24	0.24	AET

No toxicity data was located in the literature for aluminum, barium, cobalt, vanadium, heptachlor epoxide, endosulfan II, methoxychlor, and endrin aldehyde. Therefore these COPCs could not be further evaluated.

7.3.2.3 Surface Soil Quality

There are no standards, criteria, or other screening values for assessing potential impacts to terrestrial ecological receptors from contaminants in soils. In addition, the amount of literature data evaluating adverse ecological effects on terrestrial species exposed to contaminants in surface soils is limited. However, toxicological effects on plants and/or invertebrates inhabiting contaminated soils were obtained from various studies in the literature for the following chemicals: arsenic, barium, chromium, copper, lead, and zinc. This data was used to evaluate decreased integrity of terrestrial flora and invertebrates from COPCs in the soil. No soil toxicity data was located in the literature for the other COPCs, therefore potential impacts to soil organisms/plants from these COPCs could not be evaluated in the ERA.

Arsenic concentration ranged from 0.29 to 66.1 mg/kg of which 10 of the 11 detections were less than one mg/kg. Therefore, only one sample out of 13 was greater than the 25 mg/kg that depressed crop yields (Eisler, 1988). Barium concentrations ranged from 6.2 to 86 mg/kg which were below the 2,000 mg/kg that induced plant toxicity (Adriano, 1986). Chromium concentrations of 1.9 to 98.1 mg/kg were greater than the 10 mg/kg No Observed Effects Level (NOEL) for various soil invertebrates. However, only two of the samples (13 mg/kg and 98.1 mg/kg) were higher than the 10 mg/kg in soil that caused mortality in the earthworm species Pheretima pesthuma. Concentrations of lead in surface soil ranged from 7.2 to 71 mg/kg. These concentrations were below the NOEL (170 to 1,667 mg/kg) for various soil invertebrates (Dallinger, 1993).

Finally, zinc concentrations in the surface soils (138-430 mg/kg) were higher than concentrations that have been reported to cause adverse impacts to plants and invertebrates (100-1,600 mg/kg) (Eisler, 1993).

7.3.2.4 Biota Quality

The fish and benthic macroinvertebrates at station 35-FS/BN01 were compared to the fish and benthic macroinvertebrates collected at background stations HC04 and HM01. All three stations were located in headwater portions of tidal creeks. They were all similar in that they were relatively shallow, narrow, with sandy sediments. All three creeks also were shaded and surrounded by forests.

The fish and benthic macroinvertebrates at the remaining stations in Brinson Creek were compared to the fish and benthic macroinvertebrates collected at background station WC02. Station WC02 was the most similar background station compared to these stations. This similarity was based primarily on the width, depth, and sediment type. In addition, the salinity at station WC02 was the lowest of the mid-stream background stations, although it was still higher than the salinity in Brinson Creek.

Fish Tissue Quality

The following sections discuss the chemical concentrations detected in the fish tissues for the samples collected from Brinson Creek. Fish tissue samples were divided into two groups for discussion: whole body tissue analysis and fillet tissue analysis. Background information from Webb Creek and Holland Mill Creek were not included in this discussion as fish were not collected for tissue analysis at these creeks. Fish were collected from Hadnot Creek and fillet tissue was analyzed, therefore, these results will be included in this discussion (data presented in Appendix S).

Brinson Creek

No criteria were located in the literature to evaluate potential risks to fish, crabs, or crayfish from contaminants in their tissue. Therefore, the chemical concentrations of the COPCs detected in the tissue samples collected from Brinson Creek were compared to background or other studies to determine if the COPCs detected in the Brinson Creek samples appeared elevated. The fish tissue results from Brinson Creek were compared to the fish fillet samples collected in the background station (Hadnot Creek) and to whole body fish tissue concentrations determined in a fish survey conducted in Albermarle and Pamlico Sounds in North Carolina (NC Study) (Benkert, 1992). The NC Study consisted of whole body composite samples from three fish species: longnose gar, white catfish, and gizzard shad. In addition, other applicable studies and/or guidance values also were utilized in this comparison.

Fish tissue positive detection tables for fillet and whole body fish tissue samples collected in Brinson Creek are located in Section 4.0. Fish tissue statistical summaries for fish collected in Brinson Creek are located in Appendix R.

Organics

As presented on Table 7-10, most of the pesticides detected in the whole body fish tissue were detected within the range (or slightly elevated) of those same pesticides detected in the fish collected in the NC Study. None of the pesticides were detected at a concentration more than twice the concentration detected in the fish tissue samples collected in the NC Study. Finally, several of the pesticides were not analyzed for in the NC Study.

All the pesticides detected in the fillet tissue samples were detected at concentrations above those same pesticides detected in the Hadnot Creek samples. In fact, only two pesticides were detected in the Hadnot Creek fish as opposed to ten in the Brinson Creek fish. All the pesticides detected in the crab samples collected in Brinson Creek were detected at higher concentrations than those same contaminants in the Hadnot Creek crab tissue samples.

All the VOCs were detected in higher concentrations in the tissue samples collected in Brinson Creek than samples collected in Hadnot Creek.

Inorganics

Most of the inorganics detected in the whole body tissue samples were detected within the range (or slightly elevated) of those same inorganics detected in the samples collected in the NC Study. Copper and zinc were detected at higher concentrations in the Brinson Creek samples, however, these higher detections were detected in crayfish samples, which were not part of the NC Study. Without the crayfish samples, the concentration of copper ranged from 3.2 to 10.9 mg/kg in the fish, and zinc ranged from 42.3 to 87.1 with most of the samples within the range of the NC Study samples. Several of the inorganics were not analyzed for in the NC Study.

Most of the inorganics detected in the fillet tissue samples were detected at concentrations above those same inorganics detected in the Hadnot Creek samples. Several of the inorganics detected in the Brinson Creek samples were not detected in the Hadnot Creek samples.

Most of the inorganics detected in the crab samples collected in Brinson Creek were detected at higher concentrations than those same contaminants in the Hadnot Creek crab tissue samples. However, manganese was detected in higher concentrations in the Hadnot Creek crabs, and several inorganics (barium, chromium, and mercury) were detected in the Hadnot Creek Crabs but not in the Brinson Creek crabs.

Fish Community

Fish were collected at the site fish stations and the background stations using a various assortment of techniques including hope nets, gill nets, electrofishing, minnow traps, and catfish traps. The use of a specific technique was dependent on the size of the creek and the success of the fish collection. For example, gill nets were attempted at the two downstream Site 35 stations, however they quickly became fouled with algae and were unsuccessful in collecting fish. Therefore, hoop nets were used to collect most of the fish at these stations. Because of this difference in fish collecting techniques, the comparison of the fish community in Brinson Creek to the fish community in Webb Creek (WC02) was limited to types of fish collected and apparent health of the fish.

As discussed earlier in this ERA, the fish community at station 35-FS01 was compared to fish community at background stations HC04 and HM01. Overall, six fish species were collected at 35-FS01 and HM01, while two fish species were collected at HC04. At station 35-FS01, 210 individuals were collected, followed by 28 at HM01 and two at HC04.

The majority of the fish collect at 35-FS01 were juvenile spot and stripped mullet while no spot or stripped mullet species were collected at the background stations. Of the remaining fish species collected at 35-FS01, pumpkinseed and a goby were the only fish also collected at HM01. No other fish collected at 35-FS01 were collected at either of the two background stations.

The fish community at the remaining two stations at Site 35 and the three stations downstream of Site 35 were compared to the fish community at background station WC02. Overall, the fish species collected in Webb Creek at station WC02 were similar to those collected in the five downstream stations in Brinson Creek. The following fish species were collected in at least one of the site stations and WC02: spot, stripped mullet, yellow bullhead catfish, longnose gar, bluegill, white catfish, largemouth bass, summer flounder, mummichog and pinfish. Redbreast sunfish was the only fish collected in WC02 that was not collected in any of the site stations, while several fish that were collected in Brinson Creek were not collected at WC02. The fish collected from all the fish stations appeared healthy and did not have tumors or other abnormalities.

Benthic Macroinvertebrate Community

As discussed previously in this ERA, the benthic macroinvertebrate community at station 35-FS/BN01 was compared to the benthic marcroinvertebrate community at background stations HC04 and HM01. In addition, the benthic macroinvertebrate communities at the remaining stations in Brinson Creek were compared to the benthic macroinvertebrate community at background station WC02.

The following present the S_j and S_s community indices that were calculated between the benthic macroinvertebrate stations. Table 7-11 presents the similarity indices between Brinson Creek and Hadnot Creek. Table 7-12 presents the similarity indices between Brinson Creek and Webb Creek. The S_j values between 35-BN01 and the two background stations were 0.14 (compared to HC04) and

0.20 (compared to HM01). The S_j values between 35-BN01 and the two background stations were 0.25 (compared to HC04), and 0.33 (compared to HM01).

The tubificidae Limnodrilus hoffmeisteri and chironomidae Chironomus decorus were the primary benthic macroinvertebrate species collected at 35-BN01. The tubificidae Isochaetides freyi and chironomidae Tribelow jucundum were the primary benthic macroinvertebrate species collected in the two background stations. The two main species collected at 35-BN01 were more tolerant than the main species collected at the background stations based on the North Carolina Biotic Index.

Overall, the number of species was slightly higher at both background stations, while the species density was higher at 35-BN01. The species diversities were less than one at all three stations, with the lowest values at station 35-BN01. Finally, the MBI value at 35-BN01 was 9.31 indicating serous water quality, while the MBI values at the two background stations were 6.87 and 7.62 indicating poor water quality.

The S_j values between the remaining six downstream stations ranged from 0.06 to 0.53, while the S_s values between the remaining six downstream site stations ranged from 0.13 to 0.70. The S_j between the remaining six downstream site stations and WC02 ranged from 0.09 to 0.43, while the S_s values between the remaining six downstream site stations and WC02 ranged from 0.17 to 0.60.

Overall, more species were collected at the six downstream site stations than at WC02. In addition, the species density was higher in four of the site stations than WC02, and the diversity values were higher in three of the site stations. Finally, the MBI values at the site stations (8.88 to 9.49) ranged around the MBI at WC02 (9.39).

7.3.2.5 Terrestrial Chronic Daily Intake

As discussed above, there are no standards, criteria, or other screening values for assessing potential impacts to terrestrial receptors from contaminants in soils. However, there are some models that exist to estimate the exposure to terrestrial receptors. The following describes the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 35 by both direct and indirect exposure to COPCs via water (surface water), soil, and foodchain transfer.

Contaminants of potential concern at Site 35 are identified in Section 7.2.1.1 for each media. Based on the regional ecology and potential habitat at the site, the indicator species used in this analysis are the white-tailed deer, cottontail rabbit, red fox, raccoon, and the bobwhite quail. The exposure points for these receptors are the surface soils, surface water, and biota transfers. The routes for terrestrial exposure to the COPCs in the soil and water are incidental soil ingestion, drinking water, vegetation (leafy plants, seeds and berries) ingestion, fish ingestion, and ingestion of small mammals.

Total exposure of the terrestrial receptors to the COPCs in the soil and surface waters was determined by estimating the Chronic Daily Intake (CDI) dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. For this analysis, TRVs were developed from NOAELs or LOAELs obtained from the IRIS, mineral tolerance levels of domestic animals (SMTA, 1992) or other toxicological data in the literature (Table 7-13). Appendix X contains the procedures that were used to develop the TRVs.

Total exposure of the terrestrial receptors to the COPCs in the soil and surface water was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. CDIs were estimated for the white-tailed deer, cottontail rabbit, bobwhite quail, raccoon, and red fox using equations in or modified from Scarano, 1993. The estimated CDI dose of receptors (bobwhite quail, cottontail rabbit, and white-tailed deer) to soils, surface water, and vegetation was determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv \text{ or } Br)(Iv)+(Cs)(Is)][H]}{BW}$$

Where:

CDI = Total Exposure, mg/kg/d
Cw = Constituent concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Constituent concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Br = Soil to plant transfer coefficient in soil (fruits, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

The estimated concentration of the small mammal was calculated by multiplying the above equation by the beef bioconcentration factor (Bb) (Travis, 1988 for organics, Baes, 1984 for inorganics). The Bv, Br, and Bb values for each COPC detected in the soil is presented in Table 7-14.

The estimated CDI dose of the raccoon was determined using the following equation.

$$CDI = \frac{(Cw)(Iw)+(Cf)(If)+[(Cs)(Br)(Iv)+(Cs)(Is)+][H]}{BW}$$

Where:

CDI = Total Exposure, mg/kg/d
Cw = Constituent concentration in the surface water, mg/L
Cf = Constituent concentration in the fish, mg/kg (whole body concentrations)
If = Rate of fish ingestion, kg/d
Iw = Rate of drinking water ingestion, L/d
Cs = Constituent concentration in soil, mg/kg
Br = Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

The estimated CDI dose of the red fox was determined using the following equation:

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

Where:

CDI = Total Exposure, mg/kg/d
Cw = Constituent concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Br = Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Cs = Constituent concentration in soil, mg/kg
Is = Incidental soil ingestion, kg/d
Im = Rate of small mammal ingestion, kg/d
Cm = Constituent concentrations in small mammals, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

The concentrations of the COPCs in the soil (Cs) used in the model were the upper 95 percent confidence limit or the maximum concentration detected of each COPC. The upper 95 percent confidence limit or the maximum concentration detected for each constituent also was used as the concentration of each COPC in the surface water. The exposure parameters used in the CDI calculations are presented in Table 7-15.

7.4 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 adverse effects on the ecological integrity at Site 35 from contaminants identified at the site.

A Quotient Index (QI) approach was used to characterize the risk to aquatic and terrestrial receptors from exposure to surface water, sediments, and/or surface soils. This approach characterizes the potential effects by comparing exposure levels of COPCs in the surface water and sediments to ARVs (WQS, Region IV WQSV, and SSVs) or TRVs presented in Section 7.2.3, Ecological Effects. The QI is calculated as follows:

$$QI = \frac{EL}{ARV \text{ or } TRV}$$

Where: QI = Quotient Index
EL = Exposure Level, mg/L or mg/kg
ARV = Aquatic Reference Value, mg/L or mg/kg
TRV = Terrestrial Reference Value, mg/kg

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 and that effects may occur. The evaluation of the significance of the QI has been judged as follows: (Menzie, 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.

7.4.1 Surface Water

Table 7-1 contains a comparison of the COPCs identified in the surface water at Site 35 to the ARVs to determine if they exceeded the published values. A QI ratio of the detected values at each sampling station to the WQS and WQSVs were calculated for each COPC that exceeded at least one ARV (see Table 7-16).

Lead, mercury, and zinc had QIs that exceeded unity. The QIs for lead and zinc ranged from 0.44-11.4 while the QIs for mercury ranged from 1.4 to 128.

7.4.2 Sediment

Table 7-9 contains a comparison of the COPCs identified in the sediment to the ARVs to determine if exceedances of published values occurred. The QI of the detected values at each sampling station to the ER-L and ER-M were calculated for each COPC that exceeded at least one ARV (see Table 7-17).

The following COPCs in Brinson Creek sediments had QIs greater than unity when compared to the ER-L and ER-M: lead, dieldrin, 4,4'-DDD, 4,4'-DDT, 4,4'-DDE, alpha-chlordane, and gamma-chlordane. Endrin only had the ER-L QIs greater than unity. The sediment QIs ranged from 1.0 to 2,600.

7.4.3 Fish Community

The fish community at station 35-FS01 was compared to fish community at background stations HC04 and HM01. Only a few fish were collected at each of these stations which is what was expected based on the small size of the creeks at these stations. In addition, based on the relatively large population of juvenile spot collected at 35-FS01, it appears that fish are successfully reproducing in the general area. Based on the limited fish population data at 35-FS01, there does not appear to be a decrease in the integrity of the fish community in Brinson Creek at station 35-FS01.

The fish community at the remaining station in Brinson Creek was compared to the fish community at background station WC02. Overall, the fish species collected in Webb Creek at station WC02 were similar to those collected in the five downstream stations in Brinson Creek. Although a species diversity was not calculated due to the differences in the fish collection techniques, the community appeared relatively diverse. In addition, no tumors, lesions, or other abnormalities were observed with the fish collected at these stations. Therefore, there does not appear to be a decrease in the integrity of the fish community in Brinson Creek at the five downstream stations.

7.4.4 Fish Tissue

Several VOCs, pesticides and inorganics were retained as COPCs in the fish and/or crab tissue samples. As previously discussed, many of these COPCs were detected at higher concentrations in the fish and crabs collected in Brinson Creek than the fish or crabs collected in Hadnot Creek or other background studies. There does not appear to be any adverse impacts to the fish community by the elevated COPCs in the fish tissue based on population statistics and the absence of pathologies. However, the consumption of these fish by humans does present a risk to health (refer to Section 6.0 of this report).

7.4.5 Benthic Macroinvertebrate

The benthic macroinvertebrates community at station 35-BN01 was compared to benthic macroinvertebrate community at background stations HC04 and HM01. As discussed in the ecological effects sections of this ERA, several of the other population statistics were higher in the background stations than the 35-BN01, and the MBI was higher at 35-BN01 than the background stations. The primary reason for the high MBI value at 35-BN01 was due to large numbers of Limnodrilus hoffmeistreri (BI of 9.4) and Chironomus decorus gr. (BI of 9.6). However, there also were several species with a few individuals that are indicative of excellent and good water quality collected at 35-BN01.

Based on the water flow at 35-BN01 during the sampling events, it does not appear that this area is tidally influenced except potentially under extremely high tide events. Therefore, this station should not be significantly influenced by site activities. No COPCs detected in the surface water samples exceeded any of the aquatic reference values. As a result, the overall slight decrease in the integrity of the benthic community at 35-BN01 as compared to the two background stations is probable due to naturally occurring conditions, and not related to site impacts.

The benthic macroinvertebrate communities at the remaining stations in Brinson Creek were compared to the benthic macroinvertebrate community at background station WC02. As discussed in the ecological effects section of this ERA, several of the population statistics were higher at the site stations than the background stations. In addition, the MBI values at the site stations (8.88 to 9.49) ranged around the MBI at WC02 (9.39).

Although the MBI values at the site stations are indicative of serious water quality, the MBI value at the background station also was indicative of poor water quality. In addition, based on the higher population statistics at the site stations, it appears that the benthic macroinvertebrate community in Brinson Creek (lower stations) is normal when compared to an ecologically similar background benthic macroinvertebrate community.

7.4.6 Surface Soil

A few of the surface soil samples contained concentrations of COPCs that have been reported in the literature to cause adverse impacts to terrestrial plants and/or invertebrates. However, samples that contained these elevated levels were detected infrequently. Therefore, there does not appear to be a significant risk to the terrestrial invertebrate of floral communities.

7.4.7 Terrestrial Chronic Daily Intake Model

As was used to characterize the risk to aquatic receptors, the QI approach was used to characterize the risk to terrestrial receptors. Table 7-18 contains the QI for the COPCs in each of the areas.

Table 7-18 contains the QIs for all the COPCs for each receptor. The terrestrial QIs ranged from 1.76 for the red fox to 88 for the cottontail rabbit. Cadmium was the surface soil COPC that contributed the majority of QI values for the bobwhite quail (21 out of 31), cottontail rabbit (24 out of 33), raccoon (12.3 out of 88) and the whitetailed deer (8.04 out of 10.3). Copper in the fish was the major contributor of the QI in the raccoon (55 out of 88). Finally, zinc accounted for most of the QI in the red fox (1.09 out of 1.76).

The risks characterized above provide insight into general effects upon animals in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

Several of the other COPC contributed a relatively large percentage of the QI, however, none of the remaining COPCs had individual QI of greater than ten, and most were less than five.

7.4.8 Other Sensitive Environments

Brinson Creek is designated at nutrient-sensitive tidal saltwater by the North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR, 1993), with the designated usage for shellfishing for market purposes, primary recreation, aquatic life propagation and survival, fishing, and wildlife. Based on the results of the HHRA and the ERA, these designated uses are not met, because there is a slight non-carcinogenic risk to humans ingesting the fish and potential risk to aquatic receptors. No areas within the boundaries of Site 35 are designated as unique or special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.

The potential impact to terrestrial organisms that are present at Site 35 is discussed in earlier sections of this report. The terrestrial organisms that may be breeding in contaminated areas at Site 35 may be more susceptible to chemical stresses due to the higher sensitivity of the reproductive life stages of organisms to these types of stresses.

7.5 Ecological Significance

This section essentially summarizes the overall risks to the ecology at the site. It addresses impacts to the ecological integrity at Site 35 from the COPCs detected in the media, and to determine which COPCs are impacting the site to the greatest degree. This information, to be used in conjunction with the human health RA, supports the selection of remedial action(s) for Site 35 that are protective of public health and the environment.

7.5.1 Aquatic Endpoints

The assessment endpoint used to assess the aquatic environment is decreased integrity of the aquatic community. Several surface water and sediment QIs were greater than unity for COPCs and a few COPCs exceeded published toxicity values. Potential impacts to aquatic life from the other COPCs that exceeded published toxicity values are low since several of the stations are unreliable, and other studies indicate that toxicity does not occur until concentrations about those detected in Brinson Creek. In the surface water, mercury exceeded aquatic reference values in both the upstream and downstream stations. Although these levels were indicative of a high potential for risk (QI>100), mercury is not believed to be site related since it was detected at similar concentrations in the upstream and downstream samples. The QI for zinc only exceeded unity slightly at one station and indicates a low potential for decreasing the aquatic receptor population. Lead has a single exceedance of the aquatic reference value by slightly greater than 10 indicating a moderate potential for risk to aquatic receptors. However, since it only exceeded the ARV at one station it would have a low potential for decreasing the aquatic receptor population.

In the sediments, lead exceeded lower sediment aquatic reference value throughout Brinson Creek. The only exceedances of the higher sediment aquatic reference value occurred downstream of Site 35 with the highest QI of 137 (lead) representing a high potential for impacting aquatic receptors. Pesticides exceeded the sediment aquatic reference values throughout Brinson Creek. The highest QI, 2,600 for dieldrin, represents a high potential for risk to aquatic receptors. There is no documented disposal or storage/preparation activities of dieldrin at Site 35. The levels detected in the sediments probably are a result of routine application in the general vicinity of Site 35, but, represent a significant potential for impacting the integrity of the aquatic community.

The results of the analysis of benthic macroinvertebrates and fish populations indicate that Brinson Creek supports an aquatic community that is representative of a tidally-influenced freshwater ecosystem with both freshwater and marine species. The presence of juvenile fish as well as blue crab, grass shrimp, and crayfish, indicates the successful use of the creek for reproductive purposes. Elevated fish tissue concentrations of several COPCs indicates that the concentrations found in the surface water and sediments may be bioaccumulating in the fish tissues. However, the absence of pathologies observed in the fish sampled from Brinson Creek indicates that the surface water and sediment quality may not adversely impact the fish community relative to this parameter.

The benthic community demonstrated the typical tidal/freshwater species trend of primarily chironmids and oligochaetes in the upper reaches and polychaetes and amphipods in the lower reaches. Species representative of both tolerant and intolerant taxa were present.

7.5.2 Terrestrial Endpoints

During the habitat evaluation, no areas of vegetation stress or gross impacts from site contaminants were noted. Habitats surrounding all three sites appeared to be diverse and the community and ecosystem structure appeared to be intact.

The assessment endpoint used to assess the terrestrial environment is decreased integrity of the terrestrial community. A few COPCs in the surface soil were detected in higher concentrations that the levels that were shown to adversely impact terrestrial invertebrates. However, these exceedances were limited to a few samples; therefore, they are not expected to cause an overall decrease in the terrestrial invertebrate population.

As Discussed in the Risk Characterization section of this ERA, cadmium and zinc in the soil, and copper in the water (only for the raccoon) were the COPCs that contributed the most potential risk to the terrestrial species. Elevated concentrations of cadmium and zinc were detected in sample 35-SS04-00. In fact, the actual concentrations of cadmium and zinc from this sample were used in the CDI model because the RMEs for these COPCs were greater than the maximum values. Therefore, the potential risk to the bobwhite quail, cottontail rabbit, and whitetailed deer is overestimated since these species will not spend all their time at this one sample location.

The high copper concentration in the fish samples used in the raccoon CDI model is due to the high copper concentration in the crayfish. However, copper was not detected in the surface water, and it was detected in similar or lower concentrations in the downstream sediments than the upstream sediments. Therefore the copper in the tissue samples does not appear to be site-related. The risk to the terrestrial receptor population from site-related COPCs appear to be low since most of the risk is due to one surface soil sample, and copper in the tissue samples does not appear to be site-related.

7.5.3 Threatened and Endangered Species

Several threatened and/or endangered species inhabit MCB Camp Lejeune. The American alligator has been observed in Brinson Creek. However, it is not known if the alligator frequents often or breeds in Brinson Creek. The alligator would be exposed to COPCs at Site 35, however, potential impacts to this species could not be evaluated. No potential adverse impacts to other threatened or endangered species from contaminants at Site 35 are expected to occur, since no other protected species are known to inhabit the site.

7.5.4 Wetlands

Site-specific wetland delineations were not conducted at Site 3~~6~~5; although, potential wetland areas were noted during the habitat evaluation.

7.5.5 Other Sensitive Environments

There are no known sensitive environments located at Site 35.

7.6 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following discusses the uncertainty in the ERA.

The chemical sampling program at Site 35 consisted of surface water, sediments, soil, tissue, and groundwater. The concentrations of chemicals in the surface water will vary with the tides; the concentrations are expected to be lower at higher tides (more dilution) and higher at low tides (less dilution).

The proximity of estuaries to landmasses renders them highly susceptible to pollution from human activities; this pollution threatens fish communities in many regions. Anthropogenic stresses on fish populations can be intense. Whereas much attention has been focused on the acute exposure of these populations to pollutants, sublethal and chronic exposures also debilitate resident and seasonal species. The mobility and migratory habits of fishes, however, make observations on anthropogenic effects more difficult to assess, and most of the evidence on pollution-induced changes in fish populations has been derived from laboratory experiments. Effects of man-made stresses on fishes in estuaries are often obscured by naturally occurring and poorly understood, long-term variations.

The ecological investigation consisted of one sampling effort. The results of this sampling will only provide a "snapshot in time" of the ecological environment. Because the biotic community can have a high amount of natural variability, the "snapshot in time" may not be an accurate representation of actual site conditions. There also is error and uncertainty in the sampling methods used to collect the fish and benthic macroinvertebrates. Because few, if any, fish were collected at the stations, the population statistics were not reliable. In addition, in several of the tissue samples, only one fish was analyzed because only one was collected of that species. Therefore, the concentrations of contaminants may not be a good representation of the average tissue concentration.

The collection of benthic macroinvertebrates has less uncertainty than the collection of fish. However, the effectiveness of the ponar depends upon the sediment type. The ponar is less effective in hard, rocky sediments, or sediments with a lot of organic debris that may prevent the ponar from completely closing, than in soft, mucky sediments. Because the sediment types varied among the stations, the effectiveness of the ponar also would have varied.

There is uncertainty in trying to attribute differences in species density, diversity, and similarities between stations to specific hazards, because these differences may be the result of natural causes. As discussed previously, fish and crabs are mobile. Therefore, the tissue contaminant concentrations cannot be correlated with the contaminants detected at Site 35 because the fish or crabs may have been exposed to the contaminants at a different location. Also, as observed in this investigation, natural conditions (salt wedge, low dissolved oxygen) can result in low numbers of individuals.

There also is uncertainty in the use of toxicological data in ecological risk assessments. The surface water and sediment values established by North Carolina and Region IV are set to be protective of a majority of the potential receptors. There will be some species, however, that will not be protected by the values because of their increased sensitivity to the chemicals. Also, the toxicity of chemicals 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.

Estuaries are physically unstable areas characterized by large spatial and temporal variations in temperature, salinity, oxygen concentration, turbidity, and other factors. Temporally, such variations take place in the short term and long term. Yet, despite these variations, the basic structure of estuarine fish communities is reasonably stable, and the fishes often have more or less predictable patterns of abundance and distribution. However, estuarine fish populations change dramatically in response to environmental perturbations; these population changes can be permanent even though the predominantly estuarine species have broad temperature tolerances and strong osmoregulatory abilities. The species composition of estuarine communities change constantly, attesting to the variable environmental conditions and the limitations of the tolerances of the fish populations to alterations in the habitat.

There is uncertainty in the ecological endpoint comparison. The values used in the ecological endpoint comparison (either the WQS of the SSV) are set to be protective of a majority of the potential receptors. There will be some species, however, that will not be protected by the values because of their increased sensitivity to the chemicals. Also, the toxicity of chemical mixtures is not well understood. All the toxicity information used in the ecological risk assessment for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals. In addition, there were several contaminants that did not have WQS or SSVs. Therefore, potential effects to ecological receptors from these chemicals cannot be determined. In addition as was discussed earlier in this RI, high concentrations of unidentified chemicals were detected in the sediment. Because the chemicals were not identified, potential impacts to the ecology from these contaminants could not be evaluated.

The SSVs were developed using data obtained from freshwater, estuarine and marine environments. Therefore, their applicability for use to evaluate potential effects to aquatic organisms from contaminants in estuarine habitats must be evaluated on a chemical specific basis because of differences in both the toxicity of individual contaminants to freshwater and saltwater organisms, and the bioavailability of contaminants in the two aquatic systems.

Several contaminants in the surface water and sediment exceeded applicable ARAR values. Some of the surface water and sediment samples were collected from areas that were not considered ecologically significant. Therefore, although the ARARs/TBCs may have been exceeded in these samples, the potential for them to impact aquatic life may not be significant.

The chronic daily intake models used to evaluate decreased viability to terrestrial receptors has a lot of uncertainty. 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. In addition, there is uncertainty in the amount that the indicator species will represent other species potentially exposed to COPCs at the site. In addition, most of the TRVs for the species evaluated in the CDI model were developed from other species (i.e., many of the TRVs were developed from rat studies) using a body-size/weight equation. This equation may not accurately predict potential risks to the studied species since the toxicity of contaminants to terrestrial receptors from contaminants is not necessarily directly proportional to body size and weight. No published toxicity information was found for several of the contaminants, so their TRV was assumed to be the same as a similar contaminant (i.e., endrin was used for endirn aldehyle and endrin ketone). However, this assumption is probably not true for most of the contaminants.

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 assumption that may not represent conditions at the site, 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, 1993).

7.7 Conclusions

Overall, metals and pesticides appear to be the most significant site related COPCs that have the potential to affect the integrity of the aquatic and terrestrial receptors at Site 35. Although the American alligator has been observed at Site 35, potential adverse impacts to this species could not be quantitatively evaluated.

7.7.1 Aquatic Ecosystem

Surface water quality showed exceedances of aquatic reference values for lead, mercury, and zinc. In addition, iron, cobalt and manganese were above the concentration that caused adverse impacts to aquatic species in a few studies. However, most of the studies did not meet the criteria for reliability, and other studies indicated that potential impacts to aquatic organisms did not occur at the concentrations detected in the surface water at Brinson Creek. For sediments, concentrations of lead and the organics dieldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endrin, alpha-chlordane, and gamma-chlordane exceeded the aquatic reference values. In the surface water, mercury exceeded aquatic reference values in the upstream stations. Although these levels were indicative of a high potential for risk (QI > 100), mercury is not believed to be site related. Zinc only exceeded unity slightly and was only found at a single station. Lead has a single exceedance of the aquatic reference value by slightly greater than 10 indicating a moderate potential for risk to aquatic receptors. Lead also was found in the groundwater samples at similar levels and is site related.

In the sediments, lead exceeded the lower sediment aquatic reference value throughout Brinson Creek. The only exceedances of the higher sediment aquatic reference value occurred downstream of Site 35 with the highest QI of 137 representing a high potential for risk to aquatic receptors. The lead detected in the sediments is likely site related, the result of past reported surface spills/runoff and past and ongoing groundwater discharges to surface water.

Pesticides exceeded the sediment aquatic reference values throughout Brinson Creek. The highest QI, 2,600 for dieldrin, represents a high potential for risk to aquatic receptors. There is no documented pesticide disposal or storage/preparation activities at Site 35. The pesticide levels detected in the sediments probably are a result of routine application in the general vicinity of Site 35.

Although, the pesticides in the sediments were found at levels indicating contamination throughout the watershed, the highest levels were observed in the lower reaches of Brinson Creek. This deposition tread may be related to the higher organics in the sediments in the lower reach, which would accumulate more of these types of contaminants.

The fish community sampled in Brinson Creek was representative of an estuarine ecosystem with both freshwater and marine species present. In addition, the presence of blue crabs, grass shrimp, and crayfish support the active use of Brinson Creek by aquatic species.

The absence of pathologies observed in the fish collected from Brinson Creek indicates that the surface water and sediment quality may not adversely impact the fish community.

The benthic macroinvertebrate community demonstrated the typical tidal/freshwater species trend of primarily chironmids and oligochaetes in the upper reaches and polychaetes and amphipods in the lower reaches. Species representative of both tolerant and intolerant taxa were present. Species richness and densities were representative of an estuarine ecosystem.

In summary, the aquatic community in Brinson Creek is representative of an estuarine community and does not appear to be significantly impacted by surface water and sediment quality.

7.7.2 Terrestrial Ecosystem

Surface soil quality indicated a potential for adversely impacting the terrestrial receptors that have direct contact with the surface soils. This adverse impact is primarily due to cadmium in the surface soils. Cadmium was detected at a relatively high concentration in only out of ten surface soil samples.

There also appears to be impacts to the terrestrial receptors due to copper in the fish tissue. Copper was not detected in the surface water but was detected in sediment samples collected downstream of Site 35 at concentrations lower than the sediment samples taken upstream of Site 35. As such, the copper in the fish tissue does not appear to be site related.

7.7.2 Terrestrial Ecosystem

Surface soil quality indicated a potential for adversely impacting the terrestrial receptors that have indirect contact with the surface soils and copper in the tissue samples. This adverse impact is primarily due to cadmium in the surface soils. The cadmium in the surface soil is overestimating the adverse impacts since it was detected at a relatively high concentration in only one out of ten samples. In addition, the copper in the tissue samples does not appear to be site-related.

SECTION 7.0 REFERENCES

SECTION 7.0 REFERENCES

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SECTION 7.0 TABLES

TABLE 7-1

SURFACE WATER DATA SUMMARY
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Criteria					Contaminant Frequency/Range		Comparison to Criteria			
		Region IV WQSV							Positive Detects Above WQSV		
Contaminant	NCWQS(1)	Water Acute	Chronic	Average Reference Station Background Concentration	Twice the Average Reference Station Average Concentration	No. of Positive Detects/ No. of Samples	Contaminant Range	Positive Detects Above NCWQS	Acute	Chronic	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	NE	NE	NE	333.17	666.3	4/10	1 - 6,580	NA	NA	NA	1
Antimony	NE	500(3)	1,500(3)	ND	ND	4/10	1.5 - 3.9	NA	0	0	NA
Arsenic	50	69	36	ND	ND	1/10	2.7J	NA	0	0	NA
Barium	NE	NE	NE	25.7	51.4	7/10	16.7 - 48.5J	NA	NA	NA	0
Calcium	NE	NE	NE	17,566	35,132	10/10	41,700 - 63,900	NA	NA	NA	10
Chromium	20	1,100	50	ND	ND	2/10	1J - 1.2J	0	0	0	NA
Cobalt	NE	NE	NE	ND	ND	4/10	9J - 16.8J	NA	NA	NA	NA
Iron	NE	NE	NE	575.7	1,151.4	10/10	764J - 9,500	NA	NA	NA	4
Lead	25	220	8.5	ND	ND	5/10	1.4 - 97J	1	0	1	NA
Magnesium	NE	NE	NE	1,744.7	3,489.4	10/10	2,380 - 17,900	NA	NA	NA	5
Manganese	NE	NE	NE	ND	ND	10/10	24.5 - 113	NA	NA	NA	NA
Mercury	0.025	2.1	0.025(4)	ND	ND	2/10	3J - 3.2J	2	2	2	NA
Potassium	NE	NE	NE	ND	ND	10/10	2,170 - 8,210	NA	NA	NA	NA
Selenium	71	300	71	0.82	1.66	1/10	1.3J	0	0	0	0
Sodium	NE	NE	NE	9,830	19,660	10/10	42,600 - 192,000	NA	NA	NA	10
Thallium	NE	NE	NE	ND	ND	1/10	1J	NA	NA	NA	NA
Vanadium	NE	NE	NE	ND	ND	4/10	4.5 - 14.8J	NA	NA	NA	NA
Zinc	86	95	86	ND	ND	1/10	129J	1	1	1	NA

Notes: Concentrations expressed in microgram per liter (µg/L).
(1) NCWQS = North Carolina Water Quality Standards for Surface Water
(2) WQSV = Water Quality Screening Values
(3) Proposed Value
(4) Based on marketability of fish
NE - Not Established
NA - Not Applicable
J - Estimated value
All rejected results have been removed from the data. Frequencies of detection are adjusted accordingly.

TABLE 7-2

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	BCF (L/kg)	Water Solubility (mg/L)	Organic Carbon Partition Coefficient (mL/g)	Vapor Pressure (mm Hg)	Log Octanol/ Water Coefficient
Inorganics					
Aluminum	ND(1,3)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Antimony	1(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Arsenic	44(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Barium	ND(1,3)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Beryllium	19(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Cadmium	64(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Chromium	16(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Cobalt	ND(3)	ND(1,3)	ND(1)	(2)	ND(1,3,4)
Copper	36(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Iron	ND(3)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Lead	49(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Manganese	35(9)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
Mercury	4,000(3)	ND(1,3)	ND(1)	(2,3)	ND(1,3,4)
Nickel	47(8)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Selenium	6(8)	ND(1,2)	ND(1)	(1,2,3)	ND(1,3,4)
Thallium	18(3)	ND(1,3)	ND(1)	ND(2)	ND(1,3,4)
Vanadium	ND(3)	ND(1,3)	ND(1)	(2,3)	ND(1,3,4)
Zinc	1(8)	ND(1,3)	ND(1)	(1,2,3)	ND(1,3,4)
VOCs					
Acetone	0.69(9)	1,000,000(1)	2.2(1)	270(1)	-0.24(1)
Carbon Disulfide	ND(1)	2,940(1)	54(1)	360(1)	2.0(1)
Toluene	10.7(8)	535(1)	300(1)	28.1(1)	2.73(1)
Xylene	2.2(9)	198(1)	240(1)	10(1)	3.26(1)
Pesticides					
beta-BHC	130(8)	2.0(3)	3,800(1)	(2,3)	3.9(1)
Chlordane, total	14,100(8)	0.056(3)	140,000(1)	(2,3)	5.5(7)
4,4-DDE	53,600(8)	0.12(3)	4,400,000(1)	(1,2,3)	5.7(3)
4,4-DDD	53,600(8)	0.09(3)	770,000(1)	(1,2,3)	0.60(3)
4,4-DDT	53,600(8)	0.025(3)	243,000(1)	(1,2,3)	6.4(3)
Dieldrin	4,670(8)	0.2(3)	1,700(1)	(1,2,3)	4.3(7)
Endosulfan II *	270(5)	0.51(5)	2,042(5)	(2,5)	3.8(5)
Endrin	3,970(8)	0.23(3)	ND (1,2,3,4,5,6,7)	(2,3)	4.6(7)

TABLE 7-2 (Continued)

PHYSICAL/CHEMICAL CHARACTERISTICS OF COPCs
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-232
MCB LEJEUNE, NORTH CAROLINA

Contaminant	BCF (L/kg)	Water Solubility (mg/L)	Organic Carbon Partition Coefficient (mL/g)	Vapor Pressure (mm Hg)	Log Octanol/ Water Coefficient
Endrin Aldehyde	3,970(8)	50(9)	670(9)	(2,9)	3.2(9)
Endrin Ketone	ND(7,8)	ND(7)	ND(7)	ND(7)	ND(7)
Heptachlor Epoxide	11,200(8)	0.2(5)	ND(5)	(2,5)	5.40(5)
Methoxychlor	40,000(3)	0.1(3)	ND(3)	(2,3)	4.8(3)
SVOCs					
Diethylphthlate	73(8)	896(1)	142(1)	(1,2)	2.5(1)
Bis(2-ethylhexylphthlate)	130(8)	0.34(3)	ND(3)	(2,3)	5.1(3)
Benzo(b)fluorenthen	30(8)	(1,2)	550,000(1)	(1,2)	6.06(1)
Benzo(g,h,i)perylene	30(8)	(1,2)	1,600,000(1)	(1,2)	6.51(1)
Chrysene	30(8)	(1,2)	200,000(1)	(1,2)	5.61(1)
Fluoranthene	1,150(8)	0.2(1)	38,000(1)	(1,2)	4.9(1)
Phenanthrene	30(8)	1.0(1)	14,000(1)	(1,2)	4.5(1)
Pyrene	30(8)	0.13(1)	38,000(1)	(1,2)	4.88(1)
Phenol					1.5(1)

Notes:
(1) USEPA, 1986.
(2) Negligible (less than 0.1).
(3) SCDM, 1991.
(4) USEPA, 1985.
(5) Howard, 1989.
(6) Howard, 1990.
(7) Howard, 1991.
(8) USEPA, 1995a.
(9) USEPA Region III 1995b.

COPCs = Contaminants of Potential Concern
BCF = Bioconcentration Factor
L/kg = liters per kilogram
mg/L = milligrams per liter
mL/g = milliliters per gram
mm Hg = millimeters of mercury
ND = No data
VOCs = Volatile Organic Compounds
SVOCs = Semivolatile Organic Compounds
* Values for Endosulfan were used.

TABLE 7-3

FIELD CHEMISTRY FROM BIOLOGICAL SAMPLES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Location	Salinity (ppt)	Conductivity (micromhos/cm)	DO (mg/L)	pH (S.U.)	Temperature (deg. C)
35-SW/SD-01	surface	0	506	8.8	7.36	18.2
35-SW/SD-02 35-FS/BN01	surface	0	282 to 489	8.9 to 9.8	7.32 to 7.4	17.8 to 19.9
35-SW-03	surface	0	510 to 563	8.1 to 8.2	7.30	18.2 to 21.0
	bottom	0	515 to 572	8.1	7.30	17.3 to 21.0
35-SW/SD-04 35-FS/BN02	surface	0	269 to 583	6.0 to 7.8	6.95 to 7.20	17.8 to 19.1
	bottom	0	286 to 547	5.1 to 7.8	7.02 to 7.10	16.7 to 19.4
35-SW/SD-05	surface	0.10	500	7.90	7.30	18.0
	bottom	0	450	7.80	7.20	16.5
35-SW/SD-06 35-FS/BN03	surface	0 to 0.1	541 to 670	5.2 to 9.9	7.30 to 7.32	16.0 to 18.5
	bottom	0 to 0.1	551 to 640	4.7 to 11.0	7.26 to 7.30	17.7 to 19.5
35-SW/SD-07 35-BN04	surface	0 to 0.10	291 to 505	5.9 to 7.5	7.13 to 7.29	19.2 to 21.9
	bottom	0 to 0.20	291 to 505	5.4 to 7.4	7.09 to 7.25	19.2 to 21.6
36-SW/SD-05 36-FS/BN03	surface	0.7 to 1.2	1,088 to 3,320	16.4 to 18.0	8.60 to 8.80	23.9 to 25.0
	bottom	0.60	1,044	12.0	8.19	23.0
36-SW/SD-06 36-FS/BN02	surface	0.5 to 1.0	906 to 1,600	10.3 to 17.9	7.93 to 8.60	24.8 to 25.2
	bottom	0.4 to 1.0	703 to 1,700	11.6 to 17.4	7.57 to 8.80	23.3 to 25.3
36-SW/SD-07 36-FS/BN01	surface	0.3 to 0.5	650 to 881	5.9 to 13.0	7.73 to 8.23	19.2 to 24.2
	bottom	0.2 to .75	570 to 886	6.9 to 7.30	7.38 to 8.40	19.2 to 21.9

Notes: Sample Location = Water surface or water bottom
DO = Dissolved Oxygen level
ppt = parts per thousand
mg/L = milligrams per liter
S.U. = Standard Units
deg. C = degrees Celsius
SW/SD = Surface water/sediment sample
FS = Fish sample
BN = Benthic macroinvertebrate sample

TABLE 7-4

TOTAL NUMBER OF AQUATIC SPECIES IDENTIFIED PER STATION
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

SPECIES	BRINSON CREEK			Total Detected	BRINSON CREEK			Total Detected
	35-FS01	35-FS02	35-FS03		36-FS01	36-FS02	36-FS03	
FISH SPECIES								
Spot	76	216	95	387			1	1
Stripped mullet	125	55	8	188	8	4	8	20
Mudcatfish (Yellow bullhead)		3	10	13				0
Pumpkinseed	1	6	7	14	2		1	3
Longnose gar		1	9	10			2	2
Banded killifish		1		1				0
Lesser killifish		2		2				0
Fat sleeper		1		1				0
Green sunfish	1			1				0
Brown bullhead		1		1				0
Warmouth			2	2			1	1
Bluegill			7	7	1			1
White catfish				0	3	8	10	21
Largemouth bass				0		1	2	3
Sheepshead minnow		12		12	21			21
Summer flounder		1		1	1			1
Mummichog		3		3	19		2	21
Pinfish		4	7	11	1	2	7	10
Sharptail goby	2			2		1		1
Eastern mosquitofish		2	1	3		1	1	2
American eel	5	4	1	10				0
NUMBER OF SPECIES	**6**	**15**	**10**	**19**	**8**	**6**	**10**	**14**
NO. OF INDIVIDUALS	**210**	**312**	**147**	**669**	**56**	**17**	**35**	**108**

TABLE 7-4 (Continued)

TOTAL NUMBER OF AQUATIC SPECIES IDENTIFIED PER STATION
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

SPECIES	BRINSON CREEK			Total Detected	BRINSON CREEK			Total Detected
	35-FS01	35-FS02	35-FS03		36-FS01	36-FS02	36-FS03	
OTHER AQUATIC SPECIES								
Blue crab				0		11	21	32
Grass shrimp				0			23	23
Crayfish		12	1	13				
NUMBER OF SPECIES	**0**	**1**	**1**	**1**	**0**	**1**	**2**	**2**
NO. OF INDIVIDUALS	**0**	**12**	**1**	**13**	**0**	**11**	**44**	**55**

TABLE 7-5

FISH DISTRIBUTION AND CHARACTERIZATION
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Common Name	Scientific Name	Length N.C. (cm)	Length Atlas (cm)	Water Type	Habitat	Spawning	Tolerance	Family	Sources
Atlantic Menhaden	Brevoortia tyrannus	20	46	Brackish or marine, enters freshwater	Rivers, streams	NA	Intermediate	Clupeidae	1,2,3,4
Spot	Leiostomas xanthurus	NA	NA	Brackish or marine, enters freshwater	NA	NA	NA	Sciaenidae	1
Stripped Mullet	Mugil cephalus	NA	23-35	Brackish or marine, enters freshwater	Rivers	NA	NA	Mugilidae	1,2
Pinfish	Lagodon rhomboides	NA	38	Marine, seldom enters freshwater	Shallow waters	NA	NA	Sparidae	1,2
Longnose Gar	Lepisosteus osseus	80	-150	Freshwater may enter brackish waters	Rivers	April through May	Intermediate	Lepisosteidae	1,2,3
Banded Killifish	Fundulus diaphanus	8	5-7	Freshwater may enter brackish waters	Streams	NA	Tolerant	Cyprinodoniidae	1,2,3
Least Killifish	Heterandria formosa	2	2-3	Freshwater may enter brackish waters	Creeks	NA	NA	Poeciliidae	1,2
Pumpkinseed	Lepomis gibbosus	20	8-20	Freshwater	Streams Creeks	April through October	Moderately Tolerant	Centrarchidae	1,2,3,4
Fat Sleeper	Dormitator maculatus	10	4-25	Brackish, saltwater marshes, and freshwater	Streams Creeks	NA	NA	Electridae	1,2
Summer Flounder	Paralichthys dentatus	NA	37	Brackish or marine, enters freshwater	Rivers	NA	NA	Bothidae	1
American Eel	Anguilla rostata	NA	to 147.5	Brackish or freshwater	NA	December	Intermediate	Anguillidae	1,2,3,4,5
Green Sunfish	Lepomis cyanellus	15	15-25	Freshwater	Streams	April through June	Tolerant	Centrarchidae	1,2,3
Warmouth	Lepomis gulosus	16	8-26	Freshwater	Rivers Streams	May through August	Intermediate	Centrarchidae	1,2,3

TABLE 7-5 (Continued)

FISH DISTRIBUTION AND CHARACTERIZATION AT
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Common Name	Scientific Name	Length N.C. (cm)	Length Atlas (cm)	Water Type	Habitat	Spawning	Tolerance	Family	Sources
Bluegill	Lepomis macrochirus	25	18-20	Freshwater	Rivers Streams Creeks	May through October	Intermediate	Centrarchidae	1,2,3
White Catfish	Ictalurus catus	31	-46	Freshwater	Rivers	May through June	Intermediate	Ictaluridae	1,2,3
Sheepshead	Archosargus probatocephalus	NA	to 76	Muddy, shallow water; Occasionally enters freshwater in Florida	Over oyster beds, Around piles and piers of bridges	NA	NA	Sparidae	2,5
Largemouth Bass	Micropterus salmoides	48	12-70	Freshwater	Rivers Streams Creeks	May through June	Intermediate	Centrarchidae	1,2,3
Mummichog	Fundulus heteroclitus	7	8-10	Shallow coastal waters	Rivers Streams	April through August	NA	Cyprinodontidae	1,2,3
Sharptail Goby	Gobionellus hastatus	NA	NA	Brackish or marine; Enters freshwater	Bays and Sounds	NA	NA	Gobiidae	2
Mud Catfish (Yellow Bullhead)	Ictalurus natalis	24	-38	Freshwater	Rivers Streams	April through May	Tolerant	Ictaluridae	1,2,3

1 Menhinick, 1992.
2 Boschung, 1983.
3 USEPA, 1989d.
4 Raasch, 1991.
5 Kennish, 1986.
NA = Information not available

TABLE 7-6

SYSTEMATIC LIST OF BENTHIC MACROINVERTEBRATE SPECIES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Systematic Classification
NEMATODA	Phylumn
ANNELIDA	Phylumn
Oligochaeta	Class
Lumbricina	Order
Lumbricidae	Family
Tubificida	Order
Naididae	Family
Dero digitata	Genus Species
Stylaria lacustris	Genus Species
Tubificidae	Family
Limnodrilus hoffmeisteri	Genus Species
Polychaeta	Class
Capitellida	Order
Capitellidae	Family
Heteromastus filiformis	Genus Species
Phyllodocida	Order
Nereidae	Family
Nereis succinea	Genus Species
Spionida	Order
Spionidae	Family
Polydora sp.	Genus Species
Terebellida	Order
Ampharetidae	Family
Hypaniola grayi	Genus Species
ARTHROPODA	Phylumn
Crustacea	Class
Amphipoda	Order
Gammaride	Family
Gammarus tigrinus	Genus Species
Decapoda	Order
Palaemonidae	Family
Palaemonetes pugio	Genus Species

TABLE 7-6 (Continued)

SYSTEMATIC LIST OF BENTHIC MACROINVERTEGRATE SPECIES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Systematic Classification
Portunidae	Family
Callinectes sp.	Genus Species
Insecta	Class
Coleoptera	Order
Elmidae	Family
Dubiraphia sp.	Genus Species
Macronychus glabratus	Genus Species
Diptera	Order
Ceratopogonidae	Family
Bezzia/Palpomyia sp.	Genus Species
Palpomyia/sphaeromias sp.	Genus Species
Chironomidae	Family
Cardiocladius sp.	Genus Species
Chironomus decorus gr.	Genus Species
Cricotopus bicinctus gr.	Genus Species
Cricotopus ornatus	Genus Species
Dicrotendipes hervosus	Genus Species
Dicrotendipes modestus	Genus Species
Parstanytarsus recens	Genus Species
Polypedilum illinoense	Genus Species
Polypedilum scalaenum	Genus Species
Procladius sp.	Genus Species
Tanytarsus sp.	Genus Species
Thienemannimyia gr.	Genus Species
Tribelos jucundum	Genus Species
Tabanidae	Family
Chrysops sp.	Genus Species
MOLLUSCA	Phylumn
Bivalvia	Class
Veneroida	Order
Sphaerildae	Family
Pisidium casertanum	Genus Species
Oastropoda	Class
Basommatophora	Order
Physidae	Family
Physella sp.	Genus Species

TABLE 7-7

BIOTIC INDEX, USEPA TOLERANCE TO ORGANIC WASTE, AND SENSITIVITY TO METALS
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA[(1)] Metals	Organics	NCDEHNR[(2)] Biotic Index
NEMATODA	NA	NA	6.0
ANNELIDA			
Oligochaeta			
Lumbricina			
Lumbricidae	NA	NA	7.0
Tubificida			
Naididae			
Dero digitata	NA	2	10.0
Stylaria lacustris	NA	3	9.3
Tubificidae	NA	NA	NA
Limnodrilus hoffmeisteri	NA	5	9.4
Polychaeta			
Capitellida			
Capitellidae			
Heteromastus filiformis	NA	NA	NA
Phyllodocida			
Nereidae			
Nereis succinea	NA	NA	NA
Spionida			
Spionidae			
Polydora sp.	NA	NA	NA
Terebellida			
Ampharetidae			
Hypaniola grayi	NA	NA	NA
ARTHROPODA			
Crustacea			
Amphipoda			
Gammaride			
Gammarus tigrinus	NA	2	NA
Decapoda			
Palaemonidae			
Palaemonetes pugio	NA	NA	NA
Portunidae			
Callinectes sp.	NA	NA	NA
Insecta			
Coleoptera			
Elmidae			

TABLE 7-7 (Continued)

BIOTIC INDEX, USEPA TOLERANCE TO ORGANIC WASTE, AND SENSITIVTY TO METALS
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA[(1)] Metals	Organics	NCDEHNR[(2)] Biotic Index
Dubiraphia sp.	NA	NA	5.9
Macronychus glabratus	T	2	4.5
Diptera			
Ceratopogonidae			
Bezzia/Palpomyia sp.	NA	NA	7.0
Palpomyia/sphaeromias sp.	NA	NA	7.0
Chironomidae			
Cardiocladius sp.	NA	NA	5.8
Chironomus decorus gr.	NA	NA	9.6
Cricotopus bicinctus gr.	T	2	8.5
Cricotopus ornatus	NA	NA	NA
Dicrotendipes hervosus	NA	NA	8.1
Dicrotendipes modestus	S	3	8.7
Parstanytarsus recens	NA	NA	NA
Polypedilum illinoense	NA	3	9.0
Polypedilum scalaenum	NA	2	8.4
Procladius sp.	NA	NA	9.1
Tanytarsus sp.	NA	NA	6.7
Thienemannimyia gr.	NA	NA	5.8
Tribelos jucundum	S	1	6.3
Tabanidae			
Chrysops sp.	NA	NA	6.7
MOLLUSCA			
Bivalvia			
Veneroida			
Sphaerildae			
Pisidium casertanum	NA	4	NA
Oastropoda			
Basommatophora			
Physidae			
Physella sp.	NA	4	8.8

Notes: (1) Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters
(2) Lenat, 1993
NA = Not Available
S = Sensitive to heavy metals
T = Tolerant to heavy metals
Organics Ranking = 0 to 5 with 0 being the least tolerant

TABLE 7-8

SUMMARY STATISTICS OF BENTHIC MACROINVERTEBRATE SPECIES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Number of Species	Number of Individuals	Density (#/m^2)	Brillouin's Diversity	Shannon Wiener Diversity	Macroinvertebrate Biotic Index
35-BN01	11	430	2741	0.448	0.464	9.31
35-BN02	5	65	414	0.176	0.208	9.48
35-BN03	12	96	612	0.649	0.718	9.44
35-BN04	5	101	644	0.266	0.290	9.47
36-BN01	10	44	280	0.632	0.742	8.88
36-BN02	10	348	2218	0.424	0.456	9.10
36-BN03	13	372	2371	0.60	0.628	9.49

Notes: #/m^2 = Total number of individuals per square meter.
BN = Benthic Macroinvertebrate Sample

TABLE 7-9

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSVs)[1]		Contaminant Frequency/Range		Comparison to SSVs	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Pesticides/PCBs (μg/kg)						
Dieldrin	0.02	8	7/20	1.4J - 52	7/7	2/7
4,4'-DDD	2	20	17/20	1.1J - 1,140	16/17	14/17
4,4'-DDT	1	7	15/20	0.66J - 46J	13/15	4/15
4,4'-DDE	2	15	17/20	1J - 1,200	15/17	14/17
Endrin	0.02	45	5/20	0.44J - 0.85J	5/5	0/5
alpha-Chlordane	0.5[2]	6[2]	10/20	0.51J - 13J	10/10	5/10
gamma-Chlordane	0.5[2]	6[2]	6/20	3.6 - 9.7	6/6	4/6
Metals (mg/kg)						
Lead	35	110	18/20	4.7 - 15,100	9/18	2/18

Notes: ER-L = Effects Range-Low
ER-M = Effects Range-Medium
NE = Not Established
NA = Not Applicable
[1] Long and Morgan, 1991
[2] Values for Total Chlordane

TABLE 7-10

COMPARISON OF BIOTA TISSUE DATA COLLECTED IN BRINSON CREEK TO BIOTA TISSUE COLLECTED IN OTHER STUDIES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Brinson Creek Concentration Range(1) (Whole Body)	Pamlico Sound Study Concentration Range(2) (Whole Body)	Brinson Creek Concentration Range(1) (Fillet)	Hadnot Creek Background Samples Concentration Range (Fillets)	Brinson Creek Concentration Range (Crab Tissue)	Hadnot Creek Concentration Range (Crab Tissue)
Pesticides (µg/kg)						
Beta-BHC	4.8 - 8.3 (WC)	20	4.2 - 11 (WM)	NC	6.8 - 8.9	ND
Alpha-Chlordane	2.9 - 60 (SM)	NA	3.5 - 46 (SM)	0.17	3.6 - 8.8	1.2 - 1.8
Gamma-Chlordane	12 - 22 (SM)	NA	ND	ND	ND	ND
Dieldrin	3.2 - 59 (AE)	ND - 30	4.3 - 48 (SM)	ND	6 - 9.4	ND
4,4'-DDD	5.2 - 319 (AE)	20 - 160	22 - 256 (SM)	ND	19 - 49	5.6 - 6.6
4,4'-DDE	27 - 434 (AE)	30 - 850	39 - 572 (LG)	9.7 - 12	42 - 101	4.6 - 8.7
4,4'-DDT	5.8 - 58 (AE)	ND - 30	2.5 - 15 (WM)	ND	2.5	ND
Endrin	3 - 27 (SM)	ND	2.5 - 52 (LG)	ND	ND	ND
Endrin Aldehyde	3.3 - 6.5 (LG)	NA	2.8 - 13 (SM)	ND	ND	ND
Endrin Ketone	3.1 - 14 (AE)	NA	3.6 - 3.8 (WM)	ND	ND	ND
Endosulfan IV	3.4 - 3.4 (SM)	NA	3.6 - 9.6 (LG)	ND	ND	ND
VOCs (µg/kg)						
Acetone	39 - 24,684 (MC)	NA	58 - 2,788 (LMB)	13-28	54,320 - 372,323	99 - 111
Toluene	33 (WC)	NA	NR	ND	ND	ND
Inorganics (µg/kg)						
Aluminum	23.7 - 53.2 (CF)	NA	19.3 - 27.3 (SM)	36.5	19.3	ND
Barium	0.89 - 5.0 (SM)	NA	0.4 - 2.2 (SM)	ND	ND	10.1
Chromium	2.3 - 3.6 (WC)	0.45 - 9.73	NR	0.21 - 0.68	ND	0.52

TABLE 7-10 (Continued)

COMPARISON OF BIOTA TISSUE DATA COLLECTED IN BRINSON CREEK TO BIOTA TISSUE COLLECTED IN OTHER STUDIES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Brinson Creek Concentration Range(1) (Whole Body)	Pamlico Sound Study Concentration Range(2) (Whole Body)	Brinson Creek Concentration Range(1) (Fillet)	Hadnot Creek Background Samples Concentration Range (Fillets)	Brinson Creek Concentration Range (Crab Tissue)	Hadnot Creek Concentration Range (Crab Tissue)
Copper	3.2 - 70.3 (CF)	1.43 - 5.33	2.3 - 5.6 (SM)	0.18 - 0.46	22.3 - 27.5	5.8 - 7.9
Iron	60.9 - 392 (LG)	NA	28 - 53.6 (WC)	ND	20.4 - 40.2	ND
Lead	2.5 (AE)	0.04 - 1.15	ND	ND	0.51 - 0.61	ND
Manganese	1.6 - 11.2 (CF)	NA	0.86 - 3.10 (MC)	0.8 - 0.38	1.7	1.8 - 13.6
Mercury	0.68 - 0.7 (CF)	0.04 - 1.26	0.29 - 1.3 (LMB)	0.05 - 0.24	ND	0.02 - 0.08
Selenium	0.43 - 1.0 (WC)	NA	0.6 - 5.8 (LMB)	ND	0.72 - 0.8	ND
Zinc	42.3 - 102 (CF)	44.9 - 67.7	18.2 - 58.3 (WC)	3.9 - 5	93.8 - 130	17.9 - 25

AE - American Eel
CF - Crayfish
LG - Longnosed Gar
LMB - Large Mouth Bass
MC - Mud Catfish
SM - Stripped Mullet
WC - White Catfish
NA - Not Analyzed
ND - Not Detected
NR - Not Retained as a COPC

(1) Species in parenthesis is sample with the highest detection

(2) Benkert, 1992

TABLE 7-11

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSVs)[1]		Contaminant Frequency/Range		Comparison to SSVs	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Pesticides/PCBs (µg/kg)						
Dieldrin	0.02	8	7/20	1.4J - 52	7/7	2/7
4,4'-DDD	2	20	17/20	1.1J - 1,140	16/17	14/17
4,4'-DDT	1	7	15/20	0.66J - 46J	13/15	4/15
4,4'-DDE	2	15	17/20	1J - 1,200	15/17	14/17
Endrin	0.02	45	5/20	0.44J - 0.85J	5/5	0/5
alpha-Chlordane	0.5[2]	6[2]	10/20	0.51J - 13J	10/10	5/10
gamma-Chlordane	0.5[2]	6[2]	6/20	3.6 - 9.7	6/6	4/6
Metals (mg/kg)						
Lead	35	110	18/20	4.7 - 15,100	9/18	2/18

Notes: ER-L = Effects Range-Low
ER-M = Effects Range-Medium
NE = Not Established
NA = Not Applicable
[1] Long and Morgan, 1991
[2] Values for Total Chlordane

TABLE 7-12

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTEBRATE STATIONS

BRINSON CREEK AND HADNOT CREEK
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Sj

	STATION	35-BN01	HC01	HC04
	35-BN01	NA	0.20	0.14
Ss	HC01	0.33	NA	0.18
	HC04	0.25	0.31	NA

Notes: 35-BN01 = Brinson Creek Station
HC01, HC04 = Hadnot Creek Stations

TABLE 7-13

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTEBRATE STATIONS
BRINSON CREEK AND WEBB CREEK
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Sj

	STATION	35-BN02	35-BN03	35-BN04	36-BN01	36-BN02	36-BN03	WC02
	35-BN02	NA	0.21	0.43	0.07	0.07	0.06	0.09
	35-BN03	0.35	NA	0.31	0.16	0.29	0.19	0.19
	35-BN04	0.60	0.47	NA	0.07	0.15	0.13	0.09
	36-BN01	0.13	0.27	0.13	NA	0.43	0.35	0.31
Ss	36-BN02	0.13	0.45	0.27	0.60	NA	0.53	0.42
	36-BN03	0.11	0.32	0.22	0.52	0.70	NA	0.43
	WC02	0.17	0.32	0.17	0.47	0.59	0.60	NA

Notes: 35-BN02 - 35-BN04 = Brinson Creek Stations
36-BN01 - 36-BN03 = Brinson Creek Stations
WC02 = Webb Creek Station

TABLE 7-14

TERRESTRIAL REFERENCE VALUES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Whitetailed Deer (mg/kg/day)	Bobwhite Quail (mg/kg/day)	Eastern Cottontail (mg/kg/day)	Red Fox (mg/kg/day)	Racoon (mg/kg/day)
Aluminum	6.51E+00 (c)	1.41E+01 (p)	1.16E+01 (rb)	2.11E+01 (d)	6.78E+00 (rb)
Antimony	6.91E-03 (rt)	4.39E-02 (rt)	4.06E+00 (rb)	1.49E-02 (rt)	1.36E-02 (rt)
Arsenic	3.25E-01 (c)	3.53E+00 (p)	2.90E+00 (rb)	1.31E-01 (m)	1.20E-01 (m)
Barium	1.30E-01 (c)	1.41E+00 (p)	1.16E+00 (rb)	1.06E-01 (rt)	9.72E-02 (rt)
Cadmium	3.25E-03 (c)	3.53E-02 (p)	2.90E-02 (rb)	1.06E-01 (d)	1.55E-03 (rt)
Chromium	6.51E+00 (c)	7.07E+01 (p)	5.80E+01 (rb)	1.03E+00 (rt)	9.37E-01 (rt)
Cobalt	6.51E-02 (c)	7.07E-01 (p)	5.80E-01 (rb)	3.71E-01 (rb)	3.39E-01 (rb)
Copper	6.51E-01 (c)	2.12+01 (p)	1.16E+01 (rb)	2.11E-02 (mk)	1.93E-02 (mk)
Iron	6.51E+00 (c)	7.07E+01 (p)	2.90E+01 (rb)	1.86E-01 (rb)	1.69E+01 (rb)
Lead	1.95E-01 (c)	2.12E+00 (p)	1.74E+00 (rb)	2.13E-00 (rt)	1.94E+00 (rt)
Manganese	6.51E+00 (c)	1.41E+02 (p)	2.32E+01 (rb)	1.49E+01 (rb)	1.36E+01 (rb)
Mercury	1.30E-02 (c)	1.41E-01 (p)	1.20E-01 (rb)	1.36E-01 (rt)	1.24E-01 (rt)
Nickel	3.25E-01 (c)	2.12E+01 (p)	2.90E+00 (rb)	3.52E+01 (d)	1.94E+00 (rt)
Selenium	1.30E-02 (c)	1.41E-01 (p)	1.20E-01 (rb)	1.07E-02 (rt)	1.55E-02 (rt)
Thallium	4.94E-03 (rt)	3.14E-02 (rt)	1.66E-02 (rt)	1.06E-02 (rt)	9.71E-03 (rt)
Vanadium	3.25E-01 (c)	7.07E-01 (p)	5.80E02 (rb)	3.71E-02 (rb)	3.39E-02 (rb)
Zinc	3.25E+00 (c)	7.07E+01 (p)	2.90E+01 (rb)	1.41E+00 (d)	1.69E+01 (rb)

TABLE 7-14 (Continued)

TERRESTRIAL REFERENCE VALUES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Whitetailed Deer (mg/kg/day)	Bobwhite Quail (mg/kg/day)	Eastern Cottontail (mg/kg/day)	Red Fox (mg/kg/day)	Racoon (mg/kg/day)
Benzo(b)fluoranthene	8.71E-03 (m)	5.53E-02 (m)	2.93E-02 (m)	1.88E-02 (m)	1.71E-02 (m)
Benzo(ghi)perylene	8.71E-03 (m)	5.53E-02 (m)	2.93E-02 (m)	1.88E-02 (m)	1.71E-02 (m)
Chrysene	8.71E-03 (m)	5.53E-02 (m)	2.93E-02 (m)	1.88E-02 (m)	1.71E-02 (m)
Fluoranthene	1.09E+00 (m)	6.92E+00 (m)	3.67E+00 (m)	2.35E+00 (m)	2.14E+00 (m)
Phenanthrene	8.10E+00 (rt)	5.15E+01 (rt)	2.73E+01 (rt)	1.74E+01 (rt)	1.59E+01 (rt)
Phenol	1.19E+00 (rt)	7.53E+00 (rt)	3.99E+00 (rt)	2.55E+00 (rt)	2.33E+00 (rt)
Pyrene	6.53E-01 (m)	4.15E+00 (m)	2.20E+00 (m)	1.41E+00 (m)	1.28E+00 (m)
Beta-BHC	9.88E-01 (rt)	6.28E+00 (rt)	3.33E+00 (rt)	2.13E+00 (rt)	1.94E+00 (rt)
Alpha-chlordane	1.30E+00 (c)	6.28E-03 (rt)	3.66E-02 (rt)	1.06E-01 (d)	2.14E-02 (rt)
Gamma-chlordane	1.30E+00 (c)	6.28E-03 (rt)	3.66E-02 (rt)	1.06E-01 (d)	2.14E-02 (rt)
4,4'-DDD	9.88E-04 (c)	3.56E-01 (rt)	3.33E-03 (rt)	2.13E-03 (d)	1.94E-03 (rt)
4,4'-DDE	9.88E-04 (c)	3.56E-01 (rt)	3.33E-03 (rt)	2.13E-03 (d)	1.94E-03 (rt)
4,4'-DDT	9.88E-04 (c)	3.56E-01 (rt)	3.33E-03 (rt)	2.13E-03 (d)	1.94E-03 (rt)
Dieldrin	6.51E-01 (c)	6.28E-03 (rt)	3.33E-03 (rt)	7.04E-03 (d)	1.94E-03 (rt)
Endosulfan II	1.19E-01 (rt)	6.28E-03 (rt)	3.99E-01 (rt)	2.82E-01 (d)	2.33E-01 (rt)
Endrin	1.64E-02 (d)	5.34E-02 (p)	5.51E-02 (d)	3.52E-02 (d)	3.21E-02 (d)
Endrin aldehyde	1.64E-02 (d)	5.34E-02 (p)	5.51E-02 (d)	3.52E-02 (d)	3.21E-02 (d)

TABLE 7-14 (Continued)

TERRESTRIAL REFERENCE VALUES
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Whitetailed Deer (mg/kg/day)	Bobwhite Quail (mg/kg/day)	Eastern Cottontail (mg/kg/day)	Red Fox (mg/kg/day)	Racoon (mg/kg/day)
Endrin ketone	1.64E-02 (d)	5.34E-02 (p)	5.51E-02 (d)	3.52E-02 (d)	3.21E-02 (d)
Acetone	1.98E+00 (rt)	1.26E+00 (rt)	6.65E+00 (rt)	4.26E+00 (rt)	3.88E+00 (rt)
Carbon disulfide	3.27E+00 (rb)	2.08E+01 (rb)	1.10E+01 (rb)	7.04E+00 (rb)	6.42E+00 (rb)
Toluene	4.41E+00 (rt)	2.80E+01 (rt)	1.48E+01 (rt)	9.49E+00 (rt)	8.66E+00 (rt)
Xylenes	3.54E+01 (rt)	2.25E+02 (rt)	1.19E+02 (rt)	7.62E+01 (rt)	6.95E+01 (rt)

(c) - Derived from cattle
(p) - Derived from poultry
(rb) - Derived from rabbit
(rt) - Derived from rat
(m) - Derived from mouse
(d) - Derived from dog
(mk) - Derived from mink

TABLE 7-15

SOIL TO PLANT TRANSFER COEFFICIENTS
AND BEEF BIOCONCENTRATION FACTORS
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Bv	Br*	Bb
Dieldrin	0.097(1)	0.097	1.00E-03(1)
4,4'-DDE	0.019(1)	0.019	1.26E-02(1)
4,4'-DDD	0.013(1)	0.013	2.51E-02(1)
4,4'-DDT	0.008(1)	0.008	6.31E-02(1)
Endrin	0.09(1)	0.09	1.00E-02(1)
Endrin Aldehyde **	0.09(1)	0.09	1.00E-02(1)
Endrin Ketone **	0.09(1)	0.09	1.00E-02(1)
Alpha-Chlordane	0.026(1)	0.026	7.94E-03(1)
gamma-Chlordane	0.026(1,3)	0.026	7.94E-03(1)
Beta-BHC	0.216(1)	0.216	2.00E-04(1)
Endosulfan II	0.322(1)	0.322	1.00E-04(1)
Benzo(b)fluranthene	0.006(1)	0.006(1)	1.00E-01(1)
Benzo(g,h,i)perylene	0.007(1)	0.007(1)	7.94E-02(1)
Chrysene	0.020(1)	0.020(1)	1.26E-02(1)
Fluoranthene	0.057(1)	0.057(1)	2.00E-03(1)
Phenanthene	0.097(1)	0.097(1)	7.94E-04(1)
Phenol	5.26(1)	5.26	7.94E-07(1)
Pyrene	0.033(1)	0.033(1)	2.51E-08(1)
Acetone	53.30(1)	53.30(1)	1.45E-08(1)
Carbon Disulfide	38.73	38.73	2.51E-08(1)
Toluene	1.065(1)	1.065	1.26E-05(1)
Xylenes	0.548(1)	0.548	3.98E-05(1)
Aluminum	0.004(2)	0.00065(2)	1.53E-03(4)
Antimony	0.2(2)	0.03(2)	1.00E-03(4)
Arsenic	0.040(2)	0.006(2)	2.00E-03(4)
Barium	0.150(2)	0.015(2)	1.50E-04(4)
Cadmium	0.550(2)	0.150(2)	5.40E-04(4)
Chromium	0.008(2)	0.005(2)	5.50E-03(4)
Cobalt	0.02(2)	0.007(2)	2.00E-02(4)
Copper	0.400(2)	0.250(2)	1.00E-02(4)
Iron	0.004(2)	0.00(2)	2.00E-02(4)
Lead	0.045(2)	0.009(2)	3.00E-04(4)
Manganese	0.250(2)	0.050(2)	4.00E-04(4)
Mercury	0.900(6)	0.200(2)	2.50E-01(2)
Nickel	0.060(2)	0.060(2)	6.00E-03(2)

TABLE 7-15 (continued)

SOIL TO PLANT TRANSFER COEFFICIENTS AND BEEF BIOCONCENTRATION FACTORS
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Bv	Br*	Bb
Selenium	0.025(2)	0.025(2)	1.50E-02(2)
Thallium	0.004(2)	0.0004(2)	4.00E-02(2)
Vanadium	0.006(2)	0.003(2)	2.50E-03(2)
Zinc	1.500(2)	0.900(2)	1.00E-01(2)

Notes: NA - Information not available
* - Br is assumed to be the same as Bv for organics
** - Value is for endrin

(1) Travis, 1988
(2) Baes, 1984

Bv - Soil-to-plant concentration factor which is associated with reproductive or storage functions of the plant

Br - Soil-to-plant concentration factor which is associated with the vegetative functions

Bb - Beef bioconcentration factor

TABLE 7-16

TERRESTRIAL CHRONIC DAILY INTAKE MODEL EXPOSURE PARAMETERS(1
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Raccoon	Small Mammal (Meadow Vole)
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 40% Fish 60%	Vegetation 1008
Feeding Rate	kg/d	1.6(2)	0.1(3)	0.014(4)	0.446(4)	0.319(4)	0.112(4)
Incident Soil Ingestion	kg/d	0.019(1)	0.002(5)	0.001(5)	0.012(5)	0.030(5)	0.003(5)
Rate of Drinking Water Ingestion	L/d	1.1(2)	0.119(4)	0.019(4)	0.399(4)	0.331(4)	0.0652(4)
Rate of Vegetation Ingestion	kg/d	1.6	0.1	0.014	0.089	0.128	0.112
Body Weight	kg	45.4(2)	1.229(4)	0.177(4)	4.69(4)	3.99(4)	0.3725(4)
Rate of Small Mammal Ingestion	kg/d	NA	NA	NA	0.356	NA	NA
Rate of Fish Ingestion	kg/d	NA	NA	NA	NA	0.192	NA
Home Range Size	acres	454(2)	9.29(4)	8.89(4)	1,771(4)	385(4)	0.032(4)

NA - Not Applicable
(1) Scarano, 1993
(2) Dee, 1991
(3) Newell, 1987
(4) USEPA, 1993c
(5) Beyer, 1993

TABLE 7-17

SURFACE WATER QUOTIENT INDEX
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sample Number	Sample Concentration (µg/L)	North Carolina (WQS)(1) Quotient Ratio	Region IV Screening Values (WQSV)(2) Quotient Ratio	
				Acute	Chronic
Lead	35-SW07	97J	3.9	0.44	11.4
Mercury	35-SW01	3J	125	1.4	120
	35-SW04	3.2J	128	1.5	128
Zinc	35-SW07	129J	1.5	1.4	1.5

Notes: (1) WQS = North Carolina Water Quality Standards
(2) WQSV = USEPA Region IV Water Quality Screening Values

µg/L = micrograms per liter
NA = Not Available
J = Result is quantitatively estimated

TABLE 7-18

SEDIMENT SCREENING VALUES QUOTIENT INDEX
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sample Number	Sample Concentration	SSV(1) QUOTIENT RATIO	
			ER-L	ER-M
Pesticides/PCBs (μg/kg)				
Dieldrin	35-SD02-612	1.7J	85	0.21
	35-SD04-06	1.6J	80	0.20
	35-SD04-612	3.1J	155	0.39
	35-SD07-06	1.4J	70	0.18
	35-SD07-612	2.6J	130	0.33
	36-SD06-06	52	2,600	6.50
	36-SD07-612	14J	700	1.75
4,4'-DDD	35-SD02-06	2.3J	1.2	0.12
	35-SD02-612	40	20	2.00
	35-SD04-06	43	21.5	2.15
	35-SD04-612	111	55.5	5.55
	35-SD05-06	43	21.5	2.15
	35-SD05-612	28	14	1.40
	35-SD06-06	39	19.5	1.95
	35-SD06-612	5.9	3.0	0.30
	35-SD07-06	40	20	2.00
	35-SD07-612	60	30	3.00
	36-SD05-06	223J	111.5	11.15
	36-SD05-612	1,140	570	57.00
	36-SD06-06	221	110.5	11.05
	36-SD06-612	159	79.5	7.95
	36-SD07-06	74	37	3.70
	36-SD07-612	41	20.5	2.05
4,4'-DDT	35-SD02-612	1.6J	1.6	0.23
	35-SD04-06	4.9J	4.9	0.70
	35-SD04-612	5.2	5.2	0.74
	35-SD05-06	3.7J	3.7	0.53
	35-SD05-612	1.3J	1.3	0.19
	35-SD06-06	1.7J	1.7	0.24
	35-SD07-06	2.3J	2.3	0.33
	35-SD07-612	2.1J	2.1	0.30
	36-SD05-06	31J	31	4.43
	36-SD05-612	46J	46	6.57

TABLE 7-18 (Continued)

NOAA SEDIMENT SCREENING VALUES QUOTIENT INDEX
SITES 35 AND 36
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sample Number	Sample Concentration	SSV(1) QUOTIENT RATIO ER-L	SSV(1) QUOTIENT RATIO ER-M
4,4'-DDT (Continued)	36-SD06-06	14J	14	2.00
	36-SD06-612	8J	8	1.14
	36-SD07-612	5.7J	5.7	0.81
4,4'-DDE	35-SD02-612	38	19	2.54
	35-SD04-06	31J	15.5	2.07
	35-SD04-612	82	41	5.47
	35-SD05-06	80	40	5.34
	35-SD05-612	46	23	3.07
	35-SD06-06	115	57.5	7.67
	35-SD06-612	7.7	3.9	0.51
	35-SD07-06	34	17	2.27
	35-SD07-612	57	28.5	3.80
	36-SD05-06	242J	121	16.14
	36-SD05-612	1,200	600	80.00
	36-SD06-06	249	124.5	16.60
	36-SD06-612	179	89.5	11.94
	36-SD07-06	51	25.5	3.40
	36-SD07-612	32J	16	2.14
Endrin	35-SD02-612	0.44J	22	0.01
	35-SD04-612	0.59J	29.5	0.01
	35-SD05-612	0.85J	42.5	0.02
	35-SD06-06	0.77J	38.5	0.02
	35-SD07-612	0.7J	35	0.02
alpha-Chlordane	35-SD02-06	0.51J	1.0	0.09
	35-SD02-612	6	12	1.00
	35-SD04-06	4	8	0.67
	35-SD04-612	5.6	11.2	0.94
	35-SDO5-06	9.3	18.6	1.55
	35-SD05-612	4.8	9.6	0.80
	35-SD07-06	7	14	1.17
	35-SDO7-612	8.5	17	1.42
	36-SD07-06	13J	26	2.17
	36-SD07-612	6.5J	13	1.08

TABLE 7-18 (Continued)

NOAA SEDIMENT SCREENING VALUES QUOTIENT INDEX
SITES 35 AND 36
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sample Number	Sample Concentration	SSV[(1)] QUOTIENT RATIO	
			ER-L	ER-M
gamma-Chlordane	35-SD02-612	6.7	13.4	1.12
	35-SD04-06	3.6	7.2	0.60
	35-SD04-612	7.6	15.2	1.27
	35-SD05-612	5	10	0.84
	35-SD07-06	6.1	12.2	1.02
	35-SD07-612	9.7	19.4	1.62
Inorganics (mg/kg)				
Lead	35-SD03-612	77.9	2.2	0.71
	35-SD05-06	92	2.6	0.84
	35-SD05-612	54.2	1.5	0.49
	35-SD-SD06-06	82.6	2.4	0.75
	35-SD07-06	42J	1.2	0.38
	35-SD07-612	79J	2.3	0.72
	36-SD05-06	115	3.3	1.05
	36-SD06-06	15,100	431.4	137.27
	36-SD07-06	44.9	1.3	0.41

Notes: (1) SSVs = Sediment Screening Values
ER-L = Effects Range-Low
ER-M = Effects Range-Median
μg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

TABLE 7-19

TERRESTRIAL QUOTIENT INDEX
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
Aluminum	4.35E-02	2.01E+00	7.38E-01	8.52E-01	5.90E-02
Antimony	5.57E-02	3.44E+00	3.10E-02	4.84E-01	6.88E-01
Arsenic	1.03E-02	4.48E-02	2.89E-02	1.22E-01	9.06E-03
Barium	2.26E-02	5.06E-01	4.83E-01	1.51E+00	1.59E-01
Cadmium	9.21E-03	2.06E+01	2.39E+01	1.23E+01	8.04E+00
Chromium	1.70E-03	2.32E-03	9.05E-04	1.49E-01	2.44E-04
Cobalt	3.34E-03	2.11E-02	1.17E-02	7.23E-03	7.00E-03
Copper	1.94E-01	4.59E-02	7.72E-02	5.51E+01	5.19E-02
Iron	5.84E-02	9.04E-01	6.39E-01	1.06E+00	9.17E-02
Lead	3.62E-03	2.34E-01	1.58E-01	5.11E-02	5.41E-02
Manganese	5.62E-04	5.87E-03	3.09E-02	2.97E-02	4.32E-03
Mercury	2.31E-03	2.49E-03	2.58E-03	2.49E-01	5.96E-03
Nickel	1.14E-05	2.83E-03	1.25E-02	2.93E-03	3.96E-03
Selenium	2.19E-03	2.69E-02	1.42E-02	2.50E+00	4.36E-03
Silver	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Vanadium	5.43E-02	1.28E-01	4.83E-01	3.72E-01	3.26E-03
Thallium	5.55E-03	2.10E-03	3.49E-03	5.13E-03	2.94E-03
Zinc	1.09E+00	7.46E-01	1.83E+00	3.22E-01	6.21E-01
beta-BHC	4.43E-08	5.73E-06	9.11E-06	1.62E-04	1.14E-06
Alpha-chlordane	2.28E-05	4.39E-02	3.41E-03	6.73E-02	3.20E-06
Gamma-chlordane	1.71E-05	3.29E-02	2.56E-03	2.32E-02	2.40E-06
4,4'-DDD	1.21E-01	6.08E-02	2.39E+00	4.37E+00	2.50E-01
4,4'-DDE	5.19E-02	3.17E-02	1.41E+00	6.65E+00	1.54E-01
4,4'-DDT	1.28E-02	4.60E-03	1.59E-01	6.56E-01	1.59E-02
Dieldrin	1.81E-03	4.15E-01	5.29E-01	8.61E-01	9.77E-05
Endrin	1.53E-05	1.09E-03	4.61E-04	2.26E-02	5.10E-05
Endrin ketone	2.33E-06	1.66E-04	7.00E-05	1.87E-02	7.75E-06

TABLE 7-19 (Contineued)

TERRESTRIAL QUOTIENT INDEX
OPERABLE UNIT NO. 10 (SITE 35)
REMEDIAL INVESTIGATION, CTO-0232
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
Endrin aldehyde	3.11E-06	2.22E-04	9.33E-05	9.75E-03	1.03E-05
Endosulfan II	6.03E-07	1.42E-02	2.00E-04	7.23E-04	2.53E-05
Benzo(b)fluoranthene	7.36E-03	1.21E-01	6.96E-02	5.11E-02	6.82E-03
Benzo(ghi)perylene	2.22E-03	4.09E-02	2.41E-02	1.72E-02	2.39E-03
Chrysene	2.56E-03	8.86E-02	6.94E-02	3.38E-02	7.60E-03
Fluoranthene	3.66E-05	2.04E-03	2.29E-03	6.33E-04	2.73E-04
Phenanthrene	3.65E-06	2.72E-04	3.61E-04	7.35E-05	4.42E-05
Phenol	3.90E-05	9.50E-02	1.85E-01	1.35E-02	2.38E-02
Pyrene	4.93E-05	2.15E-03	2.01E-03	7.49E-04	2.31E-04
Carbon disulfide	1.47E-07	2.61E-03	5.13E-03	3.61E-04	6.59E-04
Acetone	0.00E+00	0.00E+00	0.00E+00	1.35E-01	0.00E+00
Toluene	6.80E-08	3.52E-05	6.59E-05	1.52E-04	8.42E-06
Xylenes	8.96E-09	2.52E-06	4.51E-06	4.38E-07	5.74E-07
TOTAL QI	1.76E+00	2.97E+01	3.33E+01	8.81E+01	1.03E+01

SECTION 7.0 FIGURES

8.0 CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions based on the information presented in Sections 1.0 through 7.0 and outlines recommendations for follow-up actions, as deemed appropriate, to fill informational gaps and provide a sound engineering basis for the development of remedial responses.

8.1 Conclusions

- VOCs were detected in surface soil samples 35-SS05-00, 35-SS13-00 and 35-SS07-00. Sample 35-SS05-00 contained low concentrations of toluene, sample 35-SS07-00 contained carbon disulfide and sample 35-SS13-00 contained detectable levels of total xylenes.

- SVOCs were detected in surface soil samples collected within the study area. Contamination detected in samples 35-SS11-00 and 35-SS04-00 may be related to past activities associated with the Fuel Farm or the oil/water separator located near the ASTs.

- Tetrachloroethene was the only VOC detected in the subsurface soils that could be attributed to site conditions. It was detected in four borings (35-MW37BM, 35-MW30B, 35-MW32B and 35-MW33B) drilled south of Fourth Street. The contamination may be attributed to contaminants residing in the groundwater beneath the site.

- Sample 35-MW35B was the only subsurface soil sample containing SVOC contamination. A source for the SVOC contamination detected in sample 35-MW35B is neither obvious nor suspected in the vicinity of the soil boring.

- Inorganic levels in surface and subsurface soil were similar to base-wide inorganic levels. Surface soil samples 35-SS04-00 and 35-SS13-00 as well as subsurface soil sample 35-GWDS05-03 exhibited inorganics at levels higher than two times the base background average or the maximum base background detection. One of two reasons may be responsible for these apparent results. The elevated concentrations may be due to past activities at Building TC474 (formerly a vehicle maintenance garage) or simply outside the estimated range of base background. The number of samples used to establish a background range for inorganics is small, therefore may not be completely representative of background conditions.

BTEX compounds were detected in nearly every well that was sampled during the RI. However, the only compounds detected at the site which exhibited concentrations above groundwater standards were benzene and ethylbenzene. The wells containing the highest levels of benzene are concentrated in the areas where petroleum leaks or spills were suspected to have occurred. Monitoring wells MW-16, MW-22 and EMW-7 contained concentrations of benzene which exceeded the federal MCL and NCWQS. Ethylbenzene concentrations in MW-16 and MW-22 exceeded the NCWQS standard, but did not exceed the federal MCL. The following paragraphs describe the four plumes of nonhalogenated organics observed in the surficial.

- It is apparent that, based on groundwater flow patterns in the vicinity of the Fuel Farm, a plume of nonhalogenated organics is moving eastward in relatively the same direction as groundwater flow. The plume appears to be centered in the vicinity of MW-22.

- Monitoring wells MW-21 and MW-25 contained benzene and ethylbenzene concentrations which exceeded either the Federal MCLs or the NCWQS or both. These wells are located north of the Camp Geiger Area Fuel Farm and are believed to be unrelated to the previously mentioned plume (i.e., near MW-22). However, these wells are located in an area where it is suspected that an undetermined amount of petroleum product was released onto the surface and allowed to migrate toward Brinson Creek.

- Benzene and ethylbenzene levels were detected at concentrations greater than the federal MCLs and the NCWQS in monitoring well MW-2. This well was installed during ATEC's investigation of the UST in the vicinity of building TC341, which is located west of the Fuel Farm. This contamination appears to originate from the abandoned UST located near the former Mess Hall Heating Plant. The extent of this contamination appears to be limited in size.

- Monitoring wells MW-10S and 35MW-29A contain benzene concentrations which slightly exceed the NCWQS. The source of benzene in this area may be related to former activities near the barracks. The extent of this plume appears to follow the flow of groundwater eastward toward Brinson Creek. Downgradient wells EMW-05, MW-32A, and MW-26A also exhibited benzene and ethylbenzene, at slightly lower concentrations.

Three halogenated organic plumes were observed in the surficial aquifer at OU 10. The following paragraphs describe the plumes:

- Halogenated organic contamination (TCE and cis-1,2-DCE) was detected in the shallow wells at the site with concentrations exceeding the Federal MCLs and NCWQS. The highest level of TCE was detected in monitoring well MW-14. This well is located directly west of Site 35 and appears to be part of a plume that originates in the vicinity of MW-10 and travels northeast toward Brinson Creek along a pathway marked by monitoring wells EMW-5, MW-14 and EMW-3.

- TCE and cis-1,2-DCE contamination was detected in monitoring wells EMW-7 and MW-19 located north of the former Vehicle Maintenance Garage (presently warehouse TC474). TCE contamination exceeded the Federal MCL and the NCWQS in both wells and the detected level of cis-1,2-DCE in well EMW-7 was above the Federal MCL and the NCWQS. Unlike the plume described above, the contamination in this area of the site appears to originate from the former Vehicle Maintenance Garage and may have resulted from improper disposal or mishandling of TCE based solvents used in degreasing operations.

- Monitoring well 35MW-35A contained TCE contamination which exceeded the Federal MCL and NCWQS. The well is located east of a chemical storage area located between warehouse TC470 and TC572. Given the direction of groundwater flow, it is likely that the contamination may be attributed to the storage of chemicals within this area. However, not enough data exists at this time to determine the true origin of this contamination.

- Well 35MW-32A exhibited elevated concentrations of TCE and cis-1,2-DCE exceeding the Federal MCL and the NCWQS. The well is located east of warehouse TC462. Enough data has not been gathered to determine the source area for these contaminants.

- Semivolatile compounds were detected in monitoring wells MW-21, EMW-05, MW-29A, MW-16, and MW-22. These compounds appear to be related to petroleum contamination and correlate with the previously identified plumes.

- The only pesticide detected in the shallow groundwater which exceeded the NCWQS was heptachlor. It was detected in MW-29A with no apparent source for the contaminant. The concentration is low enough to indicate that it may have originated from the application of pest controls to the surface soils.

- Inorganic contamination was detected within the upper portion of the water table aquifer throughout the site. Since the distribution of the contaminants does not reflect a particular trend or pattern, it is difficult to assess the entire extent of metals contamination and identify specific source areas. The data suggests that the elevated total metals are due to suspended particulates in the sample.

- Nonhalogenated organic contamination (e.g., BTEX) was detected at low levels in the lower portion of the water table aquifer in nearly every intermediate well location. However, the concentrations of the contaminants detected were much lower than the concentrations detected in the upper portion of the aquifer. This trend complies with the properties of the compounds (i.e., specific gravity). The only exception to the trend is MTBE. The concentration of MTBE increased in the lower portion of the aquifer rather than decreased. A reason for this exception cannot be determined at this time and may require more information to formulate an explanation.

The primary nonhalogenated organic compounds that were detected at levels exceeding the Federal MCL and/or NCWQS were benzene, ethylbenzene and MTBE. Two primary plumes of nonhalogenated compounds were identified within the study area.

- The first to be discussed is located in the western, southwestern and southern portions of the site. The highest concentrations were centered around MW-10D. Benzene was not detected in this well but ethylbenzene and MTBE were detected at concentrations which exceeded the NCWQS. The surrounding wells (MW-09D, 35MW-31B, 35MW-32B, 35MW-30B, 35MW-29B and 35MW-37B) contained benzene at concentrations which exceeded the NCWQS. Three of the wells possessed concentrations which exceeded the federal MCL.

- The second plume is located in the eastern portion of the study area. Monitoring wells MW-19D, MW-22D and 35MW-33B contain concentrations of benzene, ethylbenzene and MTBE in excess of Federal and state groundwater standards.

During Law's investigation of the site, samples were collected from monitoring well MW-19D and MW-22D. Results from the samples indicate that greater concentrations of total BTEX resided within monitoring well MW-22D than was detected by Baker and no BTEX compounds were detected in MW-19D. This information lends credibility to the theory that dissolved nonhalogenated contamination in this area of the study area is migrating with the direction of groundwater flow toward Brinson Creek.

In addition to nonhalogenated compounds, halogenated organics such as TCE, cis-1,2-DCE and trans-1,2-DCE were detected in 10 intermediate wells within the study area. The concentrations of the halogenated organics contamination is greater in the lower portion of the aquifer than the upper portion of the aquifer. This trend is typical when halogenated hydrocarbons, such as those listed previously are identified within an aquifer system. Due to the compounds specific gravity, it is common for higher concentrations of the compound to reside within the deeper portions of the aquifer. The following paragraphs discuss the nonhalogenated oganic plumes in the lower portion of the surficial aquifer.

- Two plumes of halogenated organics have been identified at the site. The first of the two plumes is located in the area of the former Vehicle Maintenance Garage (warehouse TC474) in the eastern portion of the study area. The highest concentrations of TCE were detected in wells MW-19D and 35MW-33B. TCE, cis-1,2-DCE and trans-1,2-DCE concentrations exceeded the federal MCL and NCWQS. These concentrations correlate well to the corresponding shallow wells. The concentrations detected in MW-19D are similar to the concentrations detected by Law in their previous investigation. Based on the concentrations detected in the shallow and intermediate wells, the former Vehicle Maintenance Garage is the suspected source for the halogenated organic contamination is this portion of the study area.

- A larger plume of halogenated organics originates on the southern edge of the study area trending northeast toward Brinson Creek. Elevated TCE concentrations exceeding the Federal MCL and the NCWQS were detected in monitoring wells 35MW-30B, 35MW-32B, 35MW-29B, MW-10D, MW-09D, MW-14D and MW-21D. The highest TCE concentration was detected in MW-10D, however this does not appear to be the source area for the contamination. The southern and northeastern edge of the plume is not defined and it is Baker's belief that the contamination source is located outside of the boundaries of the study area.

- No semivolatiles were detected in the lower portion of the shallow aquifer.

- Heptachlor was detected in monitoring well 35MW-33B at a concentration that exceeded the NCWQS. The source of this contamination is unknown.

- Inorganic contamination was detected within the lower portion of the water table aquifer. In comparison to the upper portion of the aquifer, inorganic concentrations were generally lower in the lower portion of the aquifer. Since the distribution of the contaminants do not reflect a particular trend or pattern, it is difficult to assess the entire extent of metals contamination and identify specific source areas. The data suggests that suspended solids in the sample may be contributing to elevated total metals.

- No significant organic or inorganic contamination was detected in the samples collected from the deep wells (Figure 4-10). The absence of TCE in the Castle Hayne Aquifer indicates that the unit identified as a semi-confining unit is retarding the vertical migration of the contaminates. Although the unit possesses very little clay and is not the "typical" semi-confining unit, the high permeability of the soils above and below the unit as well as the groundwater gradient exhibited at the site provide for the surficial aquifer waters to flow along the top of the unit instead of passing through the unit. Vertical migration may be occurring at the site but at a very slow rate such that the contamination has not been detected in the upper portion of the Castle Hayne Aquifer.

- No VOCs were detected in surface water samples. Toluene was the only volatile organic compound detected in the sediments obtained from station 35-SW/SD03 within Brinson Creek (Figure 4-11). Although VOCs generally were not detected, heavy sheens and hydrocarbon odors were noted during sampling. During sample validation, it was noted that an unusually high number of Tentatively Identified Compounds (TICs) were identified in the samples.

- Although no SVOCs were detected in the surface water samples, a number of SVOCs were detected in the sediment samples collected from Brinson Creek. The SVOCs were detected in greater frequency in the samples collected from 6 to 12 inches. SVOCs were detected both upgradient and downgradient of Site 35. However, the highest levels of SVOCs were detected in samples obtained adjacent to Site 35.

- Pesticides were detected at all 10 sediment sample locations; however, no pesticides were observed in the surface water samples. The application of pest control to the surfaces Camp Geiger leads to pesticide detections in the sediments of Brinson Creek. The pesticides are carried from the surface soil to the creek via surface runoff and natural erosion. This statement can be further supported by the large number of pesticides detected in the surface soils at the site. PCBs were not detected in any of the surfaced water or sediment samples collected from Brinson Creek.

- Inorganics above the Federal Screening Values (WQSVs and NOAA standards) and/or NCWQS are present in one surface water and seven sediment locations. The only compound to exceed the NOAA standards in sediments was lead. The greatest concentration was detected in sample number 36-SD06-06 collected from the 0 to 6 inch interval. The detected lead is prevalent adjacent to and downstream of Site 35 and could be related to past site activities. Mercury, lead and zinc were detected at levels exceeding the Federal and North Carolina Standards in surface water samples 35-SW01, 35-SW04 and 35-SW07. The mercury was detected in two samples (35-SW01 and 35-SW04) located upstream of Site 35 which indicates contamination may originate from an upgradient location. The concentrations of lead and zinc detected in sample 35-SW07 may be attributed to past practices at

Site 35 due to its geographic location with respect to Site measurements of groundwater.

- Baker calculated that the human health risk associated with pesticides dieldrin and DDD in surface soil samples demonstrates a risk range within acceptable levels.

- Baker calculated that the overall human health risk associated with Site 35 is in excess of the acceptable range. The total risk was driven by future potential exposure to groundwater and current potential exposure to fish. However, only noncarcinogenic risks were likely with exposure to fish.

- Overall, metals and pesticides appear to be the most significant site related COPCs that have the potential to affect the integrity of the aquatic and terrestrial receptors at Site 35. Although the American alligator have been observed at Site 35, potential adverse impacts to this species could not be quantitatively evaluated.

- Surface water quality showed exceedances of aquatic reference values for lead, mercury, and zinc. In addition, iron, cobalt and manganese were above the concentration that caused adverse impacts to aquatic species in a few studies. However, most of the studies did not meet the criteria for reliability, and other studies indicated that potential impacts to aquatic organisms did not occur at the concentrations detected in the surface water at Brinson Creek. For sediments, concentrations of lead and the organics dieldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endrin, alpha-chlordane, and gamma-chlordane exceeded the aquatic reference values. In the surface water, mercury exceeded aquatic reference values in the upstream stations. Although these levels were indicative of a high potential for risk (QI > 100), mercury is not believed to be site related. Zinc only exceeded unity slightly and was only found at a single station. Lead has a single exceedance of the aquatic reference value by slightly greater than 10 indicating a moderate potential for risk to aquatic receptors. Lead also was found in the groundwater samples at similar levels and is site related.

- In the sediments, lead exceeded the lower sediment aquatic reference value throughout Brinson Creek. The only exceedances of the higher sediment aquatic reference value occurred downstream of Site 35 with the highest QI of 137 representing a high potential for risk to aquatic receptors. The lead detected in the sediments is likely site related, the result of past reported surface spills/runoff and past and ongoing groundwater discharges to surface water.

- Pesticides exceeded the sediment aquatic reference values throughout Brinson Creek. The highest QI, 2,600 for dieldrin, represents a high potential for risk to aquatic receptors. There is no documented pesticide disposal or storage/preparation activities at Site 35. The pesticide levels detected in the sediments probably are a result of routine application in the general vicinity of Site 35.

- Although, the pesticides in the sediments were found at levels indicating contamination throughout the watershed, the highest levels were observed in the lower reaches of Brinson Creek. This deposition tread may be related to the higher organics in the sediments in the lower reach, which would accumulate more of these types of contaminants.

- The fish community sampled in Brinson Creek was representative of an estuarine ecosystem with both freshwater and marine species present. In addition, the presence of blue crabs, grass shrimp, and crayfish support the active use of Brinson Creek by aquatic species.

- The absence of pathologies observed in the fish collected from Brinson Creek indicates that the surface water and sediment quality may not adversely impact the fish community.

- The benthic macroinvertebrate community demonstrated the typical tidal/freshwater species trend of primarily chironmids and oligochaetes in the upper reaches and polychaetes and amphipods in the lower reaches. Species representative of both tolerant and intolerant taxa were present. Species richness and densities were representative of an estuarine ecosystem.

- The aquatic community in Brinson Creek is representative of an estuarine community and does not appear to be significantly impacted by surface water and sediment quality.

- Surface soil quality indicated a potential for adversely impacting the terrestrial receptors that have indirect contact with the surface soils and copper in the tissue samples. This adverse impact is primarily due to cadmium in the surface soils. The cadmium in the surface soil is overestimating the adverse impacts since it was detected at a relatively high concentration in only one out of ten samples. In addition, the copper in the tissue samples does not appear to be site-related.

8.2 Recommendations

Based on the data obtained it is recommended that:

- The remedial investigation at Site 35 be extended south of Fifth Street as needed to define the extent and locate the source(s) of solvent-related groundwater contamination in the surficial aquifer.

- The monitoring wells screened within the surficial aquifer that were sampled under the RI be resampled for inorganic contaminants (total phase only) using low-flow pumping techniques in order to more accurately quantify total metals contamination. Based on past experiences with the technique at Camp Lejeune, it is anticipated that using the low-flow technique will result in lower total metals concentrations due to reduced sediment disturbances while sampling.

- Surface soils and sediments be resampled for mercury and zinc in order to replace that data which was rejected during validation. The data generated from the additional sampling of soils and sediments combined with the results of the low-flow groundwater sampling for metals should enable Baker to determine whether or not Site 35 is the source of elevated zinc and/or mercury concentrations in

Brinson Creek surface water and fish. In addition, new information regarding metals concentrations in Site 35 media will be used to further evaluate the human health and environmental risks associated with the site. The soils and sediment data and any associated analyses will be incorporated into an addendum to the RI Report.

- Sediment samples along Brinson Creek be obtained at locations adjacent to and downstream of Site 35 and analyze for TPH (EPA Methods 5030 and 3550) so as to provide data regarding the extent of organic contamination that was "masked" by TICs in results obtained under the RI.

- An Interim Remedial Action Feasibility Study be prepared that focuses on the groundwater in the vicinity of the Fuel Farm and north of Fourth Street. The purpose of this Interim FS will be to address groundwater contamination in this area which may be a continuing source of contamination to Brinson Creek.

- The northeastern edge of the halogenated organic plume has not been delineated. Therefore soil and groundwater samples should be collected on the northern side of Brinson Creek in order to determine if Brinson Creek is acting as a barrier to groundwater contamination that may be migrating off-site.

- Special precautions be taken when soil excavation is performed during the construction of the new highway. Specifically, it is recommended that the written construction workplans reference the need for monitoring of volatile organic contaminant concentrations in the breathing zone of the workers, and that institutional and engineering controls be established to minimize human exposure to both VOCS and fugitive dust particulates. Although the calculated risk to human health for future construction workers on Site 35 is well below the EPA acceptable range, adverse exposure to a volatilized fraction of contaminants in the subsurface soil or inhalation of airborne contaminants is possible.